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Knock, knock! who's there? Putting the user in control of managing interruptions ☆

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ABSTRACT

The abundance of communication technology, such as the omnipresence of cell phones, has not only increased our ability to reach people anytime anywhere, but also the likelihood of being interrupted. As a result, there is value in understanding how to design technology so that gains are realized from desired interruptions, while the losses from unwanted interruptions are minimized. This paper presents the findings of two complementary field studies, one quantitative and the other qualitative, exploring how the provision of additional incoming cell phone call information impacts people's interruption decision making. These studies were enabled by, *Telling Calls*, a research application built to enable users to provide and receive information such as what the call is about and the caller's circumstances. The qualitative study showed how the additional call information helps people make informed call handling decisions and acts as an aid to effective conversation. The quantitative study elucidated these findings and showed that reducing the uncertainty about the nature of an incoming call improves people's ability to predict the value of an interruption. By combining these diverse research approaches: (1) theory instantiation through tool building; (2) context-aware surveys; and (3) semi-structured interviews, we were able to gain unique insights into the nature of interruption management in the wild, and related design implications.

1. Introduction

In today's multi-tasking and socially connected world, interruptions are inevitable. As a result, researchers are continually on a quest to understand how to help people better manage their interruptions. Most work in interruption management has focused on gaining an understanding of how interruptions affect one's task performance (Adamczyk and Bailey, 2004; Avrahami and Hudson, 2006; Bailey et al., 2001; Iqbal and Bailey, 2005) and how to reduce their negative effects (Fogarty et al., 2005), inspired by theories of attention and cognition (Broadbent, 1958; James, 1890; Johnston and Heinz, 1978; Kahneman, 1973; Treisman, 1960). These theories and insights were primarily based on laboratory studies, where subjects were asked to attend to an interruption, or new information, while engaged in a task within the experimental setting (Eysenck and Keane, 2002; Allport, 1980). In this paper we show how an examination of responses to real world interruptions, using a more diverse set of methods, necessitates a more nuanced account of interruption management.

Interruption may impact one's task performance, but that does not necessarily follow that this impact will determine how one handles these interruptions. People are not passive recipients of interruptions such as incoming phone calls, instead they actively interpret them, and then make decisions about if they should be engaged with or avoided. Even though our understanding of interruption-effects from laboratory studies has been complimented by observational workplace studies, the nature of these studies inherently narrows the "context" of the interruption in terms of factors such as the task, location, interruption type, interruption source (González and Mark, 2004; O'Conaill and Frohlich, 1995; Perlow, 1999; Rouncefield et al., 1994; Fogarty et al., 2005). For example, Altmann and Trafton (2007) showed in a laboratory experiment that response time in a task dropped steadily in the first 15 seconds of the recovery process from an interruption, during which time people seem to incrementally bring back the necessary cognitive resources required to resume the complicated interrupted task. The findings suggest that we should perhaps focus on the designing technologies that aid in the recovery process. However in

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the real world it may be equally if not more important to aid interruption response decision making process in the first place. Such an understanding of how people desire to manage their interruptions can only come from exploring people's interruption response behavior based on their dynamically changing social and work roles spanning across various social and work environments where technology makes people reachable anytime and anywhere.

In this paper, we present new and expanded findings from two field studies into interruption response decision-making behavior (Grandhi et al., 2011). We show how an examination of people's behavior in-situ provides insights into people's natural responses to interruptions that were lacking in prior laboratory and workplace studies. The rest of the paper is organized as follows. We briefly summarize previous research in interruption management to situate the theoretical and methodological approach we take to understanding people's interruption response decision making. We then present the design and implementation of *Telling Calls*, an interruption response management research application for cell phones used in the field studies. The two field studies are then presented followed by discussion of the utility of the field study approach to understanding interruption response behavior and deriving design implications for interruption response decision making tools.

2. Background and theoretical approach

Historically, the majority of interruption research has focused on the nature of interruption impact and how that varies with factors such as the time of interruption (Perlow, 1999; Bailey et al., 2001; Adamczyk and Bailey, 2004; Iqbal and Bailey, 2005); the frequency, length and similarity of an interruption to the main task (Gillie and Broadbent, 1989; McFarlane and Latorella, 2002); complexity of an interrupting task as well as the interrupted task (Gillie and Broadbent, 1989); social and workplace norms, expectations and culture (González and Mark, 2004; Hudson et al., 2002; Perlow, 1999); interdependencies of work patterns (O'Conaill and Frohlich, 1995; Perlow, 1999). These studies have generally been viewed as providing support for the *Interruption Impact Reduction Paradigm* (Grandhi and Jones, 2010), the notion that given interruptions have a negative effect under certain conditions, interruption management should focus on reducing the negative impacts of interruptions on those being interrupted.

Adopting the *Interruption Impact Reduction Paradigm* perspective leads to focusing on factors within the interruptee's 'local context' that cause negative impacts, namely: (1) **Cognitive context:** which is all aspects that encompass the interruptee's cognitive level of involvement in tasks (Arroyo and Selker, 2011; McFarlane and Latorella, 2002; Perlow, 1999; Zijlstra et al., 1999); and (2) **Social context:** which is all aspects that encompass the interruptee's immediate environment, as understood in a social sense, such as the place the individual is in, people present within that place, and the social nature of the activity in that place (Fogarty et al., 2005; Ho and Intille, 2005; Janssen et al., 2014; Marti and Schmandt, 2005). With such a focus, researchers and designers working within the Interruption Impact Reduction *Paradigm* have concentrated their efforts on strategies that prevent, dissuade, or present an interruption in the least intrusive manner possible. A number of simple related design features have been implemented in commercial systems including setting alerts to muting them on phones, emails and instant messaging. More sophisticated features have been explored through proof-of-concept systems focused on preventing or postponing of interruptions until an opportune time such as *Bayesphone* (Horvitz et al., 2005); *Disruption Manager* (Arroyo and Selker, 2011) or *Negotiator* (Wiberg and Whittaker, 2005), *Live Addressbook* (Milewski and Smith, 2000), *Lilsys* (Begole et al., 2004) and *Calls Calm* (Pedersen, 2001). Other studies have found value in enabling tacit or explicit negotiation between interrupters and interruptees as a way to dissuade unwanted interruptions using presence or awareness features (Nardi, 1996; Woodruff and Aoki, 2003; De Guzman et al., 2007; Avrahami et al., 2007). Many commercial applications have also focused on minimizing the burden of fully engaging in the interruption by enabling automatic or user controlled text/voice responses to missed or ignored phone calls/ instant messages inspired by proof of concept systems such as *Taming the Ring* (Nelson et al., 2002) and *Quiet Calls* (Pering, 2002), instant messaging. Together these systems and studies show how people can manage their interruptions by exclusively focusing on reducing the negative impacts they can cause on people's local context.

In contrast to the *Interruption Impact Reduction Paradigm*, the *Interruption Evaluation Paradigm* focuses on the utility brought by an interruption (Milewski, 2006; Dabbish and Baker, 2003; Szóstek and Markopoulos, 2006; Grandhi and Jones, 2010). Researchers working from this perspective do not focus solely on factors of social or cognitive context that are local to the person being interrupted, but also on factors related to who the interruption is from and under what the circumstances is the person interrupting. Those interrupted are understood to engage in a cost vs. benefit evaluation of interruption in a broader context. Thus from the *interruption evaluation paradigm's* perspective the goal of interruption management is to optimize one's ability to evaluate the utility of engaging in interruption. The role of technology should then be to aid evaluation and the decision making process of whether to engage in or ignore the interruptions. Since one is aware of their own social and cognitive contexts, the required information for interruption evaluation is outside of the local context that is termed as the **Relational Context**: this encompasses information on who the interruption is from, what the interruption is about, under what circumstances is the interrupter interrupting, and the nature of the relationship between the interrupter and interruptee including their historic interaction patterns defined by the nuances of their relationship (Grandhi and Jones, 2010).

The majority of interruption management design strategies adopt the *Interruption Impact Reduction Paradigm* even though the *Interruption Evaluation Paradigm* makes intuitive sense. Furthermore, research has shown that individuals seek relational context information to evaluate the value of an interruption such as urgency tags in emails, call screening for who the caller is, call content, urgency via an answering machine (Milewski, 2006), importance as relayed by administrative assistants (Dabbish and Baker, 2003; Szóstek and Markopoulos, 2006). Yet there is limited research on understanding what relational context information users specifically desire during various technology mediated interpersonal interruptions and how it can be used to support their response decision making.

In this research we adopt the *Interruption Evaluation Paradigm* to explore how people's interruption response decision making in everyday interpersonal communication is influenced by social, cognitive and relational contexts. The work presented in this paper builds on our previous work (Grandhi and Jones, 2010, Grandhi et al., 2011) where we developed the theoretical framework of interpersonal interruption response management that proposes that when presented with an interruption, people try to predict the value (PIV) of an interruption and in the process try to reduce the uncertainty of any unknown relevant information. Given people are aware of their own cognitive and social context they seek to reduce uncertainty about the unknown relational context such what the interruption is about, who and under what circumstances is one interrupting them to predict the value of the interruption. If the predicted value of interruption is positive they will engage in the interruption and if it is negative they will refrain from engaging in the interruption. The key constructs of this theoretical framework were validated by two studies (Grandhi and Jones, 2010, Grandhi et al., 2009) that not only confirmed the

importance of relational context (study1) but also established the relative importance and utility of various relational context factors that are desired and influential in call handling decisions was also established (Grandhi et al., 2009). Together this previous work informed our subsequent research through design efforts and the research questions of the two field studies presented in this paper.

