Interruption Management and Telephone Call Screening

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Notification-oriented computer interfaces are growing in importance, as is our understanding of how users manage interruptions. To gain insights relevant to the design of such interfaces, this study explored telephone call screening as a common example of how people manage technology-driven interruptions in their everyday residential environment. Survey results showed that audio screening is a frequent and regular practice, often used as part of an active, multicue strategy for managing interruptions. Frequent screeners estimated knowing more about the call before engaging in social interaction and were more selective when answering. Screening was viewed as an effective means of managing interruptions because screened, unanswered calls were rated as less disruptive of ongoing activities than calls that were answered. These findings on how people manage telephone call interruptions provide insights for designers of notification systems. First, audio alerts can be highly effective, especially in residential settings. Second, alerts need not be simple to be effective; they can usefully include rich information that clarifies how to respond to the interruption. Finally, informative alerts offer a situated alternative to "presence publishing" interfaces.

1. INTRODUCTION

In the field of human–computer interaction, there is currently great interest in the design of notifications and alerts and in the consequences of interrupting users while they are performing tasks (Horvitz, Koch, & Apacible, 2004). The motivation for this interest includes the growing prevalence of synchronous communication systems, especially instant messaging (IM) and alerting services, such as Microsoft .NET™ Alerts. Several researchers have argued that these notifications and interruptions require a switch in focus for user interface designers, from interfaces for user-initiated and controlled activities toward a new kind of interface where users must integrate their own ongoing activities with those that are computer initiated (e.g., McCrickard & Chewar, 2003).

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Recent research has suggested that careful design of interrupting notifications can determine their effectiveness for computer interfaces and in other domains such as cockpit and flight deck environments (McFarlane & Latorella, 2002). Users' performances on ongoing tasks are often disrupted by incoming notification (Adamczyk & Bailey, 2004; Cutrell, Czerwinski, & Horvitz, 2000), but how efficiently and effectively the interruption is handled by users depends on characteristics of the notification as well as task characteristics. For example, Latorella (1999) found that individuals initiate the handling of auditory interruptions more quickly than visual interruptions and that auditory interruptions were more disruptive to ongoing performance, although interruption modality effects also depend on task modality in complex ways. Notification timing and response requirements are also important factors. For example, interruptions are less disruptive if delayed until intertask periods or natural break points (Adamczyk & Bailey, 2004; Czerwinski, Cutrell, & Horvitz, 2000). Finally, a key characteristic determining the disruptive effects of alerts has to do with response requirements. McFarlane (1999) delineated four situations: (a) *Immediate interruption* requires the recipient to respond without delay, (b) *negotiated interruption* involves an announcement that an interruption is needed and then lets its recipient negotiate when and how the interruption will be dealt with, (c) *mediated interruption* allows for a third party (e.g., an agent) to receive the interruption and plan a response, and (d) *scheduled interruption* restricts interruptions to prearranged times. McFarlane found that negotiated interruptions resulted in the best performance except when extreme timeliness was critical.

Much of the past research on interruption has been done in a carefully controlled, dual-task paradigm where participants are engaged in one specific, ongoing task and the demand characteristics for responding to a notification are high. Moreover, the majority of recent studies have concentrated on visual alerts in a desktop computing context. This research has yielded important insights about interruptions at a microlevel of memory load and basic cognitive processing. McCrickard, Czerwinski, and Bartram (2003) suggested that the investigation of notification management must broaden to include "as much of the human information awareness need domain as possible" (p. 513). Broadening includes moving beyond the computer desktop but also could include a fuller understanding of how the basic processes are utilized in a wider range of everyday environments. In everyday, natural settings, it is likely that an additional factor influencing users' reactions to interruption includes the goal-oriented strategies users adopt to deal with distraction (Latorella, 1999; McCrickard & Chewar, 2003). For example, Czerwinski, Horvitz, and Wilhite (2004), in a diary study of office work, reported frequent and deliberate task-switching activities. Residential interviews and self-reports by Nagel, Hudson, and Abowd (2004) revealed that participants' willingness to handle interruptions varied across individuals with their current location in the home as well as with their current activity.

Over the past several decades, one of the most prominent scenarios for interruption is clearly the telephone call. The average business day is filled with a significant number of telephone-related interruptions (Czerwinski et al., 2004; O'Conaill & Frohlich, 1995). Residential telephone users are also often inundated with calls (Lacohée & Anderson, 2001), and in a series of studies of residential telephony us-

age, Gillard, Bow, and Wale (1995) determined that the single most critical issue for residential telephone users is "access management," which includes protecting oneself from constant interruption by unwanted calls.

