# A user-centred social commitment model for location sharing applications in the family life domain

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**Abstract**

Mobile location-sharing technology is used increasingly by parents to know where their children are. It is our aim to make such technology more flexible in adapting to the particular social context in which it operates. We propose to realize this by allowing users to specify norms that govern the respective social contexts, to which the application should adapt at run-time to provide tailored support. The challenge we address in this paper is the development of a normative model tailored for mobile applications that support location sharing in family life. The novelty of our work lies in the fact that we employ empirical user-centered design methods and techniques for developing the model in an iterative and "bottom-up" way. This results in two main contributions: 1) a normative model, specifically a social commitment model, for family life location sharing applications shown to be useful and usable, and 2) a demonstration of how user-centered design can be employed to develop a normative model for social applications.

**Keywords:** Social media, location sharing, social commitments, normative frameworks, user values.

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## 1 Introduction

Social data sharing applications have gained a massive number of users in recent years– at the time of writing, Facebook has 1.86 billion active users, while Twitter had 319 million active users. People are spending increasing amounts of time sharing and receiving personal data such as text, photos, videos, location information, and even fitness and health data. Use of these applications can make our lives more connected, healthy, efficient and safe. However, research in value-sensitive design and philosophy of technology shows this may come with the risk of demoting other important user values such as privacy and responsibility [CDY+10, NF13, Nis10]. A value is defined in [FKB06] as "what a person or group of people consider important in life".

Research in philosophy and normative systems [BC03, vdW11, vdP13] as well as our previous research [KBG+14] (Section 2) observes that values can be promoted and demoted by (regulatory) norms, i.e., *action guiding* statements obligating or prohibiting actions [Han91]. Inspired by this observation, we have put forward the vision that in order to provide improved support for user values, social applications should be able adapt to users' norms at run-time [KBG+14], for example by monitoring users' interactions as in [KY16a]. Conceived in this way, data sharing technology can be designed as a collection of personal assistant agents that we call *Socially Adaptive Electronic Partners* (SAEPs). The idea is that these SAEPs support users for example by sharing data on their behalf, in accordance with their (data sharing) norms.

A central question in the realization of this vision – and the one which forms the focus of this paper – is: *what kind of normative model is needed to allow end users to express norms for governing the behaviour of SAEPs?* In research on normative multiagent systems a wide range of normative models and frameworks has been developed (see [AGNvdT13] for an overview). Moreover, in recent years we have seen an increase in research connecting normative models and social applications, ranging from research visions [OSS13, NPVd16] and engineering methods [MAS16, KAS16, AMGS17] to normative reasoning models [SC14, KY16b, FMSS17]. While these approaches outline how normative models could be used in the context of social applications, they do not design the normative language *itself* based on input from *end users* nor do they study how end users *experience* the use of the model for expressing their norms.

Since SAEPs are interactive applications that are meant to support their users in their daily lives, we employ a different approach: we take an investigation of user needs as our starting point for developing a normative model. We adopt a *user-centred design approach* called situated Cognitive Engineering (sCE) [NL08] (Section 3). User-centered design methods are focused on taking into account user needs throughout the design process. The sCE method emphasizes the iterative nature of such processes, i.e., developing technology in multiple cycles of requirements specification and evaluation with users. To the best of our knowledge this is the first time that an iterative user-centered design process has been used to develop and evaluate a normative model for social applications.

Central in user-centered design and in particular sCE is understanding end users and their context of use in the design of technology. For this reason it is important that we perform our research within the context of a certain user group and application domain, ensuring

that the normative model we develop is indeed in line with this context of use. As our application domain we choose mobile location sharing for families with elementary school children, between six to twelve years of age. Allowing parents and children to share their location through mobile technology can support children in exploring their environment, through, e.g., helping them go to school on their own, making new friends, participating in neighborhood events and play dates, as well as increasing parents' awareness of the location of their children. This domain is interesting for our purposes since data sharing needs may differ per situation and per person. For example, parents may want a child that starts going to school alone to inform them when s/he arrives, while this may not be needed for older children. Norms may be used as a flexible means to express data sharing needs. More and more data sharing and surveillance technology is being developed. Examples of existing location sharing applications are Life360, Glympse, and wearables such as KizON. Glympse and Life360 are family-oriented mobile apps, where for example, a parent can view the current location of her children or other family members on a map through GPS tracking. LG has released KizON, a bracelet that provides real-time location information allowing parents to track their children's whereabouts in real time. This makes the investigation of location sharing technology for families not only a means for realizing our broader aim but also relevant for its own sake.

In this paper we perform two iterations of specification and evaluation of a normative model for location sharing. In the first iteration we identify the main components of the model according to input from potential users (Section 4) and evaluate its *expressivity* (Section 5). In the second iteration we specify the syntax and semantics of the normative model in more detail (Section 6) and evaluate its *usefulness* (can the model express users' normative requirements?) and *usability* (is the model sufficiently easy to use and understand?) (Section 7). Usefulness and usability are standard measures of a technology's effectiveness employed in user-centred design [Dav89] that we translate to our setting of development and evaluation of a normative model. The main contribution of this paper is a normative model for family life location sharing applications shown to be useful and usable. In addition, through the development of this model we demonstrate how user-centered design can be employed to develop a normative model for social applications. We discuss these results and conclude the paper in Section 8.

## 2 A Value-Centric Grounded Model

The starting point of this paper is previous research [KBG+14] in which we have conducted several user studies (namely, cultural probes [GDP99] and focus groups [KC08]) with a sample of our target group (6 parents, and 6 of their children) in a town of approximately 30,000 inhabitants. The aim of the study was to understand what the main elements are that make up the social context of the target domain (location sharing in family life) and how these are related to the envisaged normative framework.

We used a qualitative method called *grounded theory* [SC98] to analyze our data. In grounded theory a model is built through a bottom-up process of labelling the transcripts of interviews with increasingly abstract codes in order to identify main themes in the data and eventually identify relations between them. The resulting "grounded model" is shown in Figure 1.

The model identifies three key elements of the social context of family life: "activities" e.g. visiting family, going to the park, playing outside; "concerns" e.g. anxiety about children

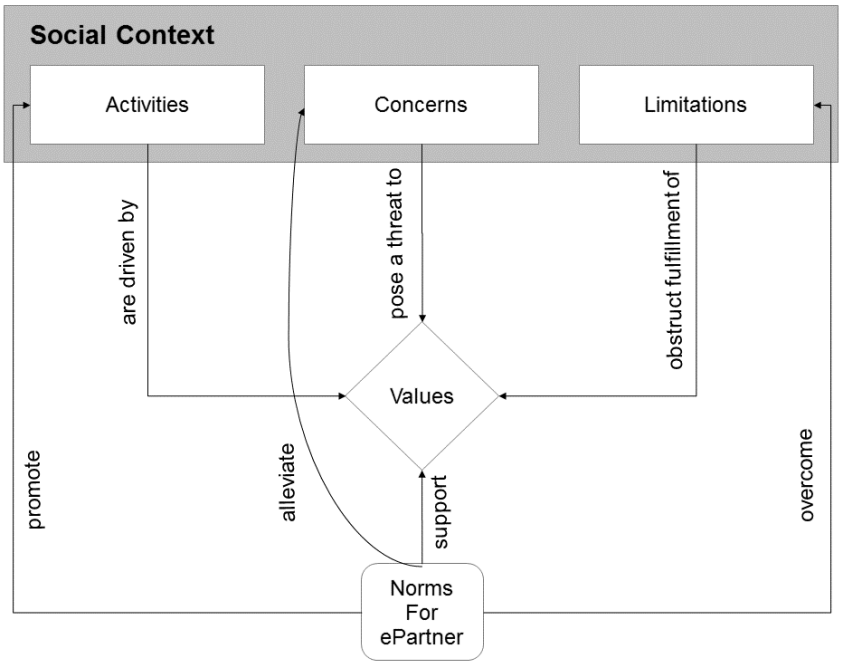


**Figure 1**: Grounded model (from [KBG+14])

going places on their own, children's exposure to the internet; and "limitations" e.g. friends living at a distance, difficulty using certain technologies. We have identified the concept of *values* as central in connecting elements of the social context to norms. In his 1973 book [Rok73], social-psychologist Milton Rokeach published a now widely used list of values such as family security, freedom and independence, based on a survey he conducted.

The concept of norm in this paper is initially taken in the broad sense as defined in [AGNvdT13], starting from their social nature– "customary rules of behaviour that coordinate the interactions in groups and societies". That paper states a common view of norms as "regulatory" mechanisms, which is the interpretation we take here. It is the purpose of our research to identify the precise form and way of using norms in the context of mobile location sharing. The groups that norms may govern in our setting can be (sub)groups of our target group, and the agents used to support them. Central to our approach is the observation that location sharing norms may differ for different families and groups of friends, and the aim of creating technology capable of supporting this diversity. This differs from work in normative multi-agent systems which often focuses on (social) norms at the level of societies. In the rest of the paper we make the normative model step by step more precise.

The connection between norms and values has already been made in philosophy and normative systems literature [Han91, VW12, MH11]. The idea is that values may be promoted and demoted by norms, which influence agents' choice of actions. An *action* changes an old situation into a new situation, and 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 [BC03, vdW11]. Since norms are *action guiding* statements, through obligat-

ing or prohibiting actions [Han91], norms can be used to influence an agent's behavior to promote or demote certain values. Values can be linked to goals in the sense that we can understand values as desirable, abstract, cross-situational goals [KS09]. That is, values are longer in term than (concrete) goals, and achieving a goal may promote or demote a number of (abstract) values.

