Understanding How the Projection of Availability State Impacts the Reception of Incoming Communication

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ABSTRACT
Many communication systems infer and project information about a user's availability, making it possible for others to decide whether and how to contact that user. Presumably when the system infers people are busy, they are less open to interruption. But analysis of 103,962 phone calls made using a popular enterprise communications tool reveals that people are actually significantly more likely to answer the phone when the system projects that they are busy than at other times. A follow-up survey of 569 users of the system suggests that this seemingly counter-intuitive fact may arise because people care a lot about the recipient's availability when initiating phone communications and are unlikely to attempt to call someone who appears to be busy unless the communication is important. Recipients thus perceive incoming calls as more important when they are busy than at other times, making them more likely to answer.

Author Keywords
Interruptions; communication; calls; presence; availability.

ACM Classification Keywords
H.5.3 [**Group and Organization Interfaces**]: Collaborative Computing—*synchronous interactions, CSCW*.

INTRODUCTION
Imagine that you are busy. Now imagine that the phone rings. It seems reasonable to assume that you would be less likely to answer the call at that point than if you were available. Phone calls, like any type of communication, are established via a negotiation between the initiator of the communication and the recipient. The person placing the call chooses when to place it, and the person receiving the call chooses whether to answer it. One way a busy person can partake in the negotiation is to ignore incoming calls.

Surprisingly, however, when analyzing over a hundred thousand enterprise phone calls we observed that people were more likely to answer the phone when busy than at other times. Via a survey of hundreds of system users we demonstrate that this counterintuitive finding appears to arise from the fact that, in the population we studied, the initiator of each phone call had access to information about the recipient's availability and could use that information to appropriately tailor their communication timing and mode. As a result, busy people perceived incoming phone calls as particularly important because they knew the caller chose to call regardless of their being unavailable. Call importance is a primary reason people answer the phone, so this shared knowledge that the recipient was busy is likely to explain why people answered the phone more when busy.

This paper presents evidence that the interruption decisions of a caller can impact the acceptance decisions of the recipient. Previous research has shown that establishing communication involves a negotiation between the parties involved [10, 13, 15], and that initiators use information about the recipient's availability in this negotiation [1, 5, 14]. But we are unaware of research that shows recipients' communication decisions are impacted by the fact that they know that information about their availability is visible to others. Additionally, previous studies have only looked at data collected from a handful of users on prototype systems; all papers cited here, for example, used fewer than 80 participants. In contrast, we study large-scale log data collected by a working enterprise communication system. The system was used by thousands of users within hundreds of different companies as they made real world, natural communication decisions. Because log data show what people do but not why, we supplement these data with a survey of hundreds of system users.

After a discussion of related work, we describe the details of the communication system we studied, highlighting how it indicates a person's availability. We then present the results of a large-scale analysis of the system's logs, which reveals that users were significantly more likely to answer the phone when the system thought they were busy than at other times. To explain why this was the case, we present the results of a survey of 569 users of the system that shows that phone call recipients use of the fact that the initiator of a call knows whether or not they are available to influence how they interpret the importance of the incoming call.

RELATED WORK
Requests for communication can be disruptive to a person's current task or social situation. A phone call from a colleague may lead to valuable new insight, but can also be distracting if one is working on a different project. Such disruptions have real costs. Czerwinski et al. [4] found that

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receiving communications during a desktop computing task can result in slower task completion times.

There are many methods people employ to mitigate the cost of interruption. For example, people control the phone calls they receive by turning off their phone's ringer [15] and by screening calls [1]. Grandhi et al. [10] explored several factors that lead people to answer or reject mobile phone calls. Bogunovich and Salvucci [3] found, via a controlled study of 20 users, that people are much more likely to respond to a phone ring during periods of lower workloads. Surprisingly, the large-scale analysis we present of real-world data reveals that users of our system did the opposite. We present the results of a survey that suggests this unexpected observation arises because call recipients believed the caller was thoughtful about when to call.

A well-timed interruption can reduce the impact of the interruption [12], and people initiating communication sometimes chose when to interrupt someone so as to minimize the disruption. De Guzman et al. [6] conducted a diary study with 13 users to understand the cues call initiators want to know about the recipient's context, and what recipients wish others would consider before calling. They found that information related to the recipient's current activity is particularly important. Avrahami et al. [1] studied the effectiveness of contextual information when establishing calls by asking 78 people to imagine the situations in which they might place or receive call and measuring the agreement between the recipients' desires and callers' decisions. Contextual information about the recipient appears to help people make more accurate decisions about placing a phone call.