In its simplest form, the telephone call is far from a perfect notification. The ringing of the telephone signifies that some potentially important event is occurring—namely, that someone wants to communicate. To determine the true importance of the event compared with ongoing activities, the recipient of the notification has to answer the call directly and engage in social interaction. Doing so can be taxing in terms of social effort and has a large impact on whatever behavior was ongoing when the interruption occurred. Those that do not respond to the notification may have no way of ever determining whether they should have responded. A person engaged in some critically important task when the phone rings is faced with this dilemma, and common experience shows that people generally respond to this notification.

The standard telephone ring, because it demands a high-overhead response, could be classified as an immediate interruption according to McFarlane's (1999) taxonomy, and this type of interruption has significant disruptive effects on the performance of ongoing activities. In the telephony domain, there are alternative methods for handling incoming calls—audio call screening is one of them (Gillard et al., 1995; Lacohée & Anderson, 2001). Audio call screening is more similar to McFarlane's negotiated interruption, which is superior to other types of interruption in that it causes less disruption. With audio call screening, the caller indicates that a conversation is desired by adding verbal information about the incoming call that can help the recipient determine its priority without engaging in social interaction. Generally, this audio information is played out loud while being captured as a message with a telephone answering machine.

The similarities of audio call screening with negotiated interruption are significant. First, no immediate response is required when audio screening, other than listening to the message. Indeed, audio screening does not even require close proximity to the telephone. It can be argued that listening to the audio message entails cognitive overhead in itself, but the relatively low overhead of listening can be used to manage the much higher overhead of social interaction required to engage in the call. Trade-offs between the disruptive aspects of interruptions and their critical information value have been recognized in both theory and empirical findings on interruptions (McCrickard, Chewar, Somervell, & Ndiwalana, 2003). Second, the recipient of a screened call has control over if and when the interruption is handled, and this control is situational (Suchman, 1987). With no prior planning and based on the immediate context, users can decide whether the alert is important enough to allow further interruption by responding to it.

Finally, in the case of audio screening, negotiation of the interruption is indirect and asynchronous. The recipient's side of the negotiation consists of deciding to answer the call or not. The caller's side consists of providing a potentially rich array of information describing the nature of the call. During audio screening, for example, a caller is likely to indicate his or her identity and the reason for calling. An indication of the caller's own future availability might also be included. This direct information is only part of the message, however. The voice quality of a verbal message often indicates its emotional content (Yang, 1996), so that recipients may de-

tect, for example, its friendliness versus tension. Finally, callers may even indirectly infer both urgency and call length. All of these cues provide information useful in deciding whether to answer the call. If one were to create a continuum of information richness, audio screening would be an example of highly "informative alerting" compared with other alerts such as the telephone ring. It is this informative alerting that gives recipients the control to manage further prolonged interruption with only the small overhead of listening. Therefore, informative alerting is one of the key aspects of similarity between audio screening and negotiated interruption.

Given the similarity to the highly efficient negotiated interruptions, one might expect that call screening would reduce the perceived disruption of telephone calls and be used frequently as part of telephone users' interruption management strategies. McFarlane's (1999) categorization of interruption types was initially intended only as a framework of system design alternatives, and there has been little study of how these interruption types interact with the strategies users develop for dealing with interruptions. Nonetheless, one might expect that, given the choice, users would incorporate more efficient interruption types into their activities and that audio screening would be an example. However, beyond the basic finding that telephone users do screen calls (Gillard et al., 1995; Lacohée & Anderson, 2001), little is known about it. For example, there is no normative data indicating how often people screen calls or what information they concentrate on when they do. It is also not clear how disruptive telephone calls are to daily activities and to what degree audio screening influences the disruption. Similarly, little is known about the communications aspect of screened calls: How do recipients use information to negotiate conversations, and what are the social implications of call screening?

The exploratory study of audio call screening presented here has the goal of better understanding how informative alerting is used to manage interruptions and negotiate communications during everyday activities. The study investigates the frequency, motivations, and basic characteristics of audio call screening. In addition, because the particular interruptions handled by call screening are of a strongly social nature, this study also explores the social acceptability of screening.

2. METHOD

A Web-based questionnaire was sent to 700 employees of a large telecommunications company. Employees were chosen randomly from the corporate directory with the restrictions that they be employed within the United States. An e-mail invitation describing the survey was accompanied by a link to the online survey. The only reward for responding was the chance of winning a drawing for one $35.00 gift certificate; the response rate was 27%. The 187 respondents were distributed among technical, marketing, and administrative staff positions. There were 109 women and 78 men. Mean age was 43.2 years (SD = 9.3 years).