Through annotating user statements in [KBG+14] with the values from Rokeach's list which were relevant to these statements, we were able to identify values from that list relevant to this domain. Specifically, we found that the user study data could be linked to the following values:

- *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 the children be able to do more activities on their own.
- *Friendship:* parents and children alike expressed 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.

In Rokeach's value survey the values above appear as separate concepts, although some of them are closely related, in particular freedom and independence. In the context of our domain, a child's freedom refers to less parental/adult supervision, while independence refers to children's *ability* in doing activities on their own. In this paper we use values as input for the design process of creating a normative model. The idea is then that users themselves specify norms to the agent/application, in accordance to how they believe these norms will influence their values. We have studied the explicit use of values as input for an agent's normative conflict resolution at run-time in follow-up research [KBG+14].

## 3 Approach

In the introduction, we highlighted the need for developing social applications while ensuring user involvement throughout the stages of development. In this section we outline our approach in more detail. Our approach is based on the *situated Cognitive Engineering* (sCE) framework [NL08]. Cognitive Engineering [HW83] concerns development of practical theories and methods that are *situated* in the domain. Using a situated approach allows for (1) better addressing of the human factors (i.e. human characteristics that influence people's behavior in a certain environment), which in turn leads to a better human-machine collaboration design and (2) a better understanding of the domain of operation. sCE is a

Cognitive Engineering framework in which the *iterative* nature of situated user-centered development processes is emphasized.

sCE comprises three main iterative phases: *foundation* – understanding the domain and characteristics of our target group, *specification* – scenarios, technological requirements and claims about the effect of the envisaged technology in the lives of the target group, and *evaluation* of certain aspects of the introduced technology during the cycles of its implementation, such as usability and user interface tests, simulations of certain models, and field testing/evaluation of prototypes.

An overview of how we employed these phases for developing a normative model is depicted in Figure 2. We instantiated sCE's foundation phase through development of the grounded model and identification of values as described in Section 2 (Box 0). Based on this foundation, we develop the normative model through a series of iterations of specification and evaluation. In this paper we focus on the first two iterations (Box 1): i) specification of the main elements of the normative model (which we call the *normative concept*, Section 4) and evaluation of its expressivity (Section 5), and ii) a more detailed specification of the syntax and semantics of the *normative model* (Section 6) and evaluation of its usability and usefulness (Section 7). Evaluation of the extent to which a location sharing application built on the basis of this normative model provides better support for people's values (Box 2), as well as specification and evaluation of a normative conflict resolution model (Box 3) are subject of future research.

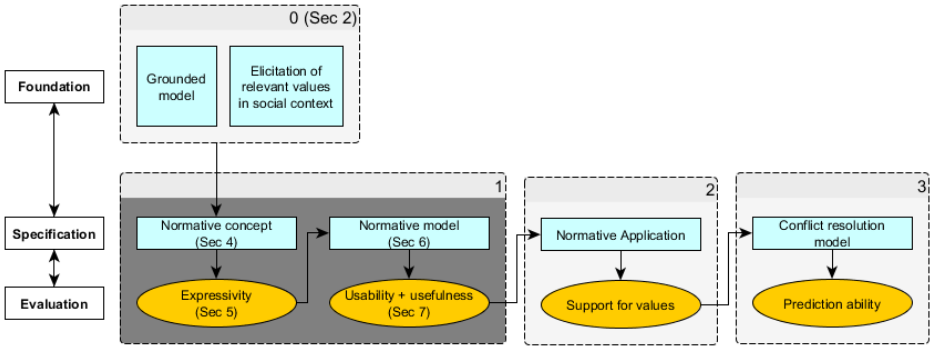


**Figure 2**: Instantiation of the three phases of the sCE framework.

## 4 Specification of the Normative Concept

In this section we present a specification of the normative concept to be used as the basis for developing the normative model. Following sCE, we perform an analysis of possible *scenarios* and corresponding technological *requirements* and *claims* about the effect of the technology. In our case this concerns identification of location sharing scenarios, requirements regarding the elements of the normative concept, and claims concerning the expected fulfillment of values in these scenarios when these requirements would be fulfilled (Section 4.1). This analysis is based on the data and grounded model from our previous user study

**Table 1** Scenarios, requirements, and claims.

| No. | Scenario | Requirements | Claims |
|---|---|---|---|
| 1 | When a child arrives at a playground, a friend's place, or at school, a parent or friend would like to know this. | *x* wants *y* to share their location with them if they arrive at a specific location. | Promotes:<br>*Social recognition*<br>*Friendship*<br>*Family security* |
| 2 | In order to keep her children safe, a mother would like to ensure that she or the children's father know when they enter a dangerous area. | *x* wants *y* to share their location with them or a third party if they enter a certain place. | Promotes:<br>*Family security* |
| 3 | During dinner or homework a parent does not want the child to receive location information from non-family members to preserve family time and quiet time. | *x* wants *y* to stop receiving location info from non-family members during certain time periods. | Promotes:<br>*Responsibility*<br>*Inner harmony* |
| 4 | A parent may not want to receive location notifications from their child during a time when they are busy. | *x* does not want to receive too many location notifications under certain conditions. | Promotes:<br>*Independence*<br>*Freedom*<br>*Inner harmony* |
| 5 | Parents do not want strangers to know where their children are. | *x* does not want *y*'s location to be shared with strangers. | Promotes:<br>*Family security*. |

[KBG+14] as summarized in Section 2. We analyze to what extent existing location sharing applications already fulfill these requirements and provide support for relevant values (Section 4.2). Then we identify the main components of the normative concept with the aim of providing support for values as envisaged (Section 4.3).

### *4.1 What should our model be capable of expressing?*

We have performed an analysis of the data from our focus groups with parents and children from [KBG+14] and identified situations (scenarios) and corresponding normative statements (requirements) regarding sharing and receiving location information. We interpret these statements as *requirements for the design of our normative model*: we aim to design a language that can express statements of this form. This can be contrasted with work on (agent-oriented) software engineering in which the term requirements is used to express desirable properties of a (socio-technical) system that is to built [KAS16], or more specifically to express social requirements for a specific system as in [AMGS17]. In our case requirements concern the normative language that is to be designed. In Table 1 we describe scenarios and corresponding requirements, and we identify values they intend to promote.

From these scenarios and requirements we extract the following general elements that a normative model for location sharing applications should allow to express, according to this analysis step.

**Social needs** In real-life social settings, requirements regarding sharing and receiving data may originate from people in the user's social circle, i.e., from a person different from the user of the application such as a child's parent or friend. These needs are *directed* from a subject to an object in the sense of [Sin13].

**Context** Social needs regarding location sharing often concern a specific context describing when data should (not) be shared or received, such as a particular location or time of day.

**Duality of data sharing** Social needs in the context of location sharing applications may concern both sides of the sharing process, i.e., not only sharing but also receiving data.

**Third party association** Social needs regarding location sharing may concern a third party, for example a mother requesting a child to share location data with the father, or not to share data with strangers. Scenario 2 in Table 1 highlights the need for this element.

**Obligations and prohibitions** Social needs regarding location sharing can be in the form of obligations (data should be shared or received) or prohibitions (data should not be shared or received).

Though these normative statements may as well demote some values, the claims column in the table intends to show what users claim for which these requirement are promoting. This analysis is in accordance with the sCE methodology, with its elements of scenarios, requirements, and claims– A "demotes" column is not yet required at this stage of the analysis.

### *4.2 Comparison with existing applications*

We now compare these elements to social and location sharing platforms that are available as of the time of writing. Existing location sharing platforms implement roughly two types of data sharing mechanisms: i) location sharing by means of *active check-ins*, where location data is shared (only) when the user actively does so, such as on Foursquare, Facebook and Twitter, and ii) location sharing by means of *GPS tracking*, where location data is continuously shared once the user agrees to do so and until it is switched off by the user, such as on Life360 and FindMyFriends.

Comparing these location sharing mechanisms with the elements we identified above, we make the following observations. Applications that feature only the possibility for user-initiated check-ins do not accommodate social location sharing needs within the application. This can demote some users' values because i) no check-in is performed at a time where they would like to know where another user is, or ii) because a check-in is performed but not shared with them. The latter can occur when users assign their contacts to custom lists and choose which of their updates are shared with which lists, such as in Facebook. Assume for example that a daughter has a list comprising family members. Then if parents would like to be notified when she is at an unsafe area, it would require the daughter to share all her check-ins with all of her family. This promotes *family security* but may demote her *freedom* because more check-ins are shared with parents than necessary and desired, as well as with

other family members. Also it may demote family members' inner harmony because they receive too many check-ins (Case 4 of Table 1). Please note that in the last case, this kind of oversharing may be avoided by creating a list only consisting of parents, and switching sharing with the list on only when creating a check-in at a dangerous area. However, this is cumbersome and it does not facilitate extensions that require the application to be aware of this social need, for example a functionality that reminds the daughter to check-in or that performs an automatic check-in at a dangerous area.

On the other hand, applications that rely on GPS tracking and continuously share location data do accommodate social needs, but the data is not shared in a context-dependent manner. This may promote family security and social recognition since parents and friends can always find out where a child is (Cases 1 and 2 of Section 4.1), but it can demote a child's freedom and independence since their decision to go somewhere has to take into account that someone else might see this. Some applications such as FindMyFriends do allow limited conditional location sharing, for example by giving permission to share GPS data only within a certain timeframe. Also conditional notification rules can be used to express that user $x$ gets a notification every time user $y$ is at a certain geographical location. However, this typically concerns a context-dependent *notification* to $x$ based on GPS data that has already been shared, rather than context-dependent *sharing* of that data from $y$ to $x$.