Many of the cues found to be valuable in these studies of interruption have been used to create digital representations of one's availability. Researchers have explored inferring availability using device activity [2, 8, 14], calendar status [9], speech [8, 9], and physical presence [2, 8, 14]. This information can be presented to potential interrupters directly. However, Dabbish and Kraut [5] found abstract displays of availability allow people to make comparable interruption decisions as information-rich displays, while requiring much less effort on the part of the interrupter. The system described here employs this approach.

In summary, the work presented in this paper builds on previous research to explore how availability information relates to people's communication decisions. While earlier work focused on how availability information impacts the people initiating communication, we focus on its impact on the decisions of the recipient. Further, we are able to study this behavior at a much larger scale than previously possible by looking at the users of a popular enterprise communication system that infers its users' availability.

DESCRIPTION OF THE COMMUNICATION SYSTEM

To study how availability information impacts incoming communication decisions, we studied Lync, a popular commercial enterprise communication system by Microsoft. Lync provides an integrated communication experience, enabling users to connect via instant messaging, screen sharing, email, voice, and video conferencing. The system is widely used throughout the world in large enterprises.

Each Lync user projects an *availability state* to other users within the same company. Availability state is intended to communicate context to facilitate interruption decisions. It is inferred using activity and calendar information, and can be manually set by the user. Below is a list of the possible availability states and how they are inferred. Users are considered *active* if they have interacted (e.g., by typing on a keyboard or moving a cursor) with one or more of the devices tracked by the system (e.g., desktop computer, laptop computer, phone, mobile phone) within a configurable time window, set by default to 20 minutes.

Available A person is active, and the system has no additional information to suggest they are busy.

Busy A person is active, and is on the phone or has an appointment scheduled on their calendar.

Do not disturb (DND) A person has manually set the state. When set, the person can only receive communication from a manually configured list of team members.

Away A person is not active on any device.

Offline A person is not logged into any device.

Table 1 shows how the different availability states are represented graphically. These representations are displayed in email messages next to the recipient's email address, in instant message windows next to all participants' names, and in a list of contacts provided by the system. Additional text related to a person's availability (such as "in a call" or "in a meeting" when *busy*, or the amount of time the person has been away when *away*) can be accessed in a variety of manners, such as by mousing over the representation.

LOG ANALYSIS OF SYSTEM USE

By analyzing the logs of Lync's use across thousands of users and multiple organizations, we are able to build a picture of how a person's availability state relates to that person's willingness to accept incoming phone calls.

Log Analysis Methodology

The data we analyze were logged in the aggregate from anonymous opt-in users of the system. Although Lync is used primarily for internal communication within a single company, many different companies use it and the logs were drawn from a cross-section of these. The logging is a part of the system itself and information is aggregated internally so as to not record or reveal any identifying information about the enterprises or individual users.

Due to these privacy preserving measures and the fact that the system is a production system deployed worldwide with many external constraints, there are limitations to depth and richness of the log data collected. Although large-scale log analyses of communication systems have not been reported

Table 1. How often a phone call was answered or missed, by the projected availability state of the recipient. The most common action for each state is highlighted in bold.

	Answered		Not Answered		Other	
	#	%	#	%	#	%
Avail.	22916	44%	**27183**	**53%**	1602	3%
Busy	**22926**	**67%**	10561	31%	737	2%
DND	**190**	**54%**	147	42%	14	4%
Away	2662	41%	**3585**	**55%**	238	4%
Offline	4487	40%	**6137**	**55%**	577	5%

previously, the limitations we encounter in our analysis are similar to the well-understood limitations that exist in areas that commonly use log analysis like web search [11]. For example, there is additional information that could have been logged that was not. We apply standard log analysis techniques to process and clean the data [7].

Our analysis focuses on a subset of the logs that represent *internal phone calls*, or calls directed from one person in an organization to another person in the same organization. Limiting our analysis to these calls ensures that both the phone call initiator and the recipient had access to the communication system and to the availability state of the other member of the call. To minimize expected or pre-scheduled calls, we excluded conference calls. However, because escalation events were not logged, the log data do include calls that were initiated as person-to-person calls but later escalated to multi-party calls.

In our analysis we look at the logs of 103,962 phone sessions for which the recipients' status was one of the five states presented in Table 1. We then look at the portion of sessions in which the recipient either chose to *answer* or *not answer* the call. Calls that are not answered continue to ring until the call goes to voicemail or the caller disconnects. Other less common actions the recipient can take include actively rejecting the call or sending it straight to voicemail.