3. Research questions

In order to test and validate the design implications drawn from our previous work (Grandhi and Jones, 2010, Grandhi et al., 2009), we took a mixed method approach and engaged in: (1) *research-through-design* (Zimmerman et al., 2007) aimed at instantiating software guided by the core theoretical constructs; (2) qualitative research that utilized individual mobile survey responses to improve recall; and (3) experience sampling using mobile context-aware surveys (Csikszentmihalyi and Larson, 1987). The *research-through-design* effort resulted in *Telling Calls*, a mobile phone research application built to enable users to provide and receive relational context information at the time of call. We limited the relational context information to items relating to caller context and call content, as findings from (Grandhi et al., 2009) indicated that the caller – receiver interaction history was least desired and mostly known to cell phone users. We then ran two field studies of *Telling Calls* used to collectively address the following research questions with respect to caller context and call content information:

1) What information do receivers like to know when receiving impromptu calls?
2) What information do receivers use to make call handling decisions?
3) What information are callers willing to share at the time of call?
4) How does the provision of additional call content and caller context information impact the call handling decision?

The findings presented in this paper substantially expand on the findings reported in our earlier work (Grandhi et al., 2011) and examine the value of the unique data collection methods used to the interruption research community.

4. Research through design: *Telling Calls*

We designed *Telling Calls*, a cell phone application that enabled receivers to receive relational context information provided by the callers. The goal of designing *Telling Calls* was not to test an "optimal" solution to interruption management but to understand the problem space of interruption management response behavior in its own right while keeping our theoretical perspectives in mind. Thus we took a research through design approach (Zimmerman et al., 2007) and sought to understand the nature of interpersonal interruption response decision making in real world cell phone use that involved exploring various design options and multiple usability testing and iterations. Our design choices and rationale were influenced by constraints and challenges of technology, people's cell phone use habits and our theoretical framework.

We sought to incorporate 8 items into *Telling Calls* (Fig. 1) *in a single screen* informed by the findings of (Grandhi et al., 2009) that highlighted the relational context items that were unknown and highly desired for call handling decisions: Subject (or call reason); Location of the caller; Activity of the caller; Caller's estimated call length; People the caller is with; Urgency of the call; Importance of the call and; Caller's mood.

Telling Calls was developed for use with AT&T Tilt Smartphones running Windows Mobile 6 that had touch screens, and included slide-out keyboards that enabled gestures, stylus based input, and typing. At the time of this study due to low adoption of high-speed data plans, we used the Short Messaging System (SMS) to transfer data between the caller and receiver's *Telling Calls* clients. This choice restricted the amount of text that could be provided by the caller.

In designing *Telling Calls*, we aimed to increase usability and utility using a number of design features. Firstly we enabling data entry using thumb based touch interface for the caller. Secondly, we provided a single unified interface for both the caller and receiver (making it easier for both caller and receiver to understand consistent information). Finally, we provided a mix of predefined and text field input to enable quick data entry. This feature choice of relational context provision was implemented as follows: The identity of the caller is provided by the standard caller ID feature of the phone. Subject, location, and activity are non-scrollable text entry fields and allow up to 50 characters per field. The remaining fields are implemented as buttons that present the caller with a scrollable list of choices to select from, as outlined below.

- Call Length: none (i.e., no value), less than 3 min, 3–10 min, 10–20 min, and more than 20 min.
- "I am with": none, alone, mutual friends, mutual acquaintances, friends, and acquaintances.
- Urgency: none, low, medium, and high.
- Importance: none, low, medium, and high.
- Mood: a range that was inspired from popular IM clients with choices such as happy, crabby, bored, and angry.

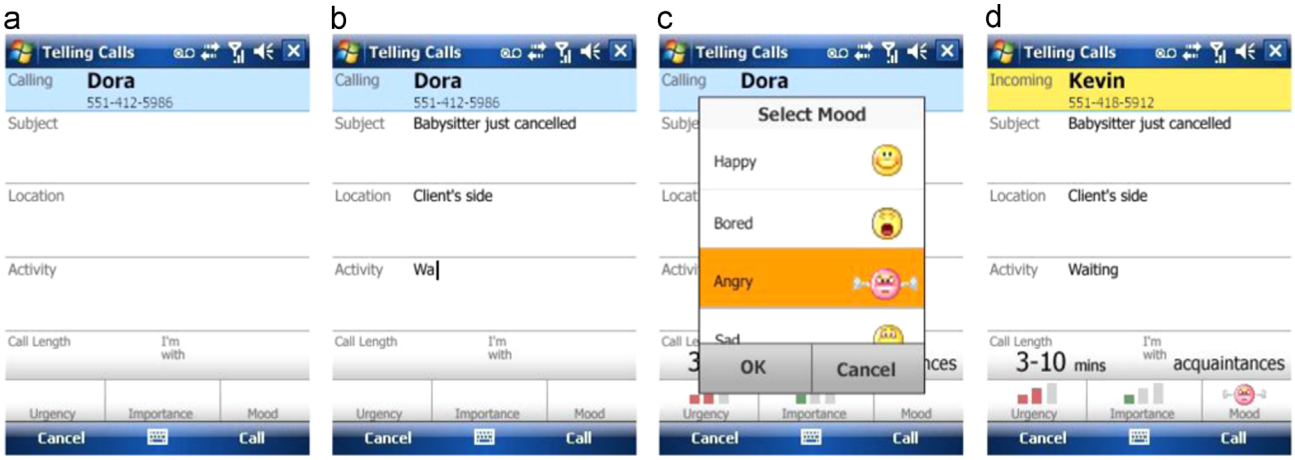

Fig. 1. Caller's interface [(a);(b);(c)] and Receiver's interface [d].

The interaction of *Telling Calls* to make and receive a call is as follows: The caller begins by selecting "Make Call" button on the home screen followed by selecting a contact initiates a call with the Caller's interface. Caller then fills out any of the various fields deemed appropriate for the call. Caller would then press the Call button and the data would be transmitted to the Receiver. The receiver's phone would alert him/her of an incoming call and the relational context information, upon which he/she would be able to accept or decline the call. *Telling Calls* also allows users to access the Call History of relational context information of all calls as outlined in Fig. 2.

5. Qualittaive user study

5.1. Research questions

The aim of this study was to obtain descriptive accounts of user experience to understand the effect of reducing uncertainty of relational context information on everyday cell phone call handling decisions. We took an interpretive approach (Klein and Myers, 1999), to address two broad questions in this field study that expands of our previous work (Grandhi et al., 2011): (1) What is the value of reducing uncertainty around the relational context in everyday call handling decisions? and (2) How is the *Telling Calls* application used and perceived in everyday cell phone use practices?

5.2. Method

5.2.1. Study procedure

In this study we conducted semi-structured interviews before and after participants used *Telling Calls* for periods ranging from 1 to 2 weeks. Pairs or groups of participants, who regularly called each other were recruited through convenience and snowball sampling techniques (Bernard, 1995) and were given a replacement AT&T Tilt Smartphone for use with their own SIM cards and service plans. Participants were trained and briefed on how to operate the phone and the *Telling Calls* application where they were asked to use the application as much as possible in the event of making calls to their study partner.

5.2.2. Participants

Thirty-seven participants (46% female) were recruited in groups of 2–3 over the course of 6 weeks. These 28 groups consisted of romantic relationships (25%), family relationships (18%), and friendships (57%). Participants were a mix of students (92%) many of whom held part-time jobs and working adults (8%). The participants belonged to the age groups less than 20 years (8%), 21–30 years (80%) and over the age of 31 years (2%).

5.2.3. Study instrument

Our semi-structured interviews were organized around obtaining a rich and descriptive understanding of participants' overall experience as callers as well as receivers in reducing uncertainty of incoming calls through *Telling Calls*. Using their call logs as a recall artifact, our questions explored three themes:

- **Influence of *Telling Calls* on call receiving process**: What did the participants like about the relational context information they received through *Telling Calls*, and why? What relational context information influenced their response decisions and how? Did the information reduce uncertainty and help them better predict what the subject of the call was?
- **Influence of *Telling Calls* on call making process**: What relational context information did the participants provide through *Telling Calls* and why? What relational context information did they like providing, and why? Did providing the information influence their calling partner the way they wanted it to, and how?
- **Likes and dislikes of the application interface**: What did the participants like and dislike about the *Telling Calls* application features and interaction techniques, from the callers' perspective as well as the receivers' perspective.

5.3. Results

We recorded 785 min of semi-structured interviews. Notes were taken during the interviews about patterns of user experience and all interviews were transcribed. Using interpretive principles outlined in (Klein and Myers, 1999; Pratt, 2008), the transcriptions were analyzed resulted in several themes that emerged within the broad research questions of the study. In this paper we highlight the important differences in the experience and perspectives of different participants within the broads themes reported in our earlier work (Grandhi et al., 2011). Representative quotes to illustrate the themes are presented below with names changed to preserve participants' anonymity.