The survey consisted of 26 items and was estimated to take approximately 5 to 10 min to fill out. Survey items were developed to obtain direct feedback from respondents about the degree to which audio screening is used as a regular and effective interruption management technique. The issues these items probed included

the frequency of screening, reasons for screening, the information utilized while screening, and the disruptiveness of answered telephone calls and audio-screened telephone calls. Additional survey items probed the social acceptability of audio screening and recipient demographics. Some survey items had constrained responses and were automatically compiled; other items allowed open-ended responses. Not every item was completed by every respondent.

3. RESULTS AND DISCUSSION

Survey results were analyzed and organized around the following key questions regarding call-screening behavior.

3.1. How Frequently Do Telephone Users Auditorily Screen Calls?

Of 187 total respondents, 147 (79%) reported having an answering machine. The preponderance of answering machines was in a residential setting. Of those with answering machines, 83% were situated in residences, whereas 15% were in offices. Three percent of the respondents reported having answering machines in both locations.

Of the respondents with answering machines, 104 (71%) reported engaging in audio screening for at least some calls, with about one third screening more than half their calls. Across all screeners, the mean estimated percentage of calls screened was 46.2%, but there was a good deal of variation between respondents in estimated screening frequency. Indeed, the distribution of audio-screening frequency, shown in Figure 1, was strongly bimodal, suggesting two classes of respon-
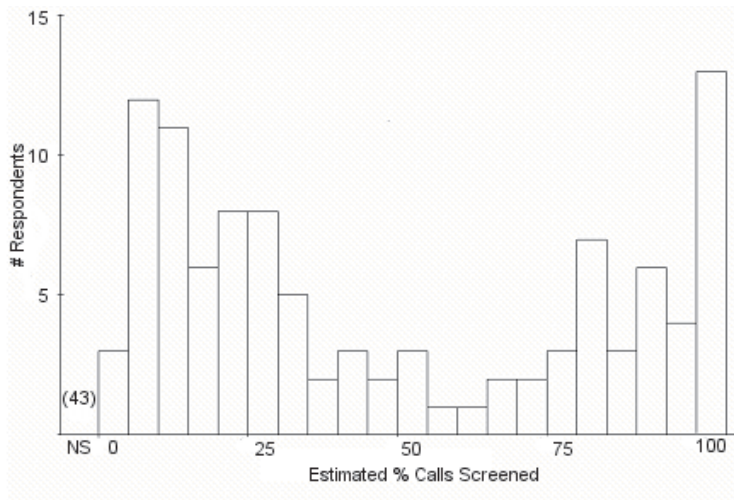

FIGURE 1   Screening frequency.

dents differing in their screening behavior: frequent screeners and infrequent screeners. For subsequent analyses, these two groups were divided according to a median split across the "% calls screened" dimension (*Mdn* = 33).

The two groups differing in estimated screening frequency also differed in several other measures, suggesting different interruption management strategies (see next) but were not found to differ in demographics (i.e., age, gender).

3.2. Why Do Telephone Users Screen?

Virtually all of the respondents that do screen (92%) report audio screening specifically to decide whether to answer the call. This, for example, compared with simply capturing the caller's message or as a way to fill time while getting to the telephone.

The fact that screening is part of an active interruption management strategy is bolstered by differences between frequent and infrequent screeners. Specifically, frequent screeners estimated not answering a larger percentage of calls because of something heard in the screened message. Overall, rejection rates were correlated with the percentage of calls screened, $r(98) = .22$, $p < .05$, and the two groups differed significantly, $t(98) = 2.19$, $p < .05$. The rejected messages were still recorded as voice messages, but frequent screeners were more selective in deciding to engage in interactive conversation. Moreover, frequent screeners had a higher estimated percentage of knowing, before answering, who the caller was, $t(96) = 2.149$, $p < .05$, and what the call was about, $t(87) = 1.74$, $p < .075$ (marginally significant).

Ninety-seven percent of the respondents reported that receiving unwanted telephone calls was an intrusion and disrupted their ongoing activities. Thirty-nine percent reported "hating it," 23% categorized unwanted calls as "a lot of trouble," and 35% said they were a minor inconvenience. Only 3% viewed unwanted calls as "no trouble at all." There were no differences between frequent and infrequent screeners in their judgment of unwanted calls. The perceived intrusiveness of unwanted calls varied with the amount of work they require, possibly because more answering activity interrupts and interferes more with ongoing tasks. Participants were asked about the intrusiveness of unwanted calls when they answered them versus when they did not answer them. The distributions of responses about intrusiveness were significantly different, with the intrusiveness of unwanted but unanswered calls much lower, $\chi^2(3, 186) = 53.2$, $p < .001$. For example, 20% of respondents viewed these to be "no trouble at all," and 52% considered them to be only a minor inconvenience. Finally, when asked about the intrusiveness of listening to audio screening, 60% indicated that listening to audio screening was an intrusion, whereas 40% viewed this as not at all intrusive or disruptive. Frequent screeners judged audio screening to be less intrusive and disruptive than did infrequent screeners, $t(102) = 2.73$, $p < .01$.