Moreover, existing applications typically focus on providing mechanisms to allow sharing but not receiving of location data (duality of data sharing), and to the best of our knowledge they do not allow to express prohibitions on sharing and receiving data nor third party location sharing needs. This may demote responsibility, for example when a child receives notifications when it is supposed to be doing homework (Case 3 of Section 4.1), or family security when a child shares location data with strangers (Case 5 of Section 4.1).

In summary, existing location sharing applications implement some aspects we identified, but a comprehensive location sharing model that is grounded in user values and allows to express contextualized social needs has not yet been developed. These limitations come with the risk of negatively affecting user values as a side effect of promoting others.

### *4.3 Components of the normative concept*

In this section we make the requirements identified in Section 4.1 more concrete by translating them into components of the normative concept. We do this by selecting a normative model from the normative multi-agent systems literature that resembles our requirements from Section 4.1, and adapting it for creating a normative model for our purposes. The advantage of connecting our model to existing research is that it will allow us to build on existing results, for example when defining the semantics.

Considering the directed nature of social needs, we take the work of Singh [Sin99, Sin13] on *social commitments (SCs)* as a starting point. A SC is a type of norm that describes an agreement between two parties, 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. A commitment can be viewed as the result of an expressed social need, e.g., a parent would like to be informed when a child arrives at school (social need), which can result in a corresponding commitment from child to parent. Specifically, we identify the following elements to form our normative concept.

Being a norm-based model, we use the term "agent" to denote the application that is sharing and receiving information on behalf of the user.

*Creditor and debtor* The creditor and debtor represent the parties involved in a social commitment, which facilitates expressing directed social needs. The directed nature of norms is central in Singh's work [Sin13]. The creditor is a user that makes a request (expresses a social need) to the debtor through its agent for data to be shared or received. For example, in Case 2 of Section 4.1, user $x$ is the creditor and $y$ is the debtor.

*Normative effect* The consequent of an SC in our case, which we refer to as the "normative effect", can be an action or the negation of an action. We use the term "obligation" to refer to the former, and "prohibition" to refer to the latter, in line with [Mey87]. In literature on SCs, e.g., [Sin13], the term commitment is reserved for obligations. Prohibitions are modelled as a separate kind of norm with the same structure but different semantics. However, negated propositions can be used as the consequent of commitments, which gives rise to the same semantics regarding fulfillment (upon true antecedent) as prohibitions. In this paper we use a single term, namely SC, as an overarching term to denote both of these types of norms. A more extensive study of the formal semantics of our model and comparison with formal theories investigating action negation in deontic logic [Bro04] is a topic for future research. The effect achieved through obligating or prohibiting an action should aim to promote a certain value. For example, in Case 1, the normative effect is "user $y$ is obliged to share their location with user $x$", and in Case 5, the normative effect is "user $y$ is prohibited from sharing notifications". In specifying the main elements of the normative concept we abstract from the specific action under consideration, i.e., the duality of data sharing and third party associations. This is further detailed in the specification of the normative model in Section 6.

*Triggering and expiry conditions* To represent the context in which a norm should have an effect, we introduce triggering and expiry conditions. A triggering condition is similar to the antecedent of a social commitment in [Sin99] or the activation condition of a norm as used for example in [KN03]. When true, it detaches the normative effect of a social commitment on an agent. For example, in Case 2, if the condition "in dangerous area" is true, the norm triggers the detachment of the normative effect "user $y$ is obliged to share location". The expiry condition [KN03] deactivates the normative effect when it becomes true. The need for expiry conditions emerged from an analysis of our user data. While in many cases this condition will be the opposite of the triggering condition, e.g. in Case 3, the trigger condition is dinner time starting, and the expiry condition is dinner time ending, some situations may require an expiry condition is not the exact opposite, e.g. the trigger condition is dinner time starting, and expiry condition is a guest leaving the house.

In summary, a social commitment is a tuple $\langle C, D, n, t, e \rangle$ where $C$ is the creditor, $D$ is the debtor, $n$ is the normative effect, $t$ is the triggering condition, and $e$ is the expiry condition.

The elements of our normative concept are comparable to other normative models that have appeared in the literature. In particular, it has resemblance to the ADICO model [CO95] (Attributes, Deontic, Aim, Conditions, Or Else) which was created as a general purpose grammar to model norms (or rules) in institutions. ADICO has been used in a number of works in the normative multi-agent systems literature, e.g., [GADN13, FPNS13]. We compare the components of the ADICO model to our normative concept. Whereas SC models, including ours, emphasize the directed nature of norms, the ADICO model has been created to describe norms for institutions. The latter leaves the creditor of the norm – the institution – implicit, and uses Attributes to describe properties of actors to whom

the norm applies. Our requirements are more in line with SC models, since in our case norms are directed and concern concrete debtors and creditors. The Deontic and Aim can be compared to our normative effect, and Conditions to our triggering and expiry conditions. The last component of ADICO concerns sanctions, which did not emerge from our user study as necessary to model in the context of mobile location sharing. Institutional statements comprising the ADIC components are referred to as norms in [CO95].

## 5 Evaluation of the Normative Concept

According to the iterative sCE approach, we evaluated the developed normative concept with members of our target group. The main purpose was to evaluate already at this early stage of development the *expressivity* of the normative concept regarding its ability to express users' normative statements. In addition, we aim to form an understanding of how potential users would use future technology that is based on our concept, as a guideline for the specification phase in the following iteration.

### *5.1 Method*

The method we selected for our evaluation is Co-Constructing Stories (CCS) [OBT12]. This is a group interview method that is particularly suited for the evaluation of technology concepts that are still in the conception phase, through allowing potential users to make future judgments about novel design concepts by linking them to their own past or current experiences. Assuming that memories, experiences and thoughts about the future are closely linked, users could make better judgments about novel design concepts if they were able to link them to their own past experiences. Utilizing that concept, CCS aims to generate in-depth qualitative user feedback.

The method consisted of two phases: sensitization and elaboration. In the sensitization phase, users were asked whether they recognize a particular story and were invited to talk about their own experiences in this context. In the elaboration phase the researcher introduces the concept to be evaluated as an additional element to the story, and participants were then invited to tell how they believe the story would play out after the introduction of that element.

These interviews provided us with a corpus of text that could be analyzed for occurrence of normative statements in natural language that pertain to the topic, as well as key elements on how potential users may use the proposed technology.

### *5.2 Participants and material*

A group of 2 boys and 2 girls, aged 8-10, and a group of 4 of their parents, were interviewed separately– the children group first, then the parents group, in a central location in their neighbourhood in a town of approximately 30,000 inhabitants. In each group, two co-constructing stories sessions were held in sequence. The scenarios of each session were identical in both groups. The scenarios were presented with the visual aid of comic-like storyboards (Figure 3).

We constructed two scenarios that represented cases where a location sharing application utilizing our model was envisioned to be of potential use, embodying the same values identified earlier, such as family security, social recognition, freedom.


**Figure 3**: The comic-like storyboards we used in CCS (translated).

In the first scenario, the sensitizing story was about a girl who was going to school by herself. She was told by her mother to be careful on her way to school. She arrived at school just in time. The story was elaborated to include a handheld smart device, where the mother asked the girl to check-in when she arrives to school, which the girl did.

The second scenario used a sensitizing story of a boy who is bored at home, not knowing that close by, two of his friends were playing outside. The elaborated story introduced a handheld smart device, which allowed the boy to see where his friends were, prompting him to go outside and join them.

### *5.3 Procedure*

The CCS-interviews were semi-structured, meaning that interviewees could divert from the questions asked, provided they remained within the general theme of discussion. This type of interview allows for the interviewer to further gather data on users' own ideas rather than merely the specific answers to the interviewer's questions. Each group's interview lasted approximately 30 minutes, i.e. 15 minutes per scenario, in which approximately 5 minutes were spent discussing the sensitizing story, and 10 minutes were spent discussing the elaboration story. First, the sensitizing story was shown as a storyboard, then the discussion was initiated by asking the participants if they recognize that story in their lives. Their answers would lead to follow-up questions to elicit more information about the shape and variation this scenario takes individually for each participant. Afterwards, the elaborating story was introduced on the storyboard, and to stimulate the discussion participants were asked if they would find the introduced technology useful. Their answers would also lead

to further questions regarding whether or not they found a certain enhancement useful, and what in specific made such an enhancement perceivably more or less useful.

Approval of the university's ethics committee was obtained before conducting the study, as well as parents' informed consent, and the entire session was audio-recorded to facilitate analysis.

### *5.4 Data analysis and results*

The data collected from CCS was approximately one hour of audio discussion, and we transcribed the data for statement analysis.

We first needed to perform a validity check, i.e. verifying whether participants were able to identify with the proposed scenarios, and whether their responses– which included natural language normative statements, were relevant to the concept, domain, and research topic. In the first scenario, both parents and children groups confirmed the difficulty of children going to school without an accompanying adult, discussing possible ways to alleviate that difficulty, e.g. going with other children altogether, having to call home from school when they arrive, or having the school alert parents in case their child did not arrive within a certain period of time. In the second scenario, both the parents and children groups highlighted various ways the children arrange to meet for playdates or other events after school. They highlighted the lack of a reliable way to arrange this, e.g. sometimes they would call their friends' house, or have a parent call one of their friends' parents, or even go to that friend's house without knowing if they are there, or to the playground to see if they can find someone they know by chance.