5.3.1. Influence of Telling Calls on call receiving process

All participants expressed the value of receiving relational context information through Telling Calls in (1) making informed call handling decisions (2) engage in more effective conversations in terms of time

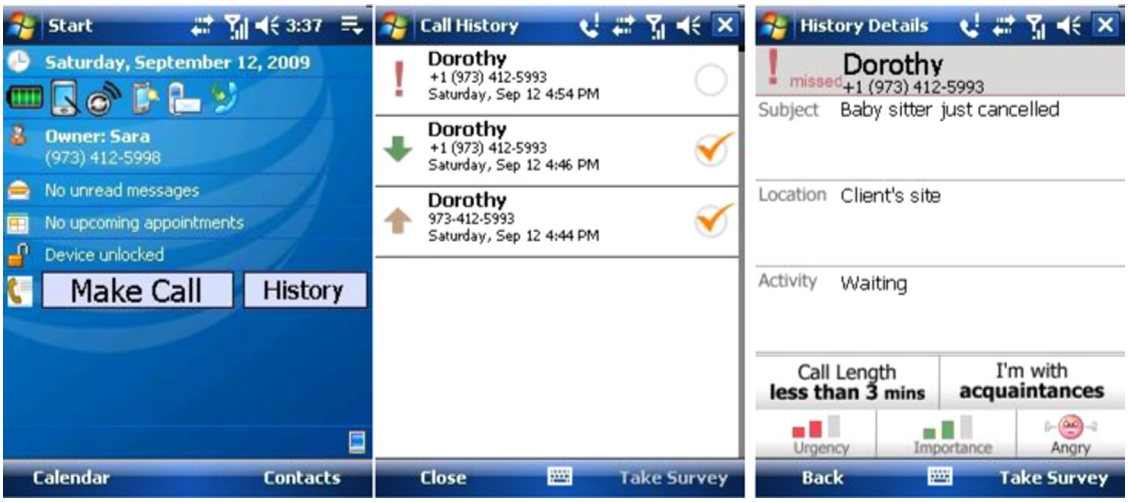

Fig. 2. Sequence of accessing relational context details from Call History.

and content (Grandhi et al., 2011). In this paper we describe the nuances of how the relational context is used in call handling decisions and how calls turned out to be more focused.

Participants felt that the uncertainty of relational context information apart from caller ID was mitigated allowing them to make call response decisions with certainty. Reema a female graduate student working full time, said how she was able to evaluate whether to pick up or ignore calls without having to wonder what the call was about when she was busy at work. "*… Because I could evaluate it - picking it up, leaving it, leaving it go to voicemail or determine its urgency or importance knowing what was reflected on the screen. I ignored a couple of calls that were 'Are you free for lunch' kinds, I was at work and we had this conference. So I couldn't pick up the call right then. So, I just ignored the call knowing that okay, it's from Vinoy - fine, just for lunch. No <I don't want to answer it>, I'm busy. So I didn't reply back for an hour or so.*"

Apart for explicit answering or ignoring calls, having the relational context information also gave participants control in how they engaged in it. Participants reported how they changed their response medium to texting, or even delegated the response task to someone else. Eli, a computer science graduate student working full time, responded to a call from his girlfriend via text messaging. "*I missed this intentionally and it was because I was having lunch with my teammates outside and I had just started. I saw the subject and I knew what it was for. I messaged her back that I'm having lunch with my teammates, that were outside. …It was about talking to someone about a girl.*"

Matt talked about how he had delegated responding to a call from his mother, to his sister, when he was busy working on a boat with his father. "*I was busy helping my dad with setting up our boat. We were going on a sailboat ride and I saw that it was a low urgency call so I knew – just from that context, I knew that she was calling to see when we would be back home. So I just had my sister call her*"

While participants universally agreed how reducing relational context aided in call handling decisions, they differed vastly, in the 8 relational context items used (Call Subject, Caller location, Caller activity, Call length, Who the caller was with, Call importance, Call urgency and Caller mood). The choice of relational context items used for response decisions, when provided, was influenced by the nature of relationship with the caller and previous interaction history.

Bob, a biomedical engineering graduate student, looked for the Subject field when receiving calls from his friend Adam, because that said it all. "*. because I was using this tool, I know where exactly I have to look for that person. I mean, like if it is Adam, I would just look at the subject*. Dora, an undergraduate female, knowing the daily routine of her roommate Samantha, thus desired, and paid attention to, only the relational context information that she did not know. "*…When I'm receiving the call, I found the subject and the location to be the primary thing.*"

Kevin, a computer science graduate student, on the other hand found importance and subject to be the most useful information in making call handling decisions about calls from his roommate Andrew. "*…most of the time I will uh, have a look at subject and uh, the importance, that's all.*" Contrary to Kevin, Andrew, a computer science graduate student, felt he could most effectively decide whether he wanted to be interrupted or not based on the call length and urgency fields. "*… if I have something important to do and I don't want other people to interrupt me for a long time.* (…) *If the call is very long, I don't want to pick up … If its very urgent, I will pick up…*".

Participants also reported the way in which conversation content was influenced with use of Telling Calls. Many reported using relational context information received to set the stage of the conversation with the person calling using the information as an icebreaker (Grandhi et al., 2011). Many participants however reported that having relational context information at the time of call, allowed them to have short and effective conversations in case of 'specific purpose calls'. Experiences such as these were very typical from our participants: *Lata*: " *Yes, getting the information was definitely better, you know. … by the time you pick up – you know everything and a lot of time is saved and you can get to the point*"; *Mark*:*". when I accepted the call, I already knew what it was going to be about so I could go straight to that when I was in a hurry or when I was with friends and I needed to have a very brief conversation.*

5.3.2. Influence of Telling Calls on call making process

The utility of the sending relational context information as caller was very similar to being a receiver when using *Telling Calls*. Participants reported that *Telling Calls* influenced their call making process by (1) enabling short and effective communication and (2) steering the conversation in the direction they desired (Grandhi et al., 2011).

Using various combinations of relational context items, participants were able to elicit the appropriate conversation from receivers who answered their calls. Sometimes all items were provided but items typically revealed were subject, urgency and importance. The relational context information participants revealed or did not reveal, to their call partners when using *Telling Calls*, was dictated by the nature of the relationship. In this paper we report the tacit assumptions and reasons for not providing certain relational context information.

Lack of relevance to the purpose of the call was often reason cited for not revealing certain information. The lack of relevance was either because of the nature of relationship, the purpose of the call or awareness of each other's daily routines. Emma, an undergraduate did not reveal importance or urgency as the nature of her friendship with her call partner seldom had anything urgent to talk about. "*Because majority of the time my calls weren't really that urgent and…I don't really think I had known of any situations where I need to immediately talk to Roberto. It can be put up to later.*" Nelly, explained why she never reported her location to her boyfriend while at work "*…subject and mood are the two things that I prefer filling up* [*provide in Telling Calls*] *because I can tell him. As far as location and activities and so on, I call only when I'm at job. So he knows, he is always aware of the fact that – what my location is and what my activity is*. " Pat, explained why she does not reveal items such as call length to her boyfriend "*. it really doesn't matter sometimes because most of the time, he used to be alone…the call duration also didn't matter much*." Simmi, explained why she never revealed who she was with at the time of the call "*…whoever is going to receive my call…I didn't feel it was very important for them to know that who I'm with or something. It's not going to matter.*" Ron explained he revealed his mood only to his girlfriend "*…If it is my girlfriend then I use the mood tool…if it's my sister, then I will not be using the mood tool*"

That conversation was more focused and concise was reported by many participants, Observations such as these from Lucy and Ron were very typical Lucy: "*I felt like – before even talking to the person, the message is conveyed*. [*when call is answered*] *I just get an answer and things got much faster*". Ron "*they* [*when answering calls*] *come straight to the point.*" Vinoy discussed how providing his location information, as he arrived at the restaurant to pick up his friend, made the conversation short and to the point. " *Before he answered my call, he knew what was up. So, he came out walking with the phone saying, "OK. I'm coming out." It was a pretty fun cool.*"

In some cases participants felt certain information about the call got rid of the need for immediate answering of the call. Ron, explained how he has requested his girlfriend to send out a fax and caller to remind her, "*Sometimes, they don't even take the call. My girlfriend -I sent the subject and the importance and the level, I mean –,' did you send the fax?' So immediately – she didn't pick up*

the call. She was very busy so she just [*sent*] *the fax, then came back and then answered – I mean, called me back saying that it's done*." When asked how he felt about her not answering the call he replied " *Oh, that's fine. I mean I get the call after some time saying that, you know, it's done, so I don't have a problem*."

5.3.3. Likes and dislikes of application interface

In general, participants enjoyed using the application as a receiver rather than as a caller. However, given that *Telling Calls* design aimed at enhancing call handling decisions, the design focus was not on making it caller friendly. This resulted in users liking the use of *Telling Calls* as receivers rather than callers (Grandhi et al., 2011). Comments such as this by Kent, were reflective of this sentiment "*… on the receiving end it was more enjoyable."* In this paper we report the nature of frustrations associated with the caller interface. Many participants felt the burden of having to re-enter information when calls were being made within short intervals *and experiences such as that of Eli were typical "The first time I put all that input < information >. If she doesn't pick it up for whatever reason then I don't feel like doing the same again …"* This burden to re-enter information sometimes resulted in participants abandoning the use of the application for immediate subsequent calls. Emma explained when she would make such as switch: *The first time I would put in information. If he didn't pick up from that then I would just go never mind and I just call regularly. Because I'm already fed up with the fact that I have to use it again and have to rewrite all the information again."* Victor expressed a similar sentiment about making back-to-back calls: *I didn't want to really type it all over again and I would just want to give her a call back immediately*

Participants also reported not using the application in case of calls that were intended to be very short, or calls that were made in emergencies. In other words providing a preview of relational context information did not provide any benefit. The following comments by Dawn and Mala are representative of how participants exercised the choice of using *Telling Callings*: *Dawn*: *"Um only when like there was an emergency that I needed to talk to her, I don't use the tool. I just call her directly" and Mala*: *"When it was very urgent like he had to pick up the phone at any cost I didn't have the time to type all that stuff, I used to call directly without using the tool.*

While participants disliked inputting data on the caller interface but they greatly appreciated the interface layout as both callers and receivers. Many commented on this with respect to the effectiveness of *Telling Calls* compared to regular voicemails and text messages (Grandhi et al., 2011). Participants felt that being able to have specific predesigned fields for various relational context items enabled ease of entry (as senders) as well as ease of comprehension (as receivers) when compared to free forms full sentences text in text messaging. Participants also experienced value in the interface design of *Telling Calls* that provided the functionality of having (1) a rich persistent history of all the relational context information in case of missed calls, and (2) a smart list that displayed previously entered text entries to enable reuse. Archiving of information reduced the burden of gathering information on missed calls, as expressed by Pia *"I think another advantage < of Telling Calls > is that when I missed a call, I don't have to – or the other person too - they don't have to leave a message. We could just see what the call was about and call back."*

5.4. Discussion of qualitative field study

The aim of the qualitative field study presented here was to obtain a rich and holistic understanding of the feasibility and utility of providing and receiving relational context information for interruption response decision making. User accounts indicate that they experienced value in using *Telling Calls* as both receivers and as callers.