In summary, telephone users appear to screen because it is a relatively easy and effective way to manage interruptions. The prevalence of unwanted calls and the major concern with finding effective ways of managing them is consistent with past findings that access management is a major residential concern (Gillard et al.,

1995; Lacohée & Anderson, 2001). Moreover, the perception that screened calls are less disruptive than answered calls is consistent with the view that audio screening shares important characteristics with McFarlane's (1999) negotiated interruptions. McFarlane found better performance and less disruption when participants were given negotiated compared with immediate interruptions. In the study presented here, respondents have a choice of immediately answering the telephone or using audio screening to decide whether to answer. The fact that a significant proportion of telephone users choose to screen suggests that they have incorporated the efficiency of negotiated interruptions into their interruption management strategies. Moreover, the observation that those who perceive audio screening to be less disruptive also screen more may further suggest a deliberate strategy.

3.3. What Information Is Used During Screening?

Respondents were asked to rate, on a 7-point scale, the importance of the several categories of information they might obtain while screening. These categories were developed prior to the survey during informal interviews conducted with several colleagues. These colleagues were asked to speculate about what information might be available in an audio screening. They are caller's name, reason for call, caller's telephone number, urgency of call, length of call, recipient of the call, and emotional impact. Ratings ranged from 7 (*almost always important*) to 1 (*rarely important*). Rating results are shown in Figure 2 averaged across all respondents.

There was a strong effect of information category, $F(6, 101) = 91.6$, $p < .01$. The results of Wilcoxon pairwise tests reveal several differences in rated importance. Caller's name or identity was most important. It was rated significantly higher in importance than each of the others. Urgency of the call was next, rated significantly
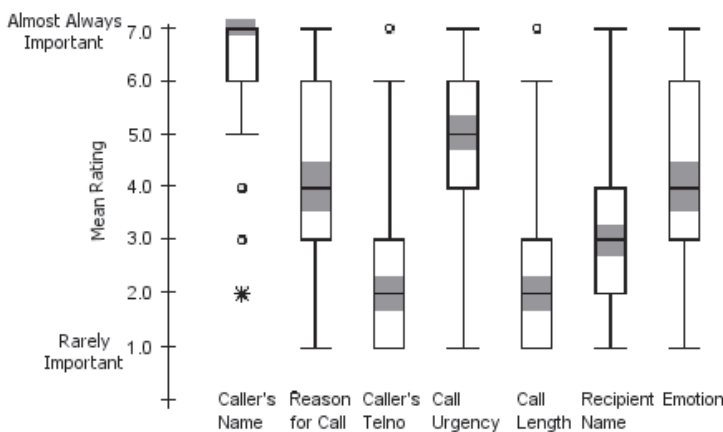

FIGURE 2   Seven-point importance rating for information obtained while screening.

more important than either reason for the call ($z = 3.98, p < .01$) or emotional impact ($z = 4.19, p < .01$), although still less important than the caller's identity ($z = 4.87, p < .01$). There were no statistical differences between reason and emotion. The recipient of the call[1] was rated next in importance; its rating was less that either reason ($z = 4.16, p < .01$) or emotion ($z = 4.05, p < .01$) but higher than caller's telephone number ($z = 3.26, p < .01$) and length of call ($z = 4.02, p < .01$).

The caller's telephone number and the estimated length of the call were rated least important.

Rating data were similar to qualitative answers about what it is that makes users pick up a call or not, after screening. Seventy-two percent of respondents (73 of 102) mentioned the caller's identity only. Of these, 5 respondents described making a simple determination of whether the caller was a telemarketer. Six percent mentioned only the reason for the call, and 14% mentioned both caller's identity and reason for calling for deciding to answer. This means 20% were concerned with the reason for the call as a factor in answering calls. A substantial number of responses also indicated that their behavior depended on call context, such as the time of day, ongoing activities, and so on.

Given the importance of context and the primacy of callers' identity, another way of determining the importance of other information is to ask "Once you have heard who is calling, how often do you wait to hear the reason for the call?" To this question, only 12% said they never waited to hear the reason for the call before picking up; 88% apparently used the reason for the call at least occasionally in deciding to answer (Figure 3). Although only 3% reported always waiting, 24% reported usually waiting to hear the reason of the call before picking up. Sixty-two percent seldom waited.

Frequent screeners and infrequent screeners had very similar information-gathering patterns. Rankings of importance across information type did not differ for the two groups, and the likelihood of waiting for the reason for the call after hearing the caller's identity was the same for frequent screeners as for infrequent screeners.