Secondly, after the validity check, we needed to identify the user statements of a normative form that concern location sharing, and evaluate the capability of our concept model to express them. We found 12 statements of that form, 11 of which our model could express, e.g. first four statements in Table 2, while one statement, the last in Table 2, contained a triggering event that could not be expressed directly using our normative concept. It cannot be expressed directly because there is no specific triggering condition mentioned in the statement. Based on common sense knowledge one may assume that it means the school should inform the parents when the child is not in school within a certain amount of time after class starts, e.g., five minutes as in Statement 1. However, this is not what the parent expressed in the interview. We are treating these user statements verbatim, and the statement "if child does not arrive to school" as a statement describes a certain state, yet cannot be translated directly into a concrete triggering condition because it does not specify when to check for arrival at school. Described in literature as a time-aware commitment, this requirement could be represented using Reactive Event Calculus [CMMT11].

This illustrates one of the challenges of representing and reasoning with people's norms in software, namely translating people's intuitive interpretation of social norms to statements that can be interpreted by the technology.

From that, we can conclude that our generic SC-based concept is powerful enough to express the large majority of potential users' behavioral requirements for a location-sharing technology in the domain. Though one of the normative statements was not fully expressible, the simplicity of the conceptual model offers a good compromise for such infrequent shortage of expressive power. Looking more in detail at what these commitments express, we make the following observations.

- *Sharing information about third party:* Statement 1 concerns a SC where the debtor (the teacher) is not the person who's location should be shared, but the commitment concerns

**Table 2** Five out of the participants' twelve natural language statements. The first four can be expressed using our normative concept, while the fifth is inexpressible.

| No. | Natural language normative statement | Expression using our concept model |
|---|---|---|
| 1 | Parent: If five minutes pass after the start of school and a child is not in class, the school should call the parents. | ⟨Parent, Teacher, Obligation(call parent), Child not in school after 5 mins, Child is in school⟩ |
| 2 | Parent: my daughter should call me when she reaches school, if she was going by herself. | ⟨Parent, Child, Obligation(call parent), Enter school, Leave school⟩ |
| 3 | Child: sometimes I ($Child_1$) want to play with someone ($Child_2$) but I don't want others to come. | ⟨$Child_1$, $Child_2$, Prohibition(send a message to other children), Start playing, Stop playing⟩ |
| 4 | Child: when I ($Child_1$) get a message from a friend ($Child_2$), then I know they want to play with me. I would find that to be nice. | ⟨$Child_1$, $Child_2$, Obligation(send a message to me), Want to play, Stopped playing⟩ |
| 5 | Parent: the school should inform parents if their child does not arrive to school. | ⟨Parent, Teacher, Obligation(call parent), *trigger and expiry components cannot be expressed.*⟩ |

location information *about* a third person (the creditor's child). This is different from the third party association identified in Section 4.1, which concerns the debtor sharing location *with* a third party. Moreover, the SC concerns information that the child is *not* in school, i.e., negative location information.

- *Triggering and expiry conditions:* A) We observe that they concern a variety of conditions: location of a third person, location of the debtor, as well as activities (playing). B) We observe that the expiry condition is the dual of the triggering condition. C) Their interpretation can be that the normative effect is detached once as soon as the triggering condition holds (Statements 1 and 2), or that the normative effect applies continually between triggering and expiry conditions holding (Statements 3 and 4).
- *Absence of deadlines:* While deadlines are commonly studied in normative frameworks [BBvdT08, BDDM04, HvR13], these normative statements do not refer explicitly to deadlines for the normative effect to be achieved. Statements 1 and 2 may be interpreted to specify the deadline implicitly, namely to fulfill the obligation as soon as possible once the triggering condition holds. This can be linked to so-called *optimization norms* as introduced in [GS12]. Statements 3 and 4 concern continuous detachment of the normative effect inbetween triggering and expiry condition, which does not require a deadline. This can be compared to various types of goals as distinguished in the agent programming literature, for example in [DvRW11]. Further exploring this connection is left for future work.
- *Commitments to oneself:* Statement 3 concerns a commitment where the creditor and debtor are the same person. Such commitments essentially express basic location shar-

ing preferences that can be expressed with lists as in existing applications (see Section 4.2), namely that location data should not be shared with certain groups of people.

Since we take a user-centred design approach in which the design of our model is guided by input from potential end users, we introduced the following constraints to our commitment model based on suggestions found in the CCS data:

1. The possibility of a commitment involving a parent and someone else's child is undesirable, though allowing delegation of commitments [SCD09] might be a way to address the issue and provide parents with the opportunity to give explicit authorization to other parents to make commitments with their child, when this is deemed useful and appropriate.
2. Additional communication mediums might be of little use amongst adults, since they are accustomed to using already existing means, e.g. SMS or WhatsApp, for communicating. This points to the need for including certain user *roles or relationships*, e.g. adult or minor, parent or child, to determine the choice a creditor has over creating a commitment. Structures for representing roles and relationships have been developed in work on agent organizations [Dig04]. In this iteration, we also used roles and relationships to further restrict the list of available debtors. Based on the additional findings in CCS, we removed the possibility of a commitment involving a parent and someone else's child, and restricted the list of available debtors available for adults, so that a parent will only be able to create commitments with their own children as debtors. The list of debtors available for children users included their own parents as well as all other children.

## 6 Specification of the Normative Model

In this iteration of the specification phase we aimed to refine the SC concept into a normative model with a concretely defined syntax and semantics. In Section 6.1 we highlight the refinements we make with respect to the normative concept based on our analysis in Section 4.1 and the findings from the evaluation described in Section 5.4. We further refine this into a definition of the syntax of the normative model (Section 6.2), and provide its semantics by means of a lifecycle specification (Section 6.3).

### *6.1 Refining the concept*

*Creditor and Debtor* In the previous iteration, we borrowed the concept of creditor and debtor as the parties involved in the commitment from existing SC literature [Sin99]. In this iteration, we made the following two changes. Firstly, for usability reasons we dropped the explicit notion of the creditor in this iteration, since from a user perspective, the creditor is always assigned as the user creating the commitment. Secondly, we placed no restriction in the previous iteration on a user creating a commitment where they also are debtor, i.e., expressing a commitment towards oneself. However since this does not express a social need nor offers additional functionality to basic preference settings in social apps, we restricted the list of available debtors to all users other than the creditor.

*Normative effect* In the previous iteration, we introduced the normative effect as the core component of a social commitment. For the model to be usable, the parts that compose

a normative effect must be precisely defined. Based our analysis in Section 4.1 and the CCS data, we define our normative effect component in three parts:

**Norm type** an obligation or a prohibition of an action, expressed as respectively an "empty" element and negation;

**Action** to share or receive data, in this case location information;

**Third party** the user or user group with whom the location information must or must not be shared, or from whom the location information must or must not be received. The third party's role within a certain commitment is passive, i.e. content shared with them or received from them is entirely determined by the creditor and debtor.

For example, in the normative effect "share location with family", the norm type is an obligation, the action is to share, and the third party would be the user group "family". In the normative effect "not receive location from me", norm type is a prohibition, the action is to receive, and third party is "me", or the creditor themselves.

We do not include the possibility for sharing information *about* a third party for reasons of simplicity, and since we encountered only a single instance of this type in the user data. Although in general such multiuser privacy aspects are important when sharing data on social media [MAS16], in our domain of location sharing in family life they appear to be less prominent.

*Triggering and expiry conditions* In the previous iteration, we introduced the triggering and expiry conditions as the conditional components of a social commitment. Since the expiry condition was found to be the dual of the triggering condition, for usability purposes we transformed trigger and expiry conditions into one conditional component. According to conditionals in the user statements in Section 4.1 and CCS normative statements, we allow these to be one of the following two:

1. A place conditional: triggered by entering a defined geographical area, and expires upon leaving that area.
2. A time conditional: triggered at a specific time and expires at another.

We do not include the possibility for expressing location of a third person, since we also omitted the possibility of sharing information about a third party. Moreover to simplify context recognition, we do not include activities as conditions but introduce a time conditional which may be used to indicate the time period in which an activity takes place, e.g., dinner time. Moreover, while in general one may consider various logical combinations of place and time as conditionals, we do not include this here for reasons of simplicity and since most of the user statements concern atomic conditions.

*Roles and relationships* Based on the findings from the CCS evaluation, we excluded the possibility of a commitment involving a parent and someone else's child, and restricted the list of available debtors available for adults, so that a parent will only be able to create commitments with their own children as debtors. The list of debtors available for children users included their own parents as well as all other children.

*Validity* Based on CCS normative statements we introduced two distinct commitment validity options that were found to be useful by our user group. A commitment can either be valid for one instance of normative detachment, i.e. removed after one compliance or violation of the norm, or valid-until-removed, i.e. normative effect may be triggered until commitment is explicitly removed.

### *6.2 Syntax: social commitment grammar*

Based on the refinements described in Section 6.1, we constructed the following grammar for social location sharing commitments. The sentence in the first line expresses a social need that translates to the corresponding commitment upon acceptance by the debtor, where the creditor is the "I" who expresses the social need. The idea is that this grammar is implemented in the location sharing app to allow users to create social commitments with one another by sending requests and accepting (or rejecting) them.

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

⟨*norm type*⟩ ::= '`not`' | $\varepsilon$

⟨*action*⟩ ::= '`share location`' | '`receive location`'

⟨*third party*⟩ ::= '`me`' | ⟨*users*⟩ | ⟨*groups*⟩

⟨*users*⟩ ::= ⟨*my parents*⟩ | ⟨*other parents*⟩ | ⟨*my children*⟩ | ⟨*other children*⟩

⟨*my parents*⟩ ::= '`Paul`' | '`Mary`' | ...

⟨*other parents*⟩ ::= '`Lisa`' | '`Peter`' | ...

⟨*my children*⟩ ::= '`Mike`' | '`Claire`' | ...

⟨*other children*⟩ ::= '`Jason`' | '`Jane`' | ...