Receivers used a combination of relational context information provided to them in making call handling decisions and engaging in effective conversations. The relational context information items used varied with the nature of the caller – receiver relationship. For example, it is seen that Mood is used only in very personal relationships, such as domestic partnerships or close friendships. Participants often desired and used dynamic information that varied in that relationship such as location, subject, importance and urgency consistent with people's general social information needs (Jones et al., 2004). This utility and benefit of using relational context information to screen an interruption provides a nuanced understanding of previous research. Our findings are consistent with the study of call screening through answering machines by Milewski (2006), which found that several potential cues could be derived from the callers' voice and content of the message. The perceived benefits of reducing the uncertainty of relational context may also be compared to the findings of a recent study by Carton and Aiello (2009), which showed that control and anticipation of an interruption, reduced stress and improved performance. They also showed that simply having the control to defer or manage interruptions, even if not exercised, lowered stress levels. In the case of *Telling Calls*, reducing uncertainty of relational context gave participants a sense of control to implicitly or explicitly manage an incoming interruption.

User experiences also indicated that participants used relational context to not only manage call response decisions, but also manage the call conversation process or interruptions in general. Apart from aiding in making decisions to ignore or accept a call, it is noted that *Telling Calls* allowed participants to structure their conversations. On one hand they made phone conversations effective and brief and on the other they set the stage for longer, personally meaningful conversations. These findings are consistent with previous studies on instant messaging, where the ability to see the subject of the interruption enabled people to better coordinate and negotiate conversations, and their availability for them through other media, such as the phone (Nardi, 1996). Our findings on using relational context to manage incoming calls is also consistent with Garrett and Danziger (2008), who found that Instant Messaging users not only negotiated their phone or face to face interruptions better, but as a result, reported being less interrupted. *Telling Calls* is seen to provide users with a similar control on how the interruption is managed, by combining the previewing ability of instant messaging in the incoming phone call notification.

In summary, this study provided insights on user experiences that established the utility of reducing uncertainty about a call's relational context information in making informed call handling decisions.

6. Quantitative user study

6.1. Research questions

The aim of this quantitative study was to statistically validate the utility of providing relational context information for everyday cell phone call handling decisions, through *Telling Calls*. Specifically, the research questions explored in this study are guided by the Interruption Response Management Framework (Grandhi and Jones, 2010), and fine-tuned based on the findings of the semi-structured interviews on the use of *Telling Calls* (Section 5). The questions examined here expand our previous work (Grandhi et al., 2011) and fall into two broad categories (1) The effect of *Telling Calls* on receivers in everyday cell phone interruption response decision making, and (2) Perceptions of using *Telling Calls*, for both receivers and callers.

6.1.1. Effect of Telling Calls on receivers

Our first goal in this study was to quantitatively test if providing a tool that enables the provision of more relational context information indeed helps in reducing the uncertainty surrounding the call. Specifically we explore the following questions:

R1: Does providing receivers with additional relational context information through *Telling Calls* reduce the uncertainty about the call?

R2: Does the use of *Telling Calls* result in receivers desiring less of the unknown relational context information.

Our second goal was to quantitatively test the utility of having relational context information in effectively evaluating and predicting the value of an interruption (PIV). This led to the following research questions.

R3: Are people less likely to answer calls to reduce uncertainty and more likely to answer calls based on the relational context provided to them in *Telling Calls*?

R4: Does knowing relational context items result in greater accuracy of predicting the value of taking the call (PIV).

6.1.2. Perception of Telling Calls use

Our final goal of this study was to measure and understand users perception of adoption of *Telling Calls* as an application. Adapted from Theory of Reasoned Action (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), Technology Acceptance Model (Davis, 1989) is one of the most empirically validated and applied model of technology acceptance and usage (Venkatesh, 2000). TAM posits that user perceptions/beliefs on technology such as usefulness, ease of use, and enjoyment, predict user's behavioral intention to use technology. Thus we wanted to know how people perceived *Telling Calls* when the application is introduced to them and if they intended to use it. Furthermore since novelty of an application can bias people with positive perceptions, we were interested in knowing if these perceptions and intentions of use change with use of *Telling Calls*. This led to the following two research questions.

R5: What are people's perceptions of usefulness and ease of use, enjoyment, and intention of use of *Telling Calls*?

R6: Do people's perceptions of usefulness and ease of use, enjoyment, and intention of use of *Telling Calls* change with use?

6.2. Method

6.2.1. Study procedure

In order to capture data on the utility of providing additional relational context information in situ, we ran an experimental field study that gathered participants' perception of use and utility using experience sampling methodology (ESM) (Csikszentmihalyi and Larson, 1987; Barrett and Barrett, 2001). A within subjects design with 1 factor (Regular Calls vs. Telling Calls) was implemented. Half the participants used Telling Calls in the first week of the study and a regular phone in the second week of the study (Condition 1). The other half used a regular phone in the first week and Telling Calls in the second week (Condition 2). Participants were randomly assigned to between the two groups and were given a Windows Mobile Pocket PC cell phone to use with their own SIM cards and service plans for the 2 weeks of the study. The phones were loaded with an ESM survey (Fig. 3) that varied in content, based on whether the call was incoming or outgoing. Incoming calls were differentiated as (a) answered calls, and (b) ignored calls (missed intentionally). The survey was triggered and administered in the following situations when calls were made/received to the study partners: (a) immediately after the end of an outgoing call, (b) after the end of an incoming call that is answered, and (c) immediately after the subject hits the ignore/silence button for an ignored call. In order to reduce the burden of repeated data entry using the ESM tool, we increased the usability of answering the ESM survey by (a) Enabling all responses to the survey using thumb based touch interface and (b) Providing the outgoing/incoming call interface of *Telling Calls* layout in the survey, to aid respondents in recalling the information they received or sent using the application. If the survey was not answered immediately by the participant (missed or deliberately postponed), it was programmed as a pending incomplete survey, for access and completion within 24 h, Respondents went to the Call History access and answer postponed surveys that also allowed them to review the call details.

All participants were trained and briefed before participating in the study on how to operate the phone, how to answer the ESM survey, how to adhere to study requirements in providing data. Data on participants' demographics and current cell phone use practices were also obtained during this training. When participants began, or switched to using the *Telling Calls* application (Condition 2), they were trained on how to use *Telling Calls*, over and above the general training described above. Further, participants were also administered a survey to measure their perceptions of usefulness, ease of use, enjoyment, and intention to use the *Telling Calls* application soon after training and at the end of 1 week use (Condition 2).

6.2.2. Participants

Thirty participants were recruited (62% Male) for the study at a mid-sized research university in groups of 2–3 between the ages of 21–30 (52%), under the age of 20 (38%), and over the age of 30 (10%). Participants were employed full time (14%), part-time (24%) and unemployed (62%). They classified their study partners as being friends (79%), family (14%), and spouse/partners (7%), and reported talking to study partners 2–5 times a day (79%), 0–1 times per week (14%), and more than five times a day (7%). All participants completed and participated in both condition 1 and condition 2.

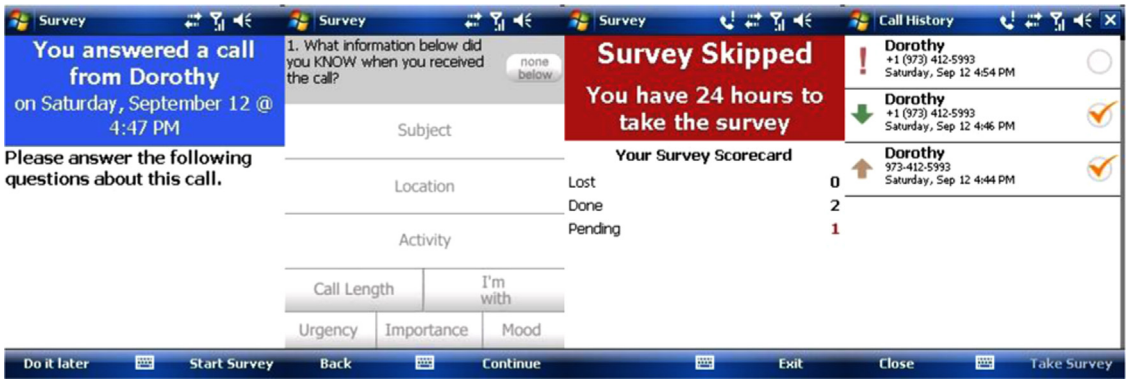

Fig. 3. ESM survey interface when survey administered and skipped.

6.2.3. Data collection and instruments

Data for this study were collected using a combination of instruments and phone logs as listed below. The ESM data collected was predominantly using nominal single item scales in order to reduce the burden of repeated in-situ data provision on user.

- ESM survey for callers (With and Without *Telling Calls*).
- ESM survey for receivers (With and Without *Telling Calls*).
- *Telling Calls* Perception survey Pre- and Post-Use (Callers and Receivers).
- *Telling Calls* application.
  - Number of calls made to study partner using the application.
  - Relational context information sent and received to/from study partner.
- Phone logs.
  - Number of calls made to study partner (Conditions 1 and 2).
  - Number of calls received from study partner – answered and ignored/missed (Condition 1 and 2).