Across all screeners, information about caller identity and reason for the call were estimated to be detected quite accurately, although not perfectly. Respondents indicated that, after screening, they had a good sense of who was calling a mean of 79.2% ($SD = 27.3$) of the time ($Mdn = 90\%$) and, similarly, that they could predict the reason for the call a mean of 75.3% ($SD = 29.0$) of the time ($Mdn = 90\%$). One of the reasons these predictions were not higher was that, according to several respondents, telemarketers often purposely do not make their identity clear until after a human answers the call.

In summary, caller identity appears to be the most critical piece of information gathered while screening by far. However, the reason for the call as well as other contextual factors, such as emotional impact, urgency, and so forth, is also important. This pattern of behavior for telephony conversations is much like the beginning of conversations in a face-to-face setting and is consistent with the notion that

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[1]Information about the call recipient could be useful in a household situation where there are several potential recipients sharing a line.
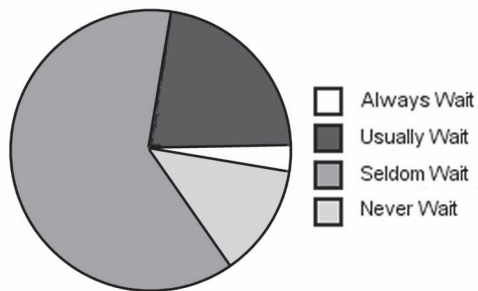
FIGURE 3 Estimated likelihood of waiting to hear reason for call before answering.

conversation "starts" on the telephone are negotiated in a way that is analogous to when one is interrupted by someone who desires a face-to-face conversation (Clark, 1996).

3.4. How Do Telephone Users Screen?

Those respondents that did screen reported having their answering machines set to an average of 3.92 rings. The majority of respondents had machines set to 4 rings, but 11 (of 104) had them set to 2 rings. These respondents were evenly distributed across the range of proportion of calls screening, making it unlikely that these respondents consciously had set their equipment to facilitate screening. Indeed, the number of rings was not a reliable predictor of any screening behavior. Frequent and infrequent screeners did not differ in this measure, and even those that reported screening 100% of their calls were evenly distributed across the range of ring settings. It is not clear if this similarity across groups reflects a failure to consciously plan for screening or simply not knowing how to modify ring settings in what is often an obscure answering machine user interface.

The survey question "How long do you screen" was open ended and could be answered with either a number or a text phrase. Seventy-two percent of respondents answered with a numeric duration estimate, and the mean estimate was 4.46 sec (*Mdn* = 3 sec). There was a small difference in listening duration means between frequent screeners (5.1 sec) and infrequent screeners (3.7 sec), but the difference was not significant and resulted from very long durations reported by two frequent screeners.

Survey responses indicated an interesting interaction between audio screening and screening with caller ID displays. Fifty-seven percent of all respondents reported having and using caller ID display devices. Those respondents with caller ID devices were no less likely to engage in audio call screening than those without caller ID devices. In fact, those respondents with caller ID service reported audio screening a significantly larger percentage of messages (48.5%) than those respondents without caller ID service (29.6%), $t(94) = 2.82$, $p < .01$. Consistent with this, re-

spondents with caller ID service were also more likely to be categorized as frequent screeners.

The estimated number of calls screened was the same for auditory screening (38.6%) and screening with caller ID service (41.3%). One interpretation is that respondents with caller ID service and answering machines used both kinds of information. It is not clear from the data if these are used in parallel or by some other strategy. In open-ended answers, five respondents explicitly said they engaged in audio screening only if the caller ID display failed to show a number. Respondents with caller ID rated the visual caller ID to be significantly less intrusive than audio screening, $t(103) = 6.4$, $p < .01$. However, several respondents noted that a significant advantage for audio screening in the residential setting was that it could be conveniently used from any room in the house.

3.5. How Is Call Screening Viewed?

Screeners were asked to compare their own likelihood of screening incoming calls with the likelihood that calls they initiate are screened by others. Both frequent and infrequent screeners estimated the likelihood of being screened as less than their own screening frequency (Figure 4). The overall estimate of screeners being screened was 28.5% (i.e., frequent and infrequent screeners averaged together). This was a relatively accurate reflection of the likelihood of actually being screened. If all respondents with answering machines are taken into account regardless of whether they screen, the total screening frequency was 32.6%. Frequent screeners tended to overestimate screening, whereas infrequent screeners underestimated screening. In summary, although participants' own screening behavior slightly biased their perceptions of how often other people screen, their estimates generally matched reality.
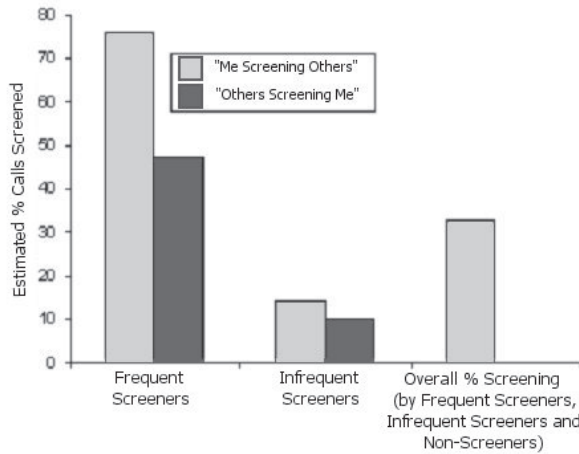