⟨*groups*⟩ ::= '`friends`' | '`family`' | '`others`' | '`everyone`'

⟨*condition*⟩ ::= ⟨*time period*⟩ | '`he/she is at`' ⟨*place*⟩

⟨*time period*⟩ ::= '`between`' ⟨*time*⟩ '`and`' ⟨*time*⟩

⟨*time*⟩ ::= '`00:00`' | '`00:01`' | ... | '`23:59`'

⟨*place*⟩ ::= '`home`' | '`school`' | '`park`' | ...

⟨*lifespan*⟩ ::= '`for one instance`' | '`valid-until-removed`'

⟨*debtor*⟩ ::= ⟨*my children*⟩ in the case of an adult creditor

⟨*debtor*⟩ ::= ⟨*my parents*⟩ | ⟨*other children*⟩ in the case of a child creditor

### *6.3 Semantics: commitment lifecycle*

In this section we define the semantics for our SC syntax through specification of a commitment lifecycle similar to the one proposed by Telang and Singh in [TS11]. We motivate how a commitment's lifecycle for social location sharing applications deviates from the one proposed by Telang and Singh. The commitment lifecycle (Figure 4) consists of a constructed

state (created by creditor), a received state (received by debtor), a rejected state (rejected by debtor), a conditional state (accepted by debtor but not yet triggered), a detached state (condition is met), violation and compliance states (agent complying or violating the normative action at this instance), and cancelled or released state (commitment ended by debtor or creditor).

We illustrate the steps of the lifecycle using the following example commitment: I want *Paula* to *share* her location with *me* if *she is in the park*, *valid-until-removed*. We assume the creditor is Paula's father, and make the distinction between the actions performed by users, i.e. Paula and her father, and their agents. We discuss the various states and transitions of the lifecycle step-by-step.

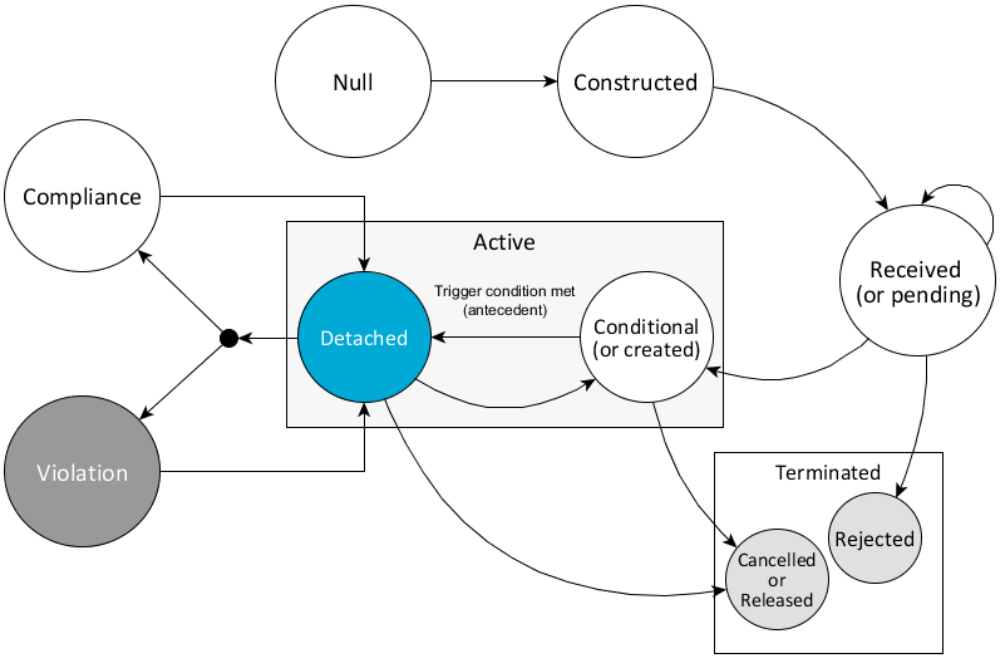


**Figure 4**: The commitment lifecycle.

*Constructed state* The creditor creates the proposed commitment. Since the creditor is Paula's father, Paula is available as debtor. The creditor's agent (Paula's father) sends the (requested) commitment to Paula's agent.

*Received state* Paula receives a commitment request through her agent. For illustration purposes, we assume that Paula has the choice to accept or reject the commitment. If Paula rejects, the commitment's lifecycle ends as it enters the rejected state. If Paula accepts, the commitment enters its active phase, conditional state.

The "Constructed" and "Received" states are not included in [TS11]. Instead, in that paper a commitment transitions directly from "null" to an "Active" state, abstracting from the commitment creation process. We envisage our SC model to be used in an application

that supports the process of commitment creation, i.e., where a creditor expresses a social need and the debtor can reject or accept the underlying commitment. In order to model this process, we include these states explicitly in our lifecycle.

*Conditional state* Without a trigger, Paula's agent is yet to be obligated or prohibited from performing any action. If Paula then enters the park, the triggering condition holds, and the normative effect is "detached" on Paula's agent, taking the commitment to the detached state. Both Paula and the creditor may remove the commitment at the conditional state, which would lead to the cancelled or released state.

*Detached state* To illustrate this state we need to assume a location sharing application's point of view. Creation of a location object may be automatic, e.g. as in Life360, or may still need an explicit event such as Paula actively performing a "check-in", e.g. as in Foursquare. The nature of the obligated action depends on the type of location sharing application.

If location sharing was automatic, or if Paula performed a "check-in", Paula's agent may share the location info with the creditor reaching a compliance state, or not; reaching a violation state. As this commitment is valid-until-removed, we go directly back to the detached state. Since, depending on the application type, the transition between the detached state and compliance or violation states may not be automatic, Paula and the creditor may cancel the commitment at the detached state. This is a notable difference from Telang and Singh's lifecycle in [TS11], where, the debtor canceling the commitment after detachment constitutes a *violation*. For location sharing applications of the "check-in" type, we can see why it is necessary to distinguish between *violation* and *cancellation of the commitment at a detached state*. We note here that if location sharing was automatic, this may potentially create an endless loop from the detached state to compliance or violation and then again to detached, as GPS sensors may erratically point to the entry and leaving of an area within seconds. In that case, it is advisable to set a time-out buffer in the application between automatically performed check-ins, e.g. 15 minutes.

*Conditional state, revisited* Paula leaves the park, which means that the expiry condition holds. This brings the commitment go back to the "conditional" state. If the triggering condition is met again, i.e. Paula goes back to the park, and since the commitment is valid-until-removed, the commitment would return to the detached state. It is worth noting here that in one-time commitment lifecycles like [TS11], it is not useful to allow the antecedent to become false after it has once become true– compliance and violation are always end states. For our case, and since commitments may be valid-until-removed, the expiry condition "Paula leaves the park" allows the antecedent to be false again without terminating the commitment's lifecycle, allowing for compliance and violation states to be reached more than once in the course of that one lifecycle.

*Cancelled or released state* We enter this state (1) momentarily if the commitment was good for one instance, and a state of compliance or violation has been reached, or (2) if Paula or the creditor remove the commitment at any state. We follow the terminology in [TS11], using the term "released" if the commitment was removed by the creditor, and "cancelled" if removed by the debtor. Once at this state, the commitment reaches the end of its lifecycle.

*Violation and compliance states* Preferences in existing social applications are treated as hard rules that the application cannot violate. This does not permit the application to deviate from these rules when necessary, e.g. in emergency situations, which may demote certain user values. Moreover, since commitments may originate from different people in a user's social circle, conflicts amongst commitments might arise which might require the application to choose to violate certain commitments (see, e.g., [AJC$^+$16]).

In this paper we do not discuss the consequences of compliance or violation for the debtor. However it is important to make the distinction between these two states in order to allow for further development on the side of the agents' choices to comply with or violate a commitment. A recorded trace of compliance and violation of certain social commitments could, for instance, have effects on future choices, e.g. a child debtor should not be violating a commitment from a parent creditor too often, the validity of the commitment, e.g. why not release a commitment with which a debtor never complies, or the restriction of the creditor's choices in creating a commitment, e.g. based on a high compliance rate from a child debtor, a parent creditor may be viewed as too imposing, etc.

In summary, the main differences between our lifecycle and that of [TS11] are the following:

- *Commitment creation process:* in contrast with [TS11] we model explicitly the expression of a social need by the creditor and the acceptance or rejection of the corresponding social commitment by the debtor, reflected in the additional "Constructed" and "Received" states.
- *Cancellation of a detached commitment:* cancellation of a detached commitment in our model does not give rise to a violation. This is because our model allows not only one-instance commitments but also commitments that are valid-until-removed, which should be allowed to be cancelled even after their detachment. In the context of location sharing one-instance commitments are satisfied as soon as possible (see discussion on absence of deadlines in Section 5.4), which means that cancellation of a commitment inbetween detachment and fulfillment may be expected to occur only rarely.
- *Repeated commitment activation:* since we allow commitments to be valid-until-removed, "Compliance" and "Violation" are not end states. Rather, the commitment returns to the "Detached" state, and if the condition becomes false it returns to the "Conditional" state. In [TS11] these backwards transitions are not included because the authors only consider one-instance commitments.

## 7 Evaluation of the Normative Model

Now that we have a specification of our normative model, we can evaluate it. Our overall aim is to demonstrate that a location sharing application built on the basis of our normative model provides better support for people's values. However, before building such an application and evaluating this (which we leave for future work), we evaluate the normative model's *usability and usefulness*. Evaluating these aspects is important in human-centered design of information technology [Dav89]. It provides a baseline check on the appropriateness of the technology under development, ensuring that support for values is not hampered by basic usability and usefulness issues. In this section we describe our approach and hypotheses

(Section 7.1), the method used to test the hypotheses (Section 7.2), we present our results (Section 7.3), and discuss to what extent these results support our hypotheses (Section 7.3.4).