Log Analysis Results

Table 1 shows the actions phone call recipients took, broken down by their availability state. For most states, calls were more likely to go unanswered than be answered. When people were *available*, 53% of calls were not answered, and when they were *away*, 55% were not answered. Likewise, when people were *offline*, 55% of calls went unanswered while only 40% were answered. The fact that people sometimes answered the phone while *offline* or *away* results from the fact that the user may be present to answer the call even if not actively using a device monitored by the communication system. For example, a person reading a printed document in their office may appear *away* but choose to answer the phone when it rings. The states can also be set manually by active users.

In contrast to recipients' behavior while *available*, *away*, or *offline*, recipients in the *do not disturb* state or in the *busy* state were much more likely to accept a call than to miss it. Only 31% of incoming calls were missed when a person was *busy*, and only 42% of the calls to people who had actively set their status to *do not disturb* were missed. It is surprising that when recipients had actively asked other people not to interrupt them (i.e., set the *do not disturb* state), they were more likely to answer the phone than when they were available. And they were even more likely to answer the phone when their status indicated that they were *busy*, either because they had a calendar appointment, on the phone, or had explicitly stated that they were busy.

If the logs contained information about the amount of time an individual spent in each availability state, we might also be able to show that people who projected a *busy* state received phone calls at a different (presumably lower) rate. Nonetheless, the data that was logged reveals very strong trends in answering behavior, with the reported differences being much larger than what is typically seen in large-scale log analysis in other domains, and these trends are further confirmed by the follow-up survey.

SURVEY OF INTERRUPTION DECISIONS

Although the log data reveals a strong and surprising trend, it provides no insight into people's motivations for answering the phone when busy. To build a richer picture of why this behavior might occur, we surveyed hundreds of system users about how they use availability information to manage phone interruptions.

Survey Methodology

In addition to collecting basic demographic information, the survey consisted of three sections:

- The first contained four questions about availability state use, including the respondent's awareness of one's own and other's availability states, how often the user set their state manually and to what,
- The second contained six questions about the placing of internal phone calls, including how often the respondent placed calls and the factors they considered when calling (including the recipient's availability state), and
- The third contained six questions about receiving internal phone calls, including how often the respondent received internal calls, factors the respondent considered when answering, and how their state impacted their response to incoming calls.

The survey questions were developed based on semi-structured interviews with 34 system users (26 male), each from a different company. Interview subjects were chosen to represent a variety of job roles, including executives, IT professionals, information workers, and management.

The resulting survey was completed by 569 Microsoft employees. Consistent with the demographics of the company, 429 (75%) were male and 412 (72%) held a technical position. To ensure familiarity with the software, all participants were required to have used it for at least 2 months, and most (75%) reported using it for at least a year.

Table 2. Recipient states, ranked by which callers see as most acceptable to call.

	Ok to Call in State (5 = most acceptable)
Avail.	4.69
Away	3.19
Offline	3.05
Busy	2.65
DND	1.42

Table 3. Perceived importance of a call by the recipient, based on the recipient's state.

	Importance of Call (5 = most important)
Busy	3.30
DND	3.30
Avail.	3.07
Away	2.69
Offline	2.64

Table 4. The rank of the different factors that participants reported considering when deciding whether to place or answer a phone call.

	Placing (5 = most important)	Receiving (5 = most important)
Recipient's availability	3.32	3.46
Importance to respondent	3.29	2.78
Importance to other	2.62	2.18
Closeness of relationship	2.36	2.32
Recipient's location	1.99	2.26
Relative status	1.42	2.00

For most of the questions in the survey, participants were asked to rate a set of availability states or factors on a five-point scale. We used these ratings to rank them within-subject, and then compared the rankings between-subjects. All differences are significant ($p < .0001$) according to nonparametric Friedman tests. Post-hoc pairwise Wilcoxon tests using Holm's sequential Bonferroni procedure reveal significant ($p < .01$) differences between all pairwise subjective responses except as indicated in the text. Table cells with values that are not significantly different are separated by dashed lines rather than solid lines.

Survey Results

Analysis of the survey responses reveals that participants use availability state to make communications decisions, and consider it unacceptable to call someone who is *busy* or has set *do not disturb* unless the call is important. As a result, participants reported perceiving incoming calls to be particularly important when in these states. Because people said they were more likely to answer important calls, this may explain the log data. We now dive into how availability state is used to establish a call, and how assumptions about call importance are incorporated while doing so.