FIGURE 4   Estimated percentage of screening and being screened.

The social acceptability of screening has often been questioned (Martin, 1996). However, out of all respondents that screen, only one respondent considered their own screening to be "always rude." Seventy-six percent considered their own screening to be "never rude," and the remaining 23% responded that it depended on whom they were screening. There were no significant differences between frequent and infrequent screeners.

Similarly, when all respondents were asked if it was rude for other people to screen them during a call that they initiated, 79% responded that it was not rude, whereas 21% thought it was. There were no differences between respondents who screened and those who did not screen.

Despite strong agreement among screeners that screening is not rude, screeners virtually never revealed to people calling them that their calls might be screened. Only 3 of 104 screeners reported indicating in their answering machine greeting that the call might be screened. This tendency to leave the situation ambiguous may indicate some doubt over screening's social acceptability, although it could also indicate a courtesy to the caller. Adding this warning to a greeting increases its duration and complexity, as it might or might not be true for any specific call.

4. CONCLUSIONS

Notification-based interfaces and interruption management has received a great deal of attention in the office desktop environment. This study set out to understand telephone screening with the intention of drawing insights about informative alerting and extending our appreciation of interruption management to the residential environment. The survey data clearly showed that unwanted telephone calls are a common occurrence and that they pose a serious inconvenience and disruption of recipients' ongoing tasks. Just as Gillard et al. (1995) reported, access management is a major household concern, and just as in the workplace (e.g., Czerwinski et al., 2004), there is a need for interruption-management tools coupled with a useful strategy. In the home, the residential answering machine and audio call screening are common elements of that strategy. Audio screening is a common practice that is performed regularly by a significant subset of telephone users.

These data show that audio screening is not considered to be as disruptive as an uninformative call alert (e.g., "ring") that requires social interaction to respond to. This is consistent with theoretical models of interruption and notification (McFarlane, 1999), which show that the least disruptive alerts are those that do not require an immediate response, provide the recipient with a degree of control over when they are handled and therefore have minimal effect on ongoing tasks. Audio screening has these characteristics in common with McFarlane's negotiated interruptions, and it is interesting to note that in both cases there is cognitive overhead associated with the interruption. It has been shown that the cognitive overhead associated with interruptions can result in degraded performance in a variety of tasks (Cutrell et al., 2000; Czerwinski et al., 2000). However, the trade-off of an interruption's cognitive overhead compared with its information value is critical

(McCrickard et al., 2003), and the finding that audio screening is a common activity suggests that its value is high.

An interesting suggestion from the findings presented here is that screening may be part of an active, deliberate strategy for negotiating interruptions. This is evidenced by the fact that those who screen more are more selective in answering calls, feel they know more about the call prior to interacting with the caller, and judge audio screening as less disruptive. Indeed, audio screening may often be just part of an interruption-management strategy that can also include caller ID technology because their use overlaps.

It has recently been shown (Hudson, Christensen, Kellog, & Erickson, 2002) that corporate research managers have a complex relationship with communications that interrupt workday activities. On one hand, these interruptions are viewed as an irritation that decreases the efficiency of ongoing tasks, but at the same time they are understood to be necessary in order to keep up with new information. In other words, users are aware of the trade-offs associated with interruptions. These findings are consistent with and extend this view. Several respondents indicated that the cognitive overhead associated with interrupting ongoing activities to screen a call was preferable to the alternative of not screening and either (a) missing an important call or (b) answering the call and risking being forced into social interaction of potentially much greater overhead. It appears that people in both management and residential settings understand the value of these interruptions and actively develop strategies to make use of them.