## *7.1 Approach and hypotheses*

The idea of the envisaged location sharing application is that users can express their social needs through the application. Therefore in order to evaluate our normative model, we created a web-style menu that allows participants to create social commitments according to the syntax presented in Section 6.2 (Figure 5). The menu allowed users to construct a social need – which upon acceptance by the debtor would be translated to a commitment – through selecting a debtor, a norm type and action, a third party, and a condition. For usability reasons we combined norm type and action into a single parameter. That is, users could select from the following four options as the second element of the web menu: share/not share/receive/not receive. Lifespan was not considered a critical element for what was intended to be a time-constrained evaluation, and was therefore omitted to avoid unnecessary complexity.

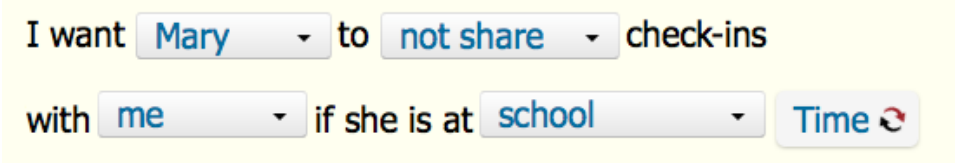


**Figure 5**: A web-style menu representation of the SC model. Commitment shown here was created by selecting debtor *Mary*, the combination of the norm type *prohibition* (expressed as "not") and action *share*, third party *me, i.e. the creditor*, and a place condition *school*. The "Time" button could be used to toggle the condition type accordingly.

Since refinement steps we took in the specification of the model were grounded in user data, we made the following hypotheses:

(1) The majority of users find our SC model representation to be usable.

(2) The majority of users find our SC model representation to be useful for location sharing in family life.

Additionally, in order to study the effect of different types of commitments on usability and usefulness we formulated the following research question:

(3) What effects do the elements norm type, i.e. *obligation* or *prohibition*, action type, i.e. *share* or *receive*, third party type, i.e. *creditor only* or *any other option*, and condition type, i.e. *place* or *time* of our SC model representation have on its usability and usefulness?

We chose these four characteristics of commitments since these highlight some main conceptual differences between commitments that may affect usability or usefulness. We could have added other characteristics, e.g., distinguishing between certain types of places, but since this is the first study in this direction, we choose these broad categories.

## *7.2 Method*

This was a within-subject, repeated measures study, i.e. participants had to perform multiple tasks dispatched from a common pool in a random order.

### *7.2.1 Task composition and material*

To start with, participants were asked to read the text of a scenario of a familiar family life situation. A scenario contained four to five lines of text on average. These scenarios contained a location sharing problem that the participant was asked to solve using the web-menu representation. It ended with the participant rating the constructed solution's usefulness in the scenario. Scenarios were taken from previous qualitative data in [KBG+14] and CCS, as well as representing fairly common situations within the family life domain, e.g. children going to school, a playground, parents taking their children to meet friends.

The total number of available tasks we constructed was 16. The scenarios were constructed such that each scenario had a different designated solution, i.e. what we believe to be the most suitable commitment for this scenario, according to the four characteristics that we identified in the third research question in Section 7.1. Since we consider four characteristics that are each split into two options, we use a total of 16 scenarios to cover all commitment types.

These scenarios and their designated solutions are provided in Appendix A.

### *7.2.2 Procedure and measurement*

Before solving the tasks, participants viewed a short instructional video which explained the background of the research and the domain of location sharing in family life. Then they had to solve an example task for practicing purposes.

After that, participants solved four tasks, chosen randomly from the 16 available ones. This was done in order to limit the time participants needed to spend on the experiment. Solutions were created using the web-menu representation of our SC model. For each task, after submitting their solution participants rated how it contributed towards solving the location sharing problem in the scenario. For this they used a continuous slider (Figure 6), with a no contribution response indicated in the middle of the scale. In the experiment social commitments were referred to as "agreements", and the menu was referred to as the "agreement menu". The contribution rating was used to operationalize *usefulness* of the normative model.

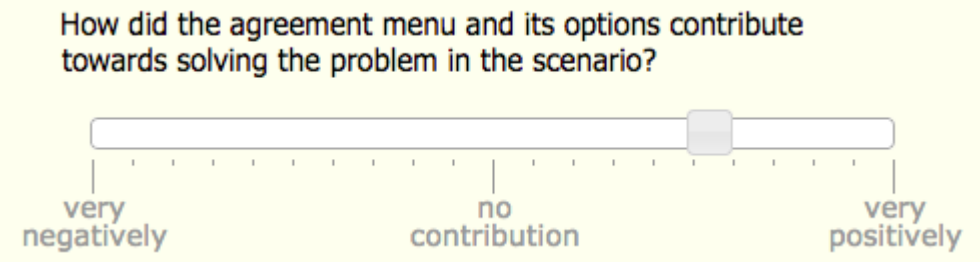


**Figure 6**: The slider used by participants to rate the commitment's contribution to solving the location sharing problem.

Finally, after the four tasks were completed, participants answered the six-item component-based usability questionnaire (CBUQ) [BHB09]. *Usability* was operationalized by perceived usability measured by the CBUQ and the ability for participants to find the designated commitment solution.

### *7.2.3 Participants and platform*

We conducted the experiment through the online crowdsourcing platform Microworkers.com. User studies are increasingly being conducted on the web, and research has shown the web to offer an environment just as powerful as the lab, with data collected online being of at least similar quality to lab data [GVSJ04] as well as results from the two environments having high congruence [KD00]. Four hundred and twenty participants were recruited. Since participants must be able to read and fully understand the scenarios, participating in the experiment was only open to members living in the US, Canada, UK, Australia, and New Zealand. Participants were compensated in accordance with the regulations of the crowdsourcing platform for tasks requiring a similar effort, which was less than one US dollar per participant. Permission from the ethics committee of the university was obtained prior to conducting the experiment.

To ensure the quality of the participant's responses, every task contained a quality control question, which appeared after the commitment was created. Only participants who had read the scenario in full would be able to, though simply, answer the question. Entries from participants who wrongfully answered the quality control question were omitted and participants were not compensated. Participants were informed about that in advance through our terms and conditions.

### *7.2.4 Data preparation and analysis*

The responses of four participants were omitted due to incorrect answers on quality control questions. The remaining 416 participants solved four tasks each and therefore 1664 tasks in total, provided a usefulness rating after every task, and answered the CBUQ. All statistical analyses were done with SPSS version 22. Reliability analysis for the six items CBUQ showed an acceptable Cronbach's alpha of .92. Therefore the six items were combined into a single usability measure. A one-sample $t$-test with bootstrapping was conducted to compare the usability score with the benchmark value of 5.29 [BHB09]. Binomial tests with a test proportion of .50 were conducted on the percentage of tasks solved using the designated correct solution, across the four tasks as well as the 16 scenarios. One sample $t$-tests with a test value of 5 and bootstrapping were conducted on the average value of participants' rating of the model's usefulness, across the four tasks as well as the 16 scenarios. Generalized Estimating Equations (GEE) analyses were also conducted with both tasks correctly solved and rated usefulness as responses, the four two-level elements of the SC representation as fixed factors, and participant as a random intercept factor, using a linear probability distribution and an unstructured covariance matrix. Data is available upon reviewers request, and will be made available via a DOI upon publishing.

## *7.3 Results*

In this section we present the results of the user study regarding our three hypotheses on usability (Section 7.3.1), usefulness (Section 7.3.2), and the effect of commitment elements on these aspects (Section 7.3.3).

### *7.3.1 Usability*

Usability was measured through the CBUQ and the extent to which participants successfully completed the tasks. The CBUQ rating ($M = 5.75, SD = 1.1$) was significantly higher

($t(415) = 8.7, p < .01$) than the benchmark value of 5.29 established in [BHB09]. This shows that the rating was more comparable to an easy to use standard set, than the more difficult to use standard set of interaction components of CBUQ. Results of participants' ability to complete the tasks successfully across the four tasks and the 16 scenarios are presented in Table 3 and Table 4, respectively. Binomial tests show a significant majority of participants was able to solve the tasks correctly across the four tasks ($p < .01$), and that a significant majority of participants was able to complete the tasks successfully in nine out of the 16 scenarios ($p < .01$). The percentage of correct solutions was below 50% in five of the 16 scenarios. However, none of these five scenarios were found to be significantly difficult to solve.

It must be noted that an "incorrect" solution in this context does not necessarily equal an irrelevant commitment. For example, scenario 16 asked participants to ensure their child does not get alerted with notifications during dinner time, which was given as between 6:30pm and 8:00pm. The designated solution was "I want Mary to not receive notifications from friends between 6:30pm and 8:00pm", however, the solution "I want Mary to not receive notifications from friends if she's at home", popular amongst participants and arguably still relevant to the scenario, was evaluated as incorrect in this experiment.

### *7.3.2 Usefulness*

The commitment menu and its options contribution to solving the location sharing problems in the respective scenarios was rated significantly high by participants across all four tasks (Table 3), and all 16 scenarios (Table 4), with $p < .01$ in all cases.