6.2.3.1. ESM survey for call receivers (with and without Telling Calls). The ESM survey questions presented to call receivers varied slightly, according to the call handling outcomes namely missed (unintentional), ignored (intentional), or answered and addressed the following aspects:

- **Relational Context Certain About**: Participants were asked which of the eight relational context items they knew when they received the call.
- **Relational Context Items Liked**: Given the information they knew about the call they received, participants were asked what information they liked knowing upon receiving the call.
- **Relational Context Items Desired**: Participants were asked what information they did not have, but desired to have, when they received a call.
- **Relational Context Items Influencing Response Decision**: Participants were asked whether knowing the relational context information (and which of the eight items) influenced their decision to answer or ignore the call. They were also asked if not knowing any relational context information influenced their decision to answer or ignore the call. For example, did they ignore a call because they did not know what the call was about, or did they answer the call in order to find out.
- **Inaccuracy of the Perceived Value of the Call**: Participants were asked how worthwhile they thought the call was before they answered/ignored it (and after they answered it), on a scale of 1–7, with 7 being worthwhile and 1 being worthless. They were also given a choice to report if they did not, or could not, evaluate the call's worth, before answering/ignoring the call. The difference in perceived value of being interrupted by the call, before and after the call, was calculated to gauge the inaccuracy of the predicted interruption value (PIV inaccuracy) for calls answered.

6.2.3.2. ESM survey for Callers. For callers using *Telling Calls*, we asked questions on the two themes: **(1) Usefulness**: Participants were asked how useful they found the tool to be when making the call on a scale of 1–7, 7 being very useful and 1 being not at all useful. **(2) Reasons for not providing relational call information**: Participants were asked what information they did not provide because they did not wish to reveal it when making this call, and what information they did not provide because it would not have been useful to the receiver when making this call.

When calls were made without *Telling Calls*, callers were asked what relational context information they would have liked to have provided when making the call.

6.2.3.3. Perception of the Telling Calls use before and after use. Participants were surveyed about their perceptions of *Telling Calls* soon after they were trained to use the application and after 1 week of using the application. Seven-point semantic differential scales adapted from Venkatesh (2000) were used to measure the following perceptions for both callers and receivers, using *Telling Calls*.

Behavioral Intention to Use (*BIU*): Participants were asked if they would use the application if they had access to it (2 Items, Venkatesh, 2000).

Perceived Enjoyment (*PE*): Participants were asked if using the application was enjoyable, pleasant and fun (3 Items, Venkatesh, 2000).

Perceived Usefulness (*PU*): Participants were asked if using the application would improve their decision making ability to answer/ignore calls (only receivers), increase their productivity, enhance effectiveness, be useful in social and work activities (3 Items, Venkatesh, 2000). For receivers we added an extra item that asked if Telling Calls improved their decision-making ability to answer/ignore calls on a scale on 1–7.

Perceived Ease of Use (*PEU*): Participants were asked if their interaction with the application was clear and understandable, required excessive mental effort, was easy to use, and easy to get the desired results (4 Items, Venkatesh, 2000).

6.3. Results

6.3.1. ESM questionnaires recorded

A total of 1714 calls were recorded, however, due to software glitches only 1628 ESM questionnaires were recorded for these calls. Since subjects had access to both regular calling service, as well as the *Telling Calls* application in Condition 2, all ESM questionnaires completed for the calls made or received through regular calling service (110) in this condition were excluded from the analysis. Thus 1518 ESM questionnaires sent were considered for data analysis. Nine hundred and ninety (990) ESM questionnaires were sent out in Condition 1 and 92% of them (914 of 990) were completed. Five hundred and twenty eight ESM questionnaires were sent out in Condition 2, and 95% of them (502 of 528) were completed. To address the research questions of this study, the 914 regular calls in Condition 1, and 502 *Telling Calls* of Condition 2, were used. From this point on, these two conditions are referred to as Regular Calls and *Telling Calls*.

6.3.2. Distribution of incoming and outgoing calls

Of the 914 Regular Calls surveyed between study partners, 253 were answered (28%), 15 were ignored (2%) after seeing who the caller was, 27 without seeing who the caller was (3%), 144 were missed unintentionally (12%), and 505 were outgoing (55%). Of the 502 *Telling Calls* surveyed between study partners, 173 were answered (34%), 4 were ignored after seeing who the caller was (1%), 18 were ignored without seeing who the caller was (4%); 59 were missed unintentionally (12%), and 248 were outgoing (49%). Since the focus of this research is intentional interruption response decision making, the research questions in this study are based on the ESM survey responses for calls that were deliberately answered, or deliberately ignored after seeing who or what the call was about. The incoming calls analysis conducted is therefore based on 268 Regular Calls (253 answered + 15 Ignored after seeing caller ID), and 177 Telling Calls (173 answered + 4 ignored after seeing relational context).

6.3.3. Relational context received and provided using Telling Calls

For 177 incoming *Telling Calls* considered in this analysis, at least one relational context item was received for 66.7% of the calls (118) and no relational context items were received for 26% of calls (44) due to *Telling Calls* software malfunction. Subject (59.9%) and location (58.9%) were the most frequently received relational context information as seen the Fig. 4 and for majority of the remaining items, this information was not received, because callers explicitly did not provide information. When calls were made using *Telling Calls*, at least one relational context item was provided in 90.7% (225) of the 248 outgoing *Telling Calls* and for approximately one in every five calls (20.2%), all eight RC items were provided (Appendix: Table 1). The items provided most frequently were subject (73.4%) and location (75.8%). (Appendix: Table 2)

Callers were asked if they did not provide a relational context item because they did not want to share that information to the receiver or because they did not think the information would be useful to the receiver (Appendix: Table 2 and Table 4). For the 248 surveys answered, callers chose not to reveal information because they did not want to share it with Location (19.3%) being the most unrevealed followed by activity (16.9%) and 'who the caller was with,' (11.6%). For the same 248 surveys answered, callers chose not to reveal information because they did not think the information would be useful to the receivers with Call length (25.3%) being most unrevealed followed by caller's activity (23.3%), and who the caller was with (22.5%).

6.3.4. Usefulness of providing relational context information

Callers, when using regular calls ($N=505$), were asked what relational context items they wished they could provide when making a call. While call subject (58.7%) and caller location (53.4%) were desired to be provided at least 1 in 2 calls, call length (6.2%) was the least desired element as seen in the Fig. 5.

In having the capability of providing relational context information while using Telling Calls, callers were asked how useful they found the tool to be on a scale of 1–7 (7 very useful and 1 Not at all useful). For the 250 outgoing *Telling Calls*, the number of observations for ratings 1, 2, 3, 4, 5, 6, and 7 were respectively: 14, 4, 21, 42, 77, 38, and 54. Majority of usefulness ratings were high [$M=4.98$. $SD=1.6$] at 95% CI [4.78,5.18].

6.3.5. Inferential statistics

We used various statistical tests to quantitatively answer the research questions proposed in this study. The results presented in this paper extend the results presented in our earlier work (Grandhi et al., 2011).

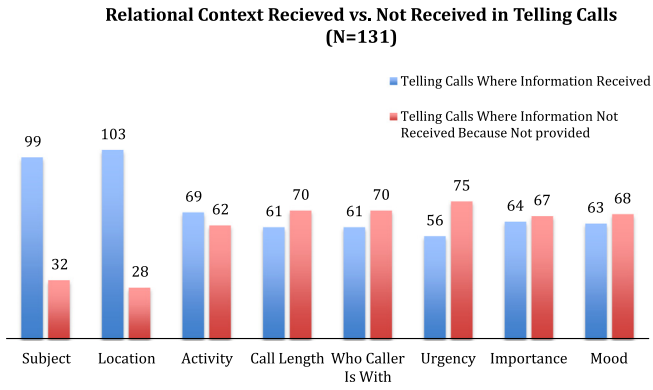

Fig. 4. Number of times Relational context items were received and not received in Telling Calls.

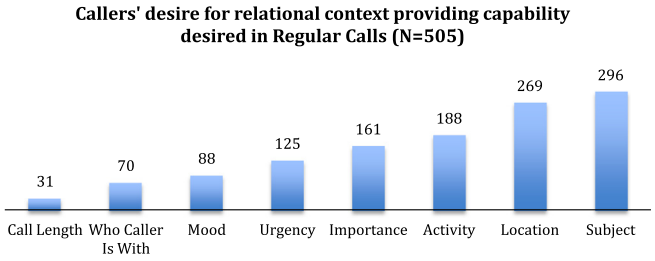

Fig. 5. Number of times for which callers desired the capability of providing Relational Context items was desired when making regular calls.

R1: Does providing receivers with additional relational context information through *Telling Calls* reduce the uncertainty about the call?

Receivers reported knowing various relational context factors to a large degree more with *Telling Calls*, than with Regular Calls. The relatively lower uncertainty of relational context factors with *Telling Calls* was further reduced when a particular relational context was provided. Appendix: Table 5 provides a break-down of every relational context information item reported to be known with (a) Regular Calls, (b) *Telling Calls*, (c) *Telling Calls* where information was received, and (d) *Telling Calls* where information was not received.

At least one relational context item was provided in 118 Telling Calls. Furthermore, providing relational context information reduced the uncertainty about the call. A significant and positive correlation was seen between total number of relational context items provided and the total number of relational context items reported to be known and hence level of certainty (Spearman's Rho $=.440$, $p<.001$, $N=118$). As the number of calls made ranged from person to person (Regular Calls: 6 to 49 per person, and *Telling Calls* ranged: 1 – 49 per person) the data was analyzed at the participant level, rather than at the call level. Responses were aggregated by the total number of calls per participant (for 27 participants who reported this measure in both conditions) in the Regular Calls and the *Telling Calls* conditions. Wilcoxon's Signed-Rank test for two related samples showed that the total number of items reported to be known in Telling Calls, when Relational Context was provided, was significantly higher than Regular Calls ($Z=-3.592$, $p<.001$ $N=27$). Furthermore, we compared relational context certainty, when reported to be known for each relational factor in (1) Regular Calls (2) *Telling Calls* where information was received, and (3) *Telling Calls* where information was not received. Wilcoxon's Signed–Rank test for two related samples showed that uncertainty was significantly reduced for *Telling Calls*, when relational context information was received for every single item (Appendix: Table 6). Further, with the exception of activity information, no significant difference was seen in people's reported certainty of relation context, when information was not received in *Telling Calls* and Regular Calls.