Compared with many kinds of computer-based notifications, telephone call screening provides a much richer stimulus. The rich set of information that is delivered directly from a speaking human can potentially be used to analyze the importance of the notification along dimensions of content, emotional impact, and urgency. The data presented here suggest that when telephone users screen calls, they do, in fact, utilize several of the potential cues. The identity of the caller is rated as the most critical, but respondents report utilizing other characteristics of the call as the situation requires. The reason for the call doubtlessly comes from the verbal content, whereas the urgency of the call and emotional impact may be extracted from other vocal characteristics. The caller's telephone number was rated as surprisingly unimportant compared with other cues, but this may be due to the joint use of caller ID services along with screening as part of many interruption management strategies. However, the general conclusion is that users utilize a wide array of information in deciding whether to react to a notification.

Although these findings suggest that audio screening represents an effective way to negotiate communications, there are aspects that could prevent attitudes toward it from being universally positive. In this paradigm, the initiators of communication (i.e., callers) are required to provide information that is filtered by recipients. It is unlikely that negative attitudes in this case are the result of a work–benefit mismatch between caller and recipient (Grudin, 1987), because the work involved in the caller leaving a message benefits the caller by increasing the chances of reaching the recipient (either immediately or later). It is more likely that there are issues of social control when the caller feels that his or her priority is being judged by the recipient. In the study presented here, a small number of respondents indicated

negative attitudes toward screening, but respondents generally claimed that screening is not considered to be rude. The finding that few respondents admit to callers that their calls may be screened could suggest either that screening may not be viewed as entirely acceptable or that respondents are hesitant to impose on callers with longer, more complex greetings. In either case, there may be a need to explore techniques for obtaining information about the call from the caller that are streamlined and inoffensive.

These results from telephone call screening have practical implications for the design of notification systems in general. First, they suggest that audio alerts can be very useful. Not only can they support rich information, but they can be dispensed with quickly because of their transient nature. Informative audio alerts may be especially useful in residential settings because they can be heard at a distance. This would suggest that even for personal computer (PC) applications, carefully constructed auditory alerts may be effective notifications in the residential environment where users may not spend lengthy periods of time in front of a visual display.

Second, the results suggest that alerts need not be simple to be effective. Some studies suggest presenting simple "warnings" with little information prior to presenting notification content (see McFarlane & Latorella, 2002). However, this conclusion may apply best to contexts with high memory requirements and has more to say about the ordering of information than its amount. Indeed, these results suggest that residential alerts can be particularly useful when they provide a significant amount of information that clarifies for the user how best to respond to the alert. In telephone call screening, this includes caller identification, purpose, emotional content, and so on. In other applications, the appropriate information may depend on other factors, but the point is that useful alerts need not be limited in information content. Consistent with earlier theory (McFarlane, 1999), alerts can be efficient if the cognitive overhead required to process the alert is small compared with that required to respond to it. Informative alerts may require more attention than simple ones but are still attractive if they can prevent further work.

It should be noted that audio call screening itself can benefit from design improvements. Although the informative alert is effective, it is also time consuming to wait for the telephone to ring several times, then to wait for the greeting, and then to listen to the caller's message. One solution would be to eliminate the telephone ring altogether and replace it with the caller's verbal message (Milewski & Smith, 2003). Doing so would increase efficiency but retain the value of the informative alert.

A growing number of PC applications help users to manage interruptions by continually publishing updated information about recipients' presence and availability. In popular IM systems, for example, users can indicate "I am available" or "I am away" or "I am busy" and can have that status published to those who may want to communicate with them. Informative alerting, of the type involved in audio call screening, can be thought of as an alternative of sorts to these presence displays. It can be argued that properly constructed notifications that have rich information but low response overhead provide a very efficient means for negotiating communication. It is important to note that the data presented here do not directly

compare the effectiveness of informative alerting with the presence publishing often used in IM systems. Each paradigm is likely to have its own advantages. However, taken together with previous findings that availability status displays are often incorrect and ignored (Milewski & Smith, 2000), these data suggest that informative alerting may be relatively more workable, at least for telephony. Indeed, the extent to which presence/availability status displays work at all for IM systems may be the result of a fairly unique characteristic of the desktop PC. That is, people who are available for messaging on the PC are nearly always performing some measurable keyboard activity, which can be used as a powerful presence cue. This is not true for landline telephones and is definitely not true for mobile or ubiquitous computing devices, which can remain powered on but dormant for hours even though the owners may be eagerly awaiting communication. Moreover, Nardi, Whittaker, and Bradner (2000) discovered that even when text IM users on PCs had status information available, they still negotiated availability in their first few message interactions. Because text-based interaction may be less socially demanding than voice, Nardi et al. suggested that augmenting telephony with early negotiation via text messages may prove useful. The data presented here suggest that many telephone users already use audio-screening technologies in this active way and that informative alerting could form the basis for useful presence-management strategies.

REFERENCES

Adamczyk, P. D., & Bailey B. P. (2004). If not now, when?: The effects of interruption at different moments within task execution. In *Human Factors in Computing Systems: Proceedings of CHI'04* (pp. 271–278). New York: ACM Press.