**Table 3** Percentage of tasks correctly solved and rated usefulness.

| | $n$ | $Solution_{\%}$ | $Mean_{RatedUsefulness}$ | $SD_{RatedUsefulness}$ |
|---|---|---|---|---|
| Task 1 | 416 | 58.7** | 7.8** | 2.0 |
| Task 2 | 416 | 60.6** | 7.8** | 2.0 |
| Task 3 | 416 | 65.4** | 7.9** | 2.0 |
| Task 4 | 416 | 62.0** | 7.9** | 2.0 |

**Table 3** *Note* $H0_{solution}$: $\mu = 50\%$, $H0_{RatedUsefulness}$: $\mu = 5$, * $< .05$, ** $< .01$

### *7.3.3 Analysis of the effect of commitment elements on usability and usefulness*

Finally, we looked into the effect of four, two-level factors of scenario types – norm type, action, third party and condition – on the user's rating of the model's usefulness. GEE analysis found that tasks involving a sharing action (540 correct and 265 incorrect solutions, or 68%) were significantly easier to complete correctly than tasks involving a receiving action (486 correct and 373 incorrect solutions, or 57%), with $\chi^2(1) = 22.7$ and $p < .01$, and that tasks involving the creditor only as a third party (602 correct and 255 incorrect solutions, or 71%) were significantly easier to complete correctly than tasks involving other third party options (424 correct and 383 incorrect solutions, or 53%), with $\chi^2(1) = 64.0$ and $p < .01$. Combined main factors also had effects. There was an interaction between norm type and condition ($\chi^2(1) = 48.1, < .01$), action and condition ($\chi^2(1) = 5.1, p = .02$), third

**Table 4** Percentage of tasks correctly solved and rating of usefulness across the 16 scenarios. *O = obligation, F = prohibition, S = share, R = receive, C = creditor only, X = other third party option, P = place, T = time.*

| | $n$ | $Solution_{\%}$ | $Mean_{RatedUsefulness}$ | $SD_{RatedUsefulness}$ |
|---|---|---|---|---|
| Scenario 1 (O,S,C,P) | 102 | 81.4** | 8.2** | 1.8 |
| Scenario 2 (O,S,C,T) | 111 | 67.6** | 7.5** | 1.8 |
| Scenario 3 (O,S,X,P) | 100 | 64.0** | 8.3** | 1.6 |
| Scenario 4 (O,S,X,T) | 103 | 52.4 | 7.2** | 2.4 |
| Scenario 5 (O,R,C,P) | 109 | 79.8** | 7.7** | 1.8 |
| Scenario 6 (O,R,C,T) | 108 | 49.1 | 7.3** | 2.4 |
| Scenario 7 (O,R,X,P) | 98 | 55.1 | 6.7** | 2.4 |
| Scenario 8 (O,R,X,T) | 97 | 43.3 | 7.7** | 1.6 |
| Scenario 9 (F,S,C,P) | 97 | 75.3** | 7.7** | 2.1 |
| Scenario 10 (F,S,C,T) | 93 | 77.4** | 8.4** | 1.8 |
| Scenario 11 (F,S,X,P) | 101 | 44.6 | 8.0** | 1.6 |
| Scenario 12 (F,S,X,T) | 98 | 75.5** | 8.3** | 2.0 |
| Scenario 13 (F,R,C,P) | 130 | 68.5** | 8.0** | 1.8 |
| Scenario 14 (F,R,C,T) | 107 | 65.4** | 7.8** | 2.3 |
| Scenario 15 (F,R,X,P) | 95 | 40.0 | 8.0** | 2.0 |
| Scenario 16 (F,R,X,T) | 115 | 46.1 | 8.4** | 1.8 |

**Table 4** *Note* $H0_{solution}$: $\mu$ = 50%, $H0_{RatedUsefulness}$: $\mu$ = 5, * < .05, ** < .01

party and condition ($\chi^2(1) = 15.9, p < .01$) and norm type, action, third party and condition ($\chi^2 = 6.3, p = .01$)

The analysis also found that users rated the model's usefulness significantly higher in scenarios involving a prohibition ($M = 8.1, SD = 1.9$) rather than an obligation norm ($M = 7.6, SD = 2.0$), with $\chi^2(1) = 34.2$ and $p < .01$, as well as in scenarios involving a sharing ($M = 8.0, SD = 1.9$) rather than a receiving action ($M = 7.7, SD2.0$), with $\chi^2(1) = 9.8$ and $p < .01$. Combined main factors also had effects. There was an interaction between norm type and action ($\chi^2(1) = 7.0, p < .01$), norm type and third party ($\chi^2(1) = 6.9, p < .01$), norm type and condition ($\chi^2(1) = 15.3, p < .01$), action and condition($\chi^2(1) = 6.4, p = .01$), norm type, action and condition ($\chi^2(1) = 30.3, p < .01$), and action, third party, and condition ($\chi^2(1) = 9.3, p < .01$).

### *7.3.4 Revisiting the hypotheses*

Our results show that a majority of participants was able to identify the designated solution across all tasks and the majority of scenarios, and found the elements of the model to be comparable to an easy to use norm set, thus confirming hypothesis 1. Same analysis also showed that users found the model to be useful in the family life location sharing domain, across all tasks and scenarios, thus confirming hypothesis 2. In terms of the third research question, GEE analysis found that constructing commitments becomes more difficult for users when more than two parties are involved, i.e. the third party involving more than just the creditor, and that users found prohibitions to be more useful than obligations within family life location sharing scenarios. The analysis also shows that commitments concerning receiving were more difficult to construct and less useful than those concerning sharing.

The interaction effects amongst these factors suggest that they cannot be fully understood in isolation, and that they may have a different impact when used in combination.

As for why our findings regarding the third research question occurred, we can only make hypotheses since to the best of our knowledge, qualitative user studies to understand usage of social commitment models for governing data sharing are not available. Our finding that constructing commitments becomes more difficult when more than two parties are involved may be linked to research on theory of mind. The ability to develop second order theory of mind, i.e., reasoning about the mental models of other people about other people, is a capacity that takes time to develop [SZTF94]. Moreover, there is evidence that usage of even higher order theory of mind is not advantageous (see [dWVV17] for recent research and references). One may see construction of commitments where third parties are involved as requiring higher order reasoning, which from these findings may be hypothesized to be more difficult. Our finding that prohibitions are considered more useful than obligations may be linked to the phenomenon of loss aversion [Kah11], which states that people weigh possible losses stronger than possible gains. One may interpret prohibitions as norms preventing bad things from happening (loss), and obligations as ensuring that good things happen (gain). Linking this to loss aversion, one may hypothesize that prohibitions are considered more useful for this reason. The finding that commitments regarding receiving were considered more difficult to construct and less useful than those for sharing may be due to the fact that most existing social data sharing applications focus on sharing, and do not consider the possibility to govern receiving of data. Future research is needed to determine whether these hypotheses hold.

## 8 Discussion and Conclusion

The main contribution of this paper is a normative model for family life location sharing applications shown to be useful and usable. In addition, this research forms a demonstration of how user-centered design can be employed to develop a normative model for social applications.

Through this approach we have provided a comprehensive location sharing model that is grounded in user values and allows to express contextualized social needs, complementing existing location sharing platforms. The SC model comprises a grammar and a semantics in the form of a lifecycle. The model allows to express social needs in family life location sharing settings through modelling creditor, debtor, and third party involvement, context information through conditions, and obligation and prohibitions on sharing and receiving location data. The semantics allows for norm violation to occur and accounts for one-instance as well as a valid-until-removed type of SC.

Developing such a model is important because social applications are becoming increasingly complex, and users will need to maintain a good degree of control over their sharing and receiving preferences– yet achieving such control should not be too complex. In this paper we have shown that SC models can be harnessed to provide a usable, flexible regulatory structure that is applicable to a real-world domain, complementing theoretical work on normative multi-agent systems. This shows the potential of normative frameworks in empowering users into making social media work more to their advantage.

### *8.1 Limitations and suggested improvements*

In CCS, a part of the participants overlapped with the participants in our previous work in [KBG+14], which limits our ability to claim the expressivity of our SC model.

Due to the nature of online empirical studies, participants in the crowdsourcing study (Section 7) were limited to those who were subscribed to the platform, and have chosen to perform the tasks through personal interest. This limits the ability to generalize the results. In particular, influence of culture, education level, as well as the application domain, i.e. location sharing in family life– may exist since users in the crowd sourcing study came only from "western" cultures, particularly English speaking countries. Moreover, the limited time of effective user participation in such studies required avoidance of too-complex tasks. This meant that we had to refrain from enhancing the grammar in various ways which may have offered additional expressibility to the model, as well as omit lifespan SC element and therefore some aspects of the semantics in the web-menu representation.

However, we demonstrated that the SC representation can be utilized in social applications, and is powerful enough to be useful in its real-world application domain. To the best of our knowledge, this is the first empirical work to demonstrate such results.

Based on our findings and discussion in Section 6.3, we see a number of ways to extend the SC model. For example:

(1) Creating composite conditions:

⟨*commitment*⟩ ::= '`I want`' ⟨*debtor*⟩ '`to`' ⟨*norm type*⟩ ⟨*action*⟩ '`with/from`' ⟨*third party*⟩ '`if`' ⟨*conditions*⟩ '`,`' ⟨*lifespan*⟩

⟨*conditions*⟩ ::= ⟨*condition*⟩
| '`(`' ⟨*condition*⟩ '`or`' ⟨*conditions*⟩ '`)`'
| '`(`' ⟨*condition*⟩ '`and`' ⟨*conditions*⟩ '`)`'

(2) Creating place conditionals that do not refer strictly to the debtor:

⟨*condition*⟩ ::= ⟨*time period*⟩ | ⟨*third party*⟩ is at' ⟨*place*⟩

⟨*third party*⟩ ::= '`me`' | ⟨*users*⟩ | ⟨*groups*⟩

(3) Integrating more lifecycle and semantic elements in the available menu options, e.g. both one-time and valid-until-removed lifespans, commitments which are not assumed to be accepted by the debtor, and the ability of agents to violate instances of normative detachments within accepted commitments, with the consequential sanctions and rewards.