R2: Does the use of *Telling Calls* result in receivers desiring less of the unknown relational context information?

To answer the above question we compared the total number of relational context items unknown, and hence desired, for Regular Calls and *Telling Calls* with respect to each person. There was no significant difference between the two conditions for the total number of items unknown and desired [Wilcoxon's Signed-Rank test ($Z=-1.41$, $p=.16$ $N=28$)]. However, when examined at the individual relational context item level, Wilcoxon's Signed-Rank test indicated that Subject ($Z=-2.66$, $p=.008$) and Location ($Z=-1.99$, $p=.046$) were the only two unknown items that were desired less, in *Telling Calls* as compared to Regular Calls (Appendix: Table 7). Given that the Subject and Location were also the most known relational

context items in Telling Calls, it is not surprising that they were hence least desired.

R3: Are people less likely to answer calls to reduce uncertainty and more likely to answer calls based on the relational context provided to them in *Telling Calls*?

To test if call handling decisions were influenced more by knowing relational context items than by their uncertainty, for each caller we calculated the following for both *Telling Calls* and Regular calls: the ratio of the number of relational context items known and reported to have influenced call handling decision, to the number of relational context items not-known but reported to have influenced call handling decision. Wilcoxon's Signed-Rank test showed that, for each caller, the proportion of unknown relational context information that influenced call response decisions was significantly higher in Regular Calls than in Telling Calls ($Z=-2.133$, $p=.033$, $N=20$). Thus, in Telling Calls, the uncertainty of the relational context did not influence call-handling decisions as much as it did in Regular Calls.

R4: Does knowing relational context items result in greater accuracy of predicting the value of taking the call (PIV)?

The inaccuracy of the PIV was calculated by taking the absolute value of the difference between the value (min=1 and max=7) perceived before answering the call to the value perceived after answering and ending the call. The inaccuracy of PIV ranged from a minimum value 0 to a maximum value 6 where higher values indicate greater accuracy. Among the 426 answered calls (253 Regular Calls and 173 *Telling Calls*), we excluded 44 answered *Telling Calls* where information was not received due to technical failures. We also removed 12 calls where participants said they either 'could not evaluate' or 'did not evaluate' PIV. A small negative, but statistically significant correlation was found between the number of relational context items known, and the inaccuracy of PIV for all calls (Spearman's Rho=−.121, $p=.02$, $N=369$). This correlation was significant for *Telling Calls* (Spearman's Rho=−.184, $P=.040$, $N=125$), but not significant for Regular Calls (Spearman's Rho=.106, $P=.100$, $N=244$).

Furthermore, given that the 'call subject/reason' to be the is the most desired as well as the most used in the qualitative study we wanted to test its influence on PIV accuracy. We found that Call Subject was significantly correlated with PIV inaccuracy in both *Telling Calls* ($N=125$, rho=−.327, $p<.001$) and Regular Calls ($N=244$, rho=−.14, $p=.029$), while other relational context items were not significantly correlated (Appendix: Table 8). In other words when the Subject of the call is known to the receiver, PIV inaccuracy is lower than when the Subject of the call is not known with or without *Telling Calls*.

Furthermore when Call Subject was provided by the caller, and reported to be known by the receiver in *Telling Calls*, a significantly lower PIV inaccuracy was noted that when Call subject was not known ($N=125$, rho=−.263, $p=.003$). Additionally, the relational context items other than subject when provided and reported to be known, had no significant correlation with PIV inaccuracy (Appendix: Table 9). Thus when the Call Subject is provided and known to the receiver using *Telling Calls*, PIV inaccuracy is lower than when the subject is not known (Appendix: Table 10).

R5: What are people's perceptions of usefulness and ease of use, enjoyment, and intention of use of *Telling Calls*?

In order to address the above question we measured users' perceived enjoyment (PE), perceived usefulness (PU) and perceived ease of use (PEU) as well as their behavioral intention to use (BIU) of *Telling Calls* when the application was introduced to them. The aggregate of the items was used to measure each construct and were normalized to a scale of 1–7 as shown in Figs. 6 and 7 for ease of comparison (Appendix: Table 8 shows the number of items as well as the minimum and maximum values of the scales.) Data from 15 of the 30 participants was not included in the analysis, either due to faulty administration of the before use survey, or incomplete survey responses. The behavioral intention to use, perceived usefulness, perceived ease of use and perceived enjoyment for both for receivers and callers at the time of introduction were higher than midpoint 4 on a scale of 1–7 suggesting positive perceptions and intentions of use (Figs. 6 and 7). The design and functionality of *Telling Calls* was thus perceived as being easy to use, useful, and enjoyable.

R6: Do people's perceptions of usefulness and ease of use, enjoyment, and intention of use of *Telling Calls* change with use?

To explore whether the initial perceptions and intentions of using *Telling Calls* change with use, we measure the same even after users used the application for a week. As seen in Figs. 6 and 7, all behavioral measures remained higher than midpoint 4 with the perceived usefulness of *Telling Calls* increasing slightly while the other measures decreasing slightly. Wilcoxon's Signed-Rank test indicated that there was no significant difference in these behavioral measures after use as shown in Table 1. This suggests that the use of *Telling Calls* did not dispel the initial positive perceptions of its ease of use, usefulness and enjoyment and that its adoption is highly likely.

6.4. Discussion of the quantitative field study

This study aimed to test the effects of reducing the uncertainty of relational context on people's real world interruption response decision making. Our findings confirmed that contextual information is mostly unknown at the time of a call, and providing it through *Telling Calls* explicitly reduced the uncertainty associated with it. This shows that there is utility in providing just in time relational context information for call handling decisions.

We found that all of the 8 relational context items were significantly more known with *Telling Calls* (H1). More importantly, given that there was no statistically significant difference between Regular Calls and *Telling Calls* when relational context information was not provided in *Telling Calls*, it rules out any artifact effect and confirms that it is the provision of the relational context information that indeed reduces uncertainty. However the relational context that is desired, when unknown, is based on the relevance and meaningfulness of that information (H2). This is noted in the lack of any significant difference in the total number of relational context items that were unknown and, hence desired, when using *Telling Calls* as compared to Regular Calls. At an individual item level, however, Call Subject and Caller Location were desired significantly less in *Telling Calls* when not provided. These items were also most shared. This suggests that these two pieces of information, when explicitly provided in *Telling Calls*, were relevant or useful information but may not have been when not provided. This could also suggest that these pieces of information could have been deduced from other information revealed such as deducing location information from caller activity.

Our findings also illustrated that call decisions were based on what was known and were driven less by uncertainty when using *Telling Calls* as compared to Regular Calls (H3). Thus, answering or ignoring a call because one did not know what the call was about,

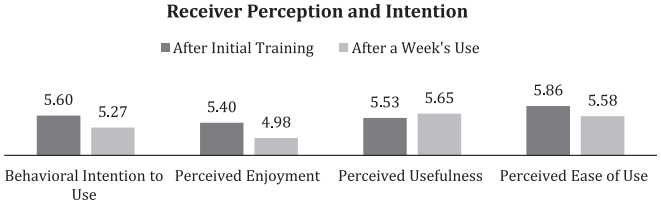

Fig. 6. User Experience Perceptions and Intention to use for Receivers of *Telling Calls.*

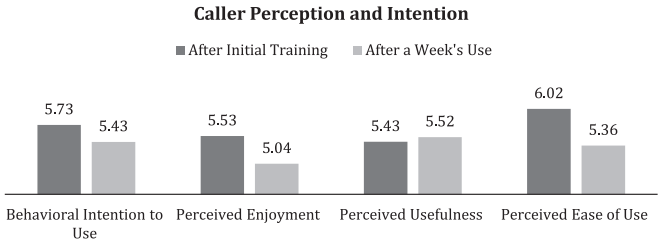

Fig. 7. User Experience Perceptions and Intention to Use for Callers of *Telling Calls*.

or why the call was being made was replaced more by an informed decision based on information provided. This strongly supports the interruption response management framework (Grandhi and Jones, 2010) that suggests that under high uncertainty of relational context, the uncertainty drives or influences people to either answer to reduce uncertainty, or ignore. Whereas when uncertainty is reduced, interruption responses are based on the relational context information known.

Our theoretical framework (Grandhi and Jones, 2010) also suggests that uncertainty of the relational context leads to less accurate PIV, which in turn can lead to ineffective, and/or inefficient response decisions. Our findings lend support to this framework by confirming that people are able to more accurately predict the value of an interruption (PIV) when relational context is known (H4). The total number of relational context items known and PIV inaccuracy indicated no strong correlation in Regular Calls, while a small but significant correlation existed for *Telling Calls*. The lack of correlation in Regular calls could be attributed to a consistently lesser number of relational context items known. This also suggests that it may not be the extent or quantity of relational context items known that contributes to accuracy of the PIV, but that there may be specific relational context items that do so. This is corroborated by the finding that when the Call Subject was received and reported to be known in *Telling Calls*, there was a significant negative correlation with PIV inaccuracy. More interestingly our data also shows that knowledge of relational context items other than Call Subject have no significant correlation with PIV inaccuracy. This suggests that, while knowing more relational context items increases the overall accuracy of PIV, items other than Call Subject did not help in increasing the accuracy of the PIV on their own.