Clark, H. (1996). *Using language*. Cambridge, UK: Cambridge University Press.

Cutrell, E., Czerwinski, M., & Horvitz, E. (2000). Effects of instant messaging interruptions on computing tasks. In *Extended Abstracts of CHI '2000, Human Factors in Computing Systems* (pp. 99–100). New York: ACM Press.

Czerwinski, M., Cutrell, E., & Horvitz, E. (2000). Instant messaging: Effects of relevance and time. In S. Turner & P. Turner (Eds.), *People and Computers XIV: Proceedings of HCI 2000* (Vol. 2, pp. 71–76). Swindon, UK: British Computer Society.

Czerwinski, M., Horvitz, E., & Wilhite, S. (2004). A diary study of task switching and interruptions. In *Human Factors in Computing Systems Proceedings of CHI'04* (pp. 175–182). New York: ACM Press.

Gillard, P., Bow, A., & Wale, K. (1995). Privacy and control: Social indicators of interest in future telecommunications. *Telecommunications Needs Research Group Technical Report.* Melbourne, Australia: Royal Melbourne Institute of Technology.

Grudin, J. (1987). Social evaluation of the user interface: Who does the work and who gets the benefit. In H.-J. Bullinger & B. Shackel (Eds.), *INTERACT 1987. IFIP Conference on Human-Computer Interaction* (pp. 805–811). Stuttgart, Germany: Elsevier Science.

Horvitz, E., Koch, P., & Apacible, J. (2004). BusyBody: Creating and fielding personalized models of the cost of interruption. In *Proceedings of Meetings of Computer Supported Collaborative Work* (pp. 507–510). New York: ACM Press.

Hudson, J. M., Christensen, J., Kellog, W. A., & Erickson, T. (2002). "I'd be overwhelmed, but it's just one more thing to do": Availability and interruption in research management. In

Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 97-102). New York: ACM Press.

Lacohée, H., & Anderson, B. (2001). Interacting with the telephone. *International Journal of Human-Computer Studies, 54*, 665–699.

Latorella, K. A. (1999). *Investigating interruptions: Implications for flightdeck performance* (NASA/TM–1999–209707). Washington, DC: National Aviation and Space Administration.

Martin, J. (1996). *Miss Manners' basic training: Communication.* New York: Crown.

McCrickard, D. S., & Chewar, C. M. (2003). User goals and attention costs. *Communications of ACM, 46*(3), 67–72.

McCrickard, D. S., Chewar, C. M., Somervell, J. P., & Ndiwalana, A. (2003). A model for notification systems evaluation–Assessing user goals for multitasking activity. *ACM Transactions on Computer-Human Interaction, 10,* 312–338.

McCrickard, D. S., Czerwinski, M., & Bartram, L. (2003). Introduction: Design and evaluation of notification user interfaces. *International Journal of Human-Computer Studies, 58,* 509–514.

McFarlane, D. (1999). Coordinating the interruption of people. In *Human Computer Interaction–Proceedings of INTERACT'99* (pp. 295–303). Amsterdam: IOS Press.

McFarlane, D. C., & Latorella K. A. (2002). The scope and importance of human interruption in human-computer interaction design. *Human–Computer Interaction, 17,* 1–61.

Milewski, A. E., & Smith, T. (2000). Providing presence cues to telephone users. In *Proceedings of the ACM Conference on Computer Supported Cooperative Work* (pp. 89–96). New York: ACM Press.

Milewski, A., & Smith, T. (2003). *Telephone voice-ringing using a transmitted voice announcement* (U.S. Patent No. 6,519,326). Washington, DC: U.S. Patent and Trademark Office.

Nagel, K. S., Hudson, J. M., & Abowd, G. D. (2004). Predictors of availability in home life context-mediated communication. In *Proceedings of the ACM Conference on Computer Supported Cooperative Work* (pp. 497–506). New York: ACM Press.

Nardi, B., Whittaker, S., & Bradner, E. (2000). Interaction and outeraction: Instant messaging in action. In *Proceedings of the ACM Conference on Computer Supported Cooperative Work* (pp. 79–88). New York: ACM Press.

O'Conaill, B., & Frohlich, D. (1995). Timespace in the workplace: Dealing with interruptions. In *Proceedings of CHI '95* (pp. 262–263). New York: ACM Press.

Suchman, L. (1987). *Plans and situated actions: The problem of human-machine communication.* New York: Cambridge University Press.

Yang, L. (1996). Interruptions and intonation. In *Proceedings of the International Conference on Spoken Language Processing '96* (pp. 1872–1875). Retrieved from http://www.isca-speech.org/archive/icslp_1996/i96_1872.html