In addition, one may consider adding the possibility to share location information *about* a third party. Moreover, instantiating contextual information from external sources, e.g. a user's calendar, as well as abstractions allowing people to express, e.g., conditions such as "when we're having dinner" or "when she's at basketball practice" may be investigated. Research has already identified frameworks where this may be possible (see [GMP+15]). Moreover, allowing commitment delegation (e.g. from one parent creditor to another) as per appropriate roles and responsibilities may as well be considered.

### *8.2 Concluding remarks and future work*

In this paper we showed that SC models can potentially overcome the limitations in sharing and receiving content that are present in current social media applications, through providing

a flexible and easy to use, yet powerful and useful structure that can be implemented within real-world social applications.

The findings in this paper may lead to a number of possibilities for future work, besides further investigating why our findings occurred as discussed in Section 7.3.4. First, an investigation of the original claim that SC models would provide better support for human values in comparison to currently available, social media preference settings is an important next step– as well as an investigation of the model's flexibility and ease of use with a user group of children. For that we propose a user study with a location sharing app with check-in capabilities, user lists, sharing and receiving preference settings, as well as an implementation of the SC model as proposed in [KBZ+14]. An evaluation can concern a comparison of two versions of the app, one which includes the menu representation of the SC model and one which does not.

Second, several extension of the SC model may be considered as discussed in the previous section.

Third, we envisage conducting an investigation of the possibilities of automatically resolving conflicts amongst commitments. Social commitments do not explicitly prohibit conflicts, and a user may be subscribed to two active commitments that detach conflicting actions. The system's ability to predict a user's preference to the resolution of such conflicts based on contextual information would increase that system's social adaptivity.

## A Scenarios and designated solutions

1. Mary is an 8 years old child. Paul is her father. Paul wants to find out when Mary arrives at the park. She is going there on her own for the first time, and Paul is worried. You are Paul. Use the menu below to construct an agreement to find out when Mary arrives at the park.

   Quality control question: where is Mary going?

   Designated solution (and type): I want *Mary* to *share* her check-ins with *me* if *she's at the park* (O,S,C,P).

2. Mary and Jason are both 8 years old children. Jason wants to play with Mary after school (some time between 3 and 5 pm). Jason does not know where Mary is going after school. You are Jason. Use the menu below to construct an agreement to find out where Mary is going after school.

   Quality control question: how old is Jason?

   Designated solution (and type): I want *Mary* to *share* her check-ins with *me* if *it's between 3pm and 5pm* (O,S,C,T).

3. Mary and Jason are both 8 years old children. Lisa is Jason's mother. Jason wants to play with Mary in the park nearby her house. Jason may forget to inform Mary when he arrives at the park. You are Lisa. Use the menu below to construct an agreement to ensure Jason informs Mary of his arrival at the park.

   Quality control question: how old is Mary?

Designated solution (and type): I want *Jason* to *share* his check-ins with *Mary* if *he's at the park* (O,S,X,P).

4. Jason is an 8 years old child. Lisa is his mother, and Peter is his father. Jason is going to play with his friends after school (some time between 3:30pm and 6pm). Lisa is supposed to drive Jason home afterwards. The parents do not know where Jason and his friends are going to play. You are Peter. Use the menu below to construct an agreement to ensure that Lisa finds out where Jason is going.

   Quality control question: what's the name of Jason's mother?

   Designated solution (and type): I want *Jason* to *share* his check-ins with *Lisa* if *it's between 3pm and 6:30pm* (O,S,X,T).

5. Jason is an 8 years old child. Lisa is his mother. Lisa wants to drive Jason home when he's done playing at the park. Lisa wants to make sure Jason is aware when she arrives. You are Lisa. Use the menu below to construct an agreement to ensure that Jason is informed of your location while he's playing at the park.

   Quality control question: where is Jason playing?

   Designated solution (and type): I want *Jason* to *receive* check-ins from *me* if *he's at the park* (O,R,C,P).

6. Mary and Jason are both 8 years old children. Mary wants Jason to come and play with her in the afternoon (sometime between 3pm and 5pm). Mary does not know yet exactly where she is going to play. You are Mary. Use the menu below to construct an agreement to ensure that Jason knows where you're going this afternoon.

   Quality control question: how old is Mary?

   Designated solution (and type): I want *Jason* to *receive* check-ins from *me* if *it's between 3pm and 5pm* (O,R,C,T).

7. Jason is an 8 years old child. Lisa is his mother, and Peter is his father. Peter wants to pick Jason from day care when he's done with work. Peter is going to be late, but Lisa agrees to pick Jason up instead. You are Peter. Use the menu below to construct an agreement to ensure that Jason finds out when Lisa arrives to pick him up.

   Quality control question: what's the name of Jason's mother?

   Designated solution (and type): I want *Jason* to *receive* check-ins from *Lisa* if *he's at daycare* (O,R,X,P).

8. Jason is an 8 years old child. Lisa is his mother. Lisa wants Jason to be more active in making friends in their neighborhood. Jason does not know where his friends play after school (some time between 4pm and 6pm), and therefore has not, up to now, joined them. You are Lisa. Use the menu below to construct an agreement to ensure that Jason finds out where his friends play after school.

Quality control question: how old is Jason?

Designated solution (and type): I want *Jason* to *receive* check-ins from *Friends* if *it's between 4pm and 6pm* (O,R,X,T).

9. Mary is an 8 years old child. Jane is her mother. Jane does not want to be notified every time Mary comes home. But Mary checks-in and informs everybody when she comes home. You are Jane. Use the menu below to construct an agreement to ensure that Mary does not notify you when she arrives home.

   Quality control question: what's the name of Mary's mother?

   Designated solution (and type): I want *Mary* to *not share* check-ins with *me* if *she's at home* (F,S,C,P).

10. Mary is an 8 years old child. Paul is her father. Paul has a meeting between 10am and 12pm, and will be very busy during that time. But Mary checks-in frequently all day long, and shares with everybody. You are Paul. Use the menu below to construct an agreement to ensure that Mary does not notify you with her location during your meeting.

    Quality control question: why is Paul busy between 10am and 12pm?

    Designated solution (and type): I want *Mary* to *not share* check-ins with *me* if *it's between 10am and 12pm* (F,S,C,T).

11. Jason is an 8 years old child. Lisa is his mother. Lisa does not want strangers to find out where her son is. But when Jason goes to the park he keeps sharing his location with everybody. You are Lisa. Use the menu below to construct an agreement to ensure that Jason does not tell strangers (as in, all people who aren't friends or family) that he's at the park.

    Quality control question: how old is Jason?

    Designated solution (and type): I want *Jason* to *not share* check-ins with *others* if *he's at the park* (F,S,X,P).

12. Jason is an 8 years old child. Peter is his father, and Lisa is his mother. Lisa has a meeting (between 2pm and 4pm) and she does not want to be interrupted during that time. But Jason does not know that, and he might share a few check-ins with her during that time. You are Peter. Use the menu below to construct an agreement to ensure that Jason does not share his location with Lisa during her meeting.

    Quality control question: how old is Jason?

    Designated solution (and type): I want *Jason* to *not share* check-ins with *Lisa* if *it's between 2pm and 4pm* (F,S,X,T).

13. Mary and Jason are both 8 years old children. Mary and Jason go to the same school. Jason therefore does not need to be notified if Mary arrives at school. But Mary

checks in when she arrives at school every day. You are Mary. Use the menu below to construct an agreement to ensure that Jason is not notified of your check-ins if he's at school.

Quality control question: do Mary and Jason go to the same school?

Designated solution (and type): I want *Jason* to *not receive* check-ins from *me* if *he's at school* (F,R,C,P).

14. Jason is an 8 years old child. Lisa is his mother. Jason does not want to bother his mom with too much check-ins. For example, Jason is going on a school trip (between 10am and 3pm) and he is going to check-in in every place they go. You are Jason. Use the menu below to construct an agreement to ensure that Lisa is not notified of your location during that school trip.

    Quality control question: what's the name of Jason's mother?

    Designated solution (and type): I want *Lisa* to *not receive* check-ins from *me* if *it's between 10am and 3pm* (F,R,C,T).

15. Jason is an 8 years old child. Peter is his father. Peter wants Jason's grades at school to improve. Jason is easily distracted by all the notifications on his smart phone when he's at school. You are Peter. Use the menu below to construct an agreement to ensure that Jason does not receive notifications from his friends while he's at school.

    Quality control question: how old is Jason?

    Designated solution (and type): I want *Jason* to *not receive* check-ins from *friends* if *he's at school* (F,R,X,P).

16. Mary is an 8 years old child. Jane is her mother. Jane wants Mary's grades at school to improve. But Mary is easily distracted by all the notifications on her smart phone during the time where she's supposed to do her homework (between 6:30pm and 8pm). You are Jane. Use the menu below to construct an agreement to ensure that Mary does not receive notifications from her friends during the time where she's supposed to do her homework.

    Quality control question: how old is Mary?

    Designated solution (and type): I want *Mary* to *not receive* check-ins from *friends* if *it's between 6:30pm and 8pm* (F,R,X,T).

## B CBUQ items

1. Learning to operate the agreement menu would be easy for me
2. I would find it easy to get the agreement menu to do what I want it to do
3. My interaction with the agreement menu would be clear and understandable

4. I would find the agreement menu to be flexible to interact with
5. It would be easy for me to become skillful at using the agreement menu
6. I would find the agreement menu easy to use

Every item in this questionnaire was followed by a seven-point Likert scale: (1) Extremely unlikely (2) Quite unlikely (3) Slightly unlikely (4) Neither (5) Slightly likely (6) Quite likely (7) Extremely likely

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