After using the *Telling Calls* application for 1 week for everyday cell phone use, users (receivers and callers) not only perceived it to be useful, easy to use and moderately enjoyable, but also expressed an intention to use it if available. These perceptions and intentions remained the same, before and after use of the application, in their everyday lives. This is further corroborated by call logs that showed *Telling Calls were* 83% ($N=528$) of the total number of calls made and received in Condition 2 where participants were requested to use the application as much as possible, but were not forced to do so.

In summary, this study provided quantitative insights on how using *Telling Calls* helped in reducing uncertainty of relational context and more accurately predicting the value of answering/ignoring incoming calls.

7. General discussion

Findings from both field studies corroborate one another in conveying an important message about interruption management namely; the impact of an interruption should not be evaluated based merely on one's local context as viewed by the proponents of the *Interruption Impact Reduction Paradigm*, but also on relational factors concerning the interrupter's context, interruption content and interrupter–interruptee interaction history. In line with *interruption evaluation paradigm*, the findings from the both the qualitative and quantitative field studies consistently demonstrated that users saw utility and satisfaction in this approach when using *Telling Calls*, and expressed the desire to use it in the future. This leads to several theoretical and design implications.

7.1. Theoretical implications

By using a mixture of qualitative and quantitative as well as design instantiation methods we were able to obtain a more complete picture of interruption management in the real world that was hidden by the nature of controlled laboratory and workplace studies.

In many instances we found that our field studies either extended or helped generalize findings from previously controlled laboratory and workplace studies. For example, in a laboratory study, Salvucci and Bogunovich (2010), show people when engaged in a primary task tend to defer processing interruptions until a desirable time. However, the study design determines what is to be considered a primary task and those interruptions are deferrable. Findings from our field studies indicate that when people do not know what an interruption is about, they desire to reduce this uncertainty thus considering the relational context beyond their own local context in making interruption response decisions. In other words, they do not know in many situations if interruptions are deferrable given the limited relational context information. Previous work place studies (Dabbish, 2006; González and Mark, 2004; O'Conaill and Frohlich, 1995; Perlow, 1999; Rouncefield et al., 1994) suggest that decisions to respond to interruptions are often influenced by factors such as interdependencies of work patterns, accountability, responsibility, and reward systems based on crisis management. Appelbaum et al. (2008) highlight the multitasking paradox of interruption benefits where, even though detrimental effects on specific task completion has been observed by previous research, overall organizational productivity was seen to increase by 4% in the United States, in tandem with the multitasking behavior and technology. Russell et al. (2007) showed that email handling strategy under tight deadlines had only 32% ignore emails completely, while 43% continued to check email, suggesting that people looked at factors beyond their immediate deadline tasks. In a recent analysis of 103,962 phone calls it was seen that people were significantly more likely to answer calls when their awareness system indicated that they were busy than when not advertising their availability. This stems from people assuming that the call content must be important if they were called in spite of appearing to be busy to the caller (Teevan and Hehmeyer, 2013). The empirical findings of our field studies not only confirmed that people's interruption management practices involve active decision making using relational context of the incoming call, but also that this behavior is consistent across their dynamically changing social roles in today's blurring boundaries of work and leisure spaces.

7.2. Design implications

Together the user experience as well as usage data from the two studies provide several implications for applications designed to manage interruptions.

1) **Provide user-control in making interruption-handling decisions for receivers**: The field studies of *Telling Calls* use confirmed that previewing relational context information aids in predicting the value of an interruption and, as a result, helps in making an effective and satisfactory decision about how to respond. Even though the effects of interruptions on people's task performance or appropriateness in a social setting may be negative at certain points as predicted by several studies (Iqbal and Bailey, 2005; Fogarty et al., 2005; Salvucci and Bogunovich,

2010), people's decisions to engage in an interruption go beyond that. This calls for the design of tools that aid people in making informed interruption response decisions by reducing the uncertainty of unknown information, rather than trying to reduce the impact of an interruption or make decisions on the receiver's behalf. Significant support for adopting this paradigm has also been expressed by Tolmie et al. (2008) and McFarlane (1999, 2002). Harr and Kaptelinin (2012) stress the need to consider the ripple effects of interruptions that go beyond how an interruption impacts the individual's immediate task in context. That is, people may consider not just how an interruption affects one's local task, but also how it may affect other tasks and interpersonal relations as well. Such an approach suggests that one might benefit from providing relevant information to the interruptees, and letting them be the judges of how the interruption could affect contexts and people beyond the local task at hand. Tolmie et al. (2008) call for moving away from a tool design that focuses on detecting inappropriate instances based on the receivers' local context, and moving towards supporting receivers in appropriately handling interruptions. This design approach is also consistent with paradigms of direct manipulation and control that argue against context–aware and agent technology (Erickson, 2001; Shneiderman, 1983) that bring to light the tension between user control vs. automatic agent control. Our findings provide strong motivation for designs that empower interruptees with the benefits of negotiating an interruption (i.e. to be able to make deliberated and informed response), by providing them control over how they respond to an interruption.

2) **Enable customizable relational context exchange between call partners**: Incorporating real world relationships in our field studies shed light on how the nature of caller – receiver relationship dictates the use of various relational context items in interruption response decision making and is consistent with previous research that has looked at the effect of interpersonal relationships on interruptions (Harr and Kaptelinin, 2007, 2012; Avrahami and Hudson, 2006; Dabbish, 2006). Our findings show that the choice of information shared and desired was influenced by the relevancy of the information and the prior knowledge of whether the information was static or dynamic in that relationship. For example, location information from someone who was not mobile was not useful, call length information was not useful from someone who only made short calls and mood was irrelevant in non-intimate relationships. This has design implications for how relational context information can be customized for effective sharing, effective interruption response decision-making and reduced cognitive load. Designers should consider enabling smart subsets of relational context fields in the interface that vary with interpersonal contacts to facilitate only relevant and meaningful sharing and use of information. This also helps to mitigate information overload for quick interruption response decisions. Prioritizing information displayed in mobile devices is particularly important as the display real estate in these devices is limited.
3) **Enable chunking and consistency of relational context information displayed**: Our findings showed that users found great value in the how relational context information was displayed on the phone interface. Compared to free form unstructured text, users found that the distinct fields allowed for quicker and easier parsing as well as sharing of information. This has implication for how relational context information is displayed on mobile interfaces. Keeping information items distinct and consistent in locations within the phone screen can quickly draw the user's attention to only items they need to share or items they are interested in call handling decisions. Creative combinations of input methods such as a mix of preset menu options as well as small text fields can give user a choice to convey rich information within a particular of relational context item/chunk.
4) **Enable relational context information history and reuse of history**: Our findings show that interruption management goes well beyond response decision making and hence support for using relational context information post calls must be provided. In scenarios where calls were missed or deliberately ignored, users used relational context call history to ground the call they would make. This allowed for one-shot visual display of the relational context on the mobile phone reducing the burden of checking voice mails. Our findings also highlight the need for making this information history reusable. Receivers, for example, should be able to reuse information to return a call suggesting the current call is about the call that they missed while callers should be able reuse information in making a second or a third repeat call when a call is not answered. Together these design features can help users quickly re-engage in call making.
5) **Customize and automatize sharing of relational context information**: While our research focused only on the receiver interface, having users use *Telling Calls* in everyday context highlighted the importance of balancing effort and benefit in designing multi-user role systems (Grudin, 1987, Milewski, 2006). Users in a receiver role valued the increased ability to have effective and focused conversations but in a caller role needed to make an effort ahead of time by filling in the appropriate information to enjoy the same benefit. Thus it is imperative to investigate design features that can improve the caller-side interface design to make the provision of relational context information lightweight and burden free. Several design features discussed above such as customizable smaller subsets of information to be shared based on relationships, chunking of information to be shared and reuse of information shared previously should be key in the caller interface. In addition, where possible, data should be automatically captured but this should be dictated by the nature of relationship with the receiver while giving the caller the flexibility to change or remove the information captured. Developing algorithms that can convert GPS location data to meaningful user generated location names such as “My Office” or “ *Daybreak* Coffee Shop” can aid in effective use of automatically captured data.

7.3. Limitations and future work

One of the key goals of this research was to develop and test the design principles that emerged from a theoretical framework as well as the empirical findings of previous studies (Grandhi and Jones, 2010; Grandhi et al., 2009). Thus we explored people's interruption response behavior in dynamically changing contexts of everyday life. While our work confirmed the validity of the interpersonal interruption response management framework, which highlights the importance of reducing uncertainty of relational context to aid response decision making, the study design choices provided several challenges and limitations that warrant further investigation.

The nature of the population sampled for the empirical studies presented in this research is mostly limited to people with direct or indirect affiliations with a mid-sized research university. The majority of the participants in our studies were students under the age of 35 years, whose cell phone handling practices may have unique characteristics when it comes to interruption response decision making. The nature of their relationships (mostly social and intimate), their life styles, and the people with whom they interact, deeply influence what constitutes their local context, as

well as the nature of relational context information they employ in their call handling decisions. Lab experiments (Dabbish, 2006) have shown that there is value in providing team identity, and the importance of the interruption in making interruption response decisions in goal oriented tasks. Thus, further work in a wider range of social and organizational contexts as well as relationships (such as work colleagues, strangers, service providers) is required to understand the choices made in the information shared and used before generalizing the findings of this research to other demographics.

Only a handful of studies have looked at how and what information is used by people to make telephone call handling decisions. Even though the participants in our study had the same study partners throughout, the relational context shared varied for several reasons as noted in our qualitative data. In particular there is great value in exploring what the correlation is between relational context factors revealed explicitly and other unrevealed relational context factors implicitly derived by the receiver. Such an understanding has implications for what and how information is solicited from the caller at the time of call. This also calls for greater exploration of strategies that can explicitly focus on the interrupter interface as compared to receiver side interface as done in this research.