Availability State Used to Establish Calls

Participants appeared to care a lot about the availability state they project to others. They tended to know what state they were in, with 80.5% of respondents reporting they "always" or "often" knew it, and only 1.8% reporting similar measures of surprise at their state. This awareness appeared to exist even in the absence of active monitoring, with 66.7% of all participants saying they "always" or "often" knew their state without looking. Participants also put effort into controlling the state they projected, with 82.2% saying they had manually set it at some point; 29.3% of those people said they did so at least daily. The most popular states to set were *busy*, *do not disturb*, and *away*.

Knowledge of other's availability state also appeared important. Over a third (34.3%) of participants reported checking on the state of other users more than 10 times a day, and all but 9.0% said they checked someone else's state at least daily.

Other's state information was used to decide when and how to contact them. Participants were asked to judge, on a 5-point scale, how acceptable they found it to call someone in each availability state. These responses were used to create a partial ordering of the states for each individual. The mean rank of these orderings can be found in Table 2. Participants consistently found it most acceptable to call *available* recipients, and least acceptable to call *busy* or *do not disturb* recipients.

Participants reported varying the mode of communication they used based on the availability state of the person being contacted. For example, they were more likely to try to IM someone who was *available* than *busy*, and more likely to email a *busy* person. The decision to call was particularly likely to be influenced by the recipient's availability state, with 425 (75%) participants selecting the phone as a potential way to contact someone who was *available*, compared to only 80 (14%) who said they would use the phone to contact a *busy* person. Given callers make interruption decisions based on the recipient's state, it is likely that people who are *busy* receive fewer calls from a different set of people than they do in other states, and this probably impacts how the incoming calls are received.

Most (69.2%) participants believed their availability state was taken into account when an internal colleague called them. Nonetheless, not all incoming calls were wanted. Consistent with previous work [15], participants used various strategies to avoid such calls. Almost half (44.3%) reported switching their availability state when receiving an unwanted phone call, in effect enabling others to make better interruption decisions in the future.

To understand the relative importance of the recipient's availability state when establishing voice communication, participants rated the importance of a number of potentially influential factors and these ratings were used to create a partial ordering. The mean rank of a subset of the factors considered is shown in Table 4. The recipient's availability emerged as the most important factor for both the person placing and receiving the call.

Factoring in the Importance of the Call

Another central factor that participants reported considering when establishing voice communication was the importance of the message. As can be seen in Table 4, when placing a

call participants were as likely to consider the importance of the message to themselves as they were to consider the recipient's availability state. This is consistent with the fact that 87.2% of participants agreed they might interrupt someone with a call in a state they normally would not if the message were important. Likewise, when receiving a call the perceived importance of the message to the recipient was second only the recipient's actual availability.

Interestingly, participants perceived an incoming phone call to be differentially important as a function of their availability state. Each state was rated by how important an incoming call was thought to be given the participant was in that state. The responses were used to create a partial ordering, and the mean rank is shown in the third column of Table 3. Incoming calls were thought to be significantly more important if received while *busy* or in *do not disturb* compared to calls received while *away* or *offline*.

It appears that not only does someone who places a call consider the recipient's state and the message importance to make an informed interruption decision, but that the recipient assumes the person placing the call has considered these factors. As stated by one participant, "I hope that others honor my [state] in the same way I do theirs, but I also understand and respect that the importance of the call to either them or me may cause them to ignore my [state]."

This mutual understanding of availability state, coupled with knowledge of one's own projected state, seems to be incorporated into how incoming calls are understood by recipients. Given message importance is a significant factor when deciding whether to answer a call, this may explain why a person in a *busy* or *do not disturb* state is particularly likely to answer the phone, as observed in the logs.

CONCLUSION

We have explored how the interruption decisions of people placing phone calls impact the acceptance decisions of the call recipients. Large-scale log data analysis of a popular communication system revealed the surprising fact that people were more likely to answer phone calls when they projected a *busy* or *do not disturb* availability state. Via a survey of 569 system users, we found evidence that this could be because the people who place phone calls to someone in one of these states choose to do so only if they think the call is important. As a result, phone call recipients perceive incoming calls from other system users to be more or less important as a function of the state they are projecting. The recipient and the initiator use availability information to jointly negotiate the best time and mode for communication based on message importance.

This paper is the first that we are aware of to show that a recipient's communication decisions are impacted by the fact that they know that their availability state is visible to others. Our findings could be used to build systems that help recipients make better acceptance decisions by providing them with additional information about what the initiator knows when starting a communication.

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