While participants reported various ways in which they used the relational context information received in their call handling decision making processes, no one reported concerns of trusting/distrusting this information. This could be because all participants were either friends or family members where their levels of trust of the information received were merely a reflection of their trust in the relationship at large. However, in case of device theft or loss, one could foresee potential privacy and security breaches of personal relational context information recorded on these devices. Furthermore, it would be interesting to explore how trust of relational context shared varies in non-social and non-intimate relationships. Future work focusing on understanding user trust, and security/privacy in sharing of relational context can help build systems that promote social and emotional safety.

Running in-situ studies in the field over several weeks not only provided great value and insight in understanding interruption response behavior in everyday life situations, but also highlighted the complexities and challenges in executing, implementing and analyzing the data acquired. Experience sampling methodology (ESM), has the inherent drawback of burdening the participants to provide repeated data over several days (Csikszentmihalyi and Larson, 1987; Hektner et al., 2007). We tried to minimize physical and cognitive effort for the participants to provide data by using smaller set of survey questions with single item nominal measures as well as simplified ESM tool interface and interaction design. In spite of this, since the surveys were programmed to be triggered at the end of each call, participants may have altered their calling making and call handling patterns that affected the quantity of data gathered for deeper analysis. However we believe our mixed methods approach to gathering data not only provided mutually corroborating evidence to our findings but collectively provided insights that were greater than the sum of the parts.

Finally the theoretical framework proposed to understand interpersonal interruption response management in technology-mediated communication, is validated specifically within the domain of cell phone call handling. The theoretical framework will require further validation when extended to other communication technology. However this work highlights the importance of conducting interruption research that involves users in their everyday context to understand their motivation and behavior. The mixed methodology adopted in this work as well as the findings of the empirical studies conducted not only provided a comprehensive theoretical understanding of interruption management behavior but also practical insights for how to design technology for interruption management in technology mediated communication.

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Appendix

See Tables 1–10.

Table 1
Amount of relational context (RC) information provided.

Number of RC items provided	Frequency (N=248)
1	39 (15.7%)
2	14 (5.6%)
3	32 (12.9%)
4	20 (8.1%)
5	21 (8.5%)
6	16 (6.5%)
7	33 (13.3%)
8	50 (20.2%)
No RC provided	23 (9.3%)

Table 2
Frequency of relational context items provided (N=248).

Relational context items	Provided	Not provided
Subject	182 (73.4%)	66 (26.6%)
Location	188 (75.8%)	60 (24.2%)
Activity	129 (52.0%)	119 (48.0%)
Call length	109 (44.2%)	139 (56.0%)
Who caller is with	111 (44.8%)	137 (55.2%)
Urgency	121 (45.4%)	127 (51.2%)
Importance	121 (48.8%)	127 (51.2%)
Mood	122 (49.2%)	126 (50.8%)

Note: The total number of *Telling Calls* recorded on the devices (249), was different from the number of ESM surveys answered (248), to provide this data.

Table 3
Relational context not provided because caller did not want to reveal.

Relational context items	Not provided because did not want to reveal (N=248)
Subject	31 (12.4%)
Location	48 (19.3%)
Activity	42 (16.9%)
Call length	29 (11.6%)
Who caller is with	44 (17.7%)
Urgency	22 (8.8%)
Importance	30 (12.0%)
Mood	34 (13.7%)

Table 4
Relational context not provided because information not useful to receiver.

Relational context items	Not provided because not useful to receiver ($N=248$)
Subject	26 (10.4%)
Location	37 (14.9%)
Activity	58 (23.3%)
Call length	63 (25.3%)
Who caller is with	56 (22.5%)
Urgency	35 (14.1%)
Importance	33 (13.3%)
Mood	44 (17.7%)

Table 9
Correlation between knowledge of relational context when provided in *Telling Calls* and PIV inaccuracy.

	Telling Calls ($N=125$)
Subject	rho$=-.263$, $p=.003$
Location	rho$=-.127$, $p=.158$
Activity	rho$=-.067$, $p=.461$
Call length	rho$=.057$, $p=.528$
Who caller is with	rho$=-.030$, $p=.738$
Urgency	rho$=-.089$, $p=.321$
Importance	rho$=-.048$, $p=.593$
Mood	rho$=.073$, $p=.421$

Table 5
Relational context known (certain about) for calls received.

	Regular calls ($N=268$)	*Telling Calls* ($N=177$)	*Telling Calls* in which information is received	*Telling Calls* in which information is not received
Subject	29.5%	53.7%	70.7% ($N=99$)	40.6% ($N=32$)
Location	26.9%	52.0%	70.9% ($N=103$)	25.0% ($N=28$)
Activity	14.2%	32.8%	58% ($N=69$)	12.9% ($N=62$)
Call length	3.4%	21.5%	52.5% ($N=61$)	7.1% ($N=70$)
Who caller is with	6.7%	17.5%	42.6% ($N=61$)	5.7% ($N=70$)
Urgency	7.1%	20.9%	55.4% ($N=56$)	6.7% ($N=75$)
Importance	7.5%	23.2%	50.0% ($N=64$)	10.4% ($N=67$)
Mood	11.2%	20.3%	52.4% ($N=63$)	2.9% ($N=68$)

Table 6
Wilcoxon's signed-rank test for uncertainty in regular vs. Telling Calls.

	Regular calls vs. *Telling Calls* with information	Regular calls vs. *Telling Calls* without information
Subject	$Z=-3.66$, $p<.000$, $N=23$	$Z=-1.1$, $p<.273$, $N=4$
Location	$Z=-3.71$, $p<.000$, $N=23$	$Z=-1.6$, $p<.109$, $N=4$
Activity	$Z=-3.18$, $p<.001$, $N=15$	$Z=-1.48$, $p<.014$, $N=7$
Call length	$Z=-3.31$, $p<.001$, $N=14$	$Z=-1.60$, $p<.109$, $N=3$
Who caller is with	$Z=-2.86$, $p<.004$, $N=11$	$Z=-1.45$, $p<.148$, $N=4$
Urgency	$Z=-3.47$, $p<.001$, $N=16$	$Z=-.37$, $p<.715$, $N=4$
Importance	$Z=-3.41$, $p<.001$, $N=16$	$Z=-1.84$, $p<.066$, $N=4$
Mood	$Z=-3.12$, $p<.002$, $N=13$	$Z=-.45$, $p<.655$, $N=2$

Table 7
Relational context unknown and desired.

	Regular calls ($N=268$)	*Telling Calls* ($N=177$)	Wilcoxon signed-rank test for regular calls vs. *Telling Calls*
Subject	31.7%	16.4%	$Z=-2.66$, $p<.008$, $N=28$
Location	45.5%	23.7%	$Z=-1.99$, $p<.046$, $N=28$
Activity	31.7%	24.9%	$Z=-.90$, $p<.370$, $N=28$
Call length	11.9%	5.6%	$Z=-1.16$, $p<.245$, $N=28$
Who caller is with	17.9%	15.3%	$Z=-.66$, $p<.507$, $N=28$
Urgency	23.5%	18.6%	$Z=-.38$, $p<.704$, $N=28$
Importance	29.1%	20.9%	$Z=-.73$, $p<.466$, $N=28$
Mood	20.5%	21.5%	$Z=-.02$, $p<.986$, $N=28$

Table 8
Correlation between knowledge of relational context and PIV inaccuracy in Regular Calls Vs. Telling Calls.

	Regular Calls ($N=244$)	*Telling Calls* ($N=125$)
Subject	rho$=-.140$, $p=.029$	rho$=-.327$, $p<.000$
Location	rho$=-.060$, $p=.349$	rho$=-.072$, $p=.423$
Activity	rho$=-.056$, $p=.380$	rho$=-.115$, $p=.202$
Call length	rho$=-.030$, $p=.643$	rho$=-.020$, $p=.825$
Who caller is with	rho$=-.106$, $p=.098$	rho$=.017$, $p=.855$
Urgency	rho$=-.008$, $p=.905$	rho$=-.123$, $p=.171$
Importance	rho$=-.032$, $p=.622$	rho$=-.064$, $p=.482$
Mood	rho$=-.153$, $p=.016$	rho$=.055$, $p=.544$

Table 10
Perceptions of telling call before and after 1 week of use for receivers and callers.

	Behavioral intention to use (BIU) 2 items (Scale: 2–14)	Perceived enjoyment (PE) 3 items (Scale: 3–21)	Perceived usefulness (PU) 4 items for receivers (Scale: 4–28) 3 items for callers (Scale: 3–21)	Perceived ease of use (PEU) 4 items (Scale: 4–28)
Receivers before	$M=11.20$, SD=2.11, 95%CI [10.03–12.36]	$M=16.20$, SD=4.07, 95%CI [13.94–18.45]	$M=22.13$, SD=4.34, 95%CI [19.72–24.53]	$M=23.46$, SD=3.79, 95%CI [21.36–25.56]
Receivers after	$M=10.53$, SD=2.97, 95%CI [8.88–12.17]	$M=14.93$, SD=4.66, 95%CI [12.34–17.51]	$M=22.60$, SD=3.62, 95%CI [20.59–24.60]	$M=22.33$, SD=6.20, 95%CI [18.89–25.77
Callers before	$M=11.46$, SD=2.26, 95%CI [10.21–12.72]	$M=16.6$, SD=3.97, 95%CI [14.39–18.8]	$M=21.73$, SD=5.04, 95%CI [18.83–24.52]	$M=24.06$, SD=3.36, 95% CI [22.20–24.93]
Callers after	$M=10.86$, SD=2.79, 95% CI [9.31–12.41]	$M=15.13$, SD=4.40, 95%CI [12.69–17.57]	$M=22.06$, SD=3.43, 95%CI [20.16–23.96]	$M=21.46$, SD=5.55, 95% CI [18.39–24.64]

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