# Coordinating Initiation and Response in Computer-Mediated Communication

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# Abstract

Communication interruptions make work sociable and interesting, and they support flexibility and knowledge transfer in the workplace. However, interruptions also delay task completion and degrade performance, with negative consequences for organizational effectiveness. When communication is technologically mediated, how can we maintain connectivity while reducing the potential disruption associated with informal interaction?

This thesis examines factors influencing the decision to initiate and respond to communication, and the impacts of communication interactions on both sender and receiver. This thesis advances previous work by considering factors that influence both members of a communication pair. Using a set of laboratory studies, the work presented explores the ways in which awareness displays—i.e., displays that make visible the task constraints of both senders and receivers—affect communication timing. Results indicate that such displays are useful for coordinating communication only when the sender and the receiver have a common social identity and joint incentives. Finally, communication decision-making is examined in the context of the most commonly used form of computer-mediated communication to date: email.

The contribution to human-computer interaction is an increased understanding of attention to workplace communication, as well as a set of practical guidelines for the design of electronic communication systems. The results also have relevance in the fields of information systems and organizational communication.

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To my parents

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# Chapter 1

# Introduction*

## 1.1 Motivation

Knowledge workers are interrupted by others every four minutes on average (Gonzales & Mark, 2004). When they aren't interrupted by others, they interrupt themselves. Communication interruptions make work sociable and interesting, and they support flexibility and knowledge transfer in the workplace (Kraut, Fish, Root, & Chalafonte, 1993), but interruptions also delay task completion and performance quality with negative consequences for organizational effectiveness (Perlow, 1999). Thus, an important research question is: How can we maintain connectivity so critical to the completion of work while reducing disruption associated with informal interaction?

Although we know that communication recipients are often harmed by disruption to their work (Adamczyk & Bailey, 2004; McFarlane, 2002; McFarlane & Latorella, 2002; McFarlane, 1999; Gillie & Broadbent, 1989), it is not yet clear how technology can help to minimize disruption while maximizing the productivity and social welfare of the involved parties. This thesis examines how the design of communication technology, such as synchronous chat, can better facilitate the kinds of spontaneous dyadic communications that are so important for the successful completion of work (Kraut, Fish, Root, & Chalafonte, 1993).

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* Parts of this chapter are adapted from Dabbish and Kraut (2004) and Dabbish (2005).

The goal of this thesis is to address the following research questions:

- What information does a communication sender use in deciding when to request attention for a communication interaction?
- What information does a communication receiver use in deciding when to respond to a request for attention?
- What effects do these initiation and response actions have on the task performance of the sender-receiver pair?
- How can information technology improve human performance in the communication process?

In order to more effectively design systems to coordinate communication, it may be useful to take a step back and to understand how individuals make the decision to initiate or respond to communication. The development of a theoretical model of communication initiation and response decisions may illuminate opportunities for intervention or aspects of the situation that should be considered in communication system design.

## 1.2 Deciding to Communicate

Knowledge workers initiate communication for many reasons. One common purpose is to seek information or advice. We focus on help-seeking communication in this thesis because it is so prevalent in organizational life and because it highlights the asymmetry in benefits and costs often experienced by the initiator and receiver of an interruption (Perlow & Weeks, 2002; Perlow, 1999). In a help-seeking interaction, the person who initiates needs information and tries to communicate with someone perceived to possess the needed information. This receiver, however, may be working on another task, which could be disrupted by the incoming help-seeking communication from the initiator (Kraut & Attewell, 1997).

Previous work on face-to-face communication interactions has considered factors affecting the decision to engage in a communication interaction from the perspectives of both the initiator and the recipient (Tan, 2006; Dabbish & Baker, 2003; Gruen, 1996; Heath, Jirotka, Luff, & Hindmarsh, 1995; Kendon, 1990; Goffman, 1959). Goffman (1959) studied gaze in face-to-face situations as a signal for availability. Kendon (1990)

observed human greeting in social situations, noting patterns of action when initiating and responding to greeting attempts. Gruen (1996) performed a set of observational studies of office workers and their interruption handling strategies. Dabbish & Baker (2003) interviewed a set of administrative assistants about their decision rules when mediating interruptions to their supervisor. Finally, Tan (2006) performed an observational study of the medication administration task in hospitals, observing nurses' decisions to respond to interruptions and the subsequent effects on their primary task performance. Each of these studies sheds light on the various influences on the decision to initiate and respond to a communication interruption.

This previous work suggests that the decision to communicate depends on what both parties are doing, why they want to communicate, their perceptions about the possible interaction, and the relationship between the parties.

Figure 1.1 presents a high-level model of the decision to communicate and incorporates factors from the points of view of both the initiator and the receiver of the communication as well as the net benefit, or cost, that the receiver may receive from the communication. We review here these factors as mentioned in previous work.

### 1.2.1 Communication Initiation

A sender's perception of the receiver's utility for a communication may depend upon the content of the communication (e.g., whether it pertains to a joint project), the sender's relationship with the receiver, and the sender's perception of the receiver's current availability (i.e., whether the communication will disrupt work that the receiver is currently doing).

#### *1.2.1.1 Perceived Availability of Receiver*

Goffman (1959) noted that in a face-to-face situation, individuals use gaze to signal availability for communication interaction. Individuals' willingness to have their eyes "caught" signals willingness to engage in an interaction. And other work on nonverbal behavior has cited the use of gaze for signaling willingness to engage in interaction (Patterson, 1992).

Kendon (1990) also notes the importance of perceived availability of the other party when deciding whether to initiate communication. He notes (where $p$ is the initiator of an interruption and $q$ is the potential receiver):

> …if, when he sights him, *q* is busy, *p* may have to wait until *q* has completed what he is doing before initiating a greeting. How ready *p* is to interrupt himself, and how ready he will be to interrupt *q* will, of course, depend upon the importance of initiating a greeting with *q*, relative to the importance of other things. (Kendon, 1990, p. 165).

Gruen (1996), in his observations of office workers, also found that "people often evaluate the extent to which others are open to interruption" (p. 109) before attempting to communicate with that person. Subjects in his studies used cues or signals given by the receiver to determine whether they were available for interaction at that time.

Dabbish & Baker (2003) discovered that administrative assistants took into account availability of their supervisors prior to allowing an interruption, mentally classifying their supervisors' current activities into full, high, routine, and low importance, thus combining both the value of the activity and the urgency associated with its completion.

#### *1.2.1.2 Urgency and Importance of the Communication*

Kendon (1990) also notes that the urgency and importance of initiating a greeting, relative to the importance of other features of the situation, will affect how ready a sender is to interrupt the receiver. In addition, if the sender perceives this as the only opportunity to interact with the receiver, the sender is more likely to interrupt an ongoing conversation.

Dabbish & Baker (2005) also found that administrative assistants compare the relative importance of an incoming interruption against their perceptions of the importance of their supervisors' current activities. As noted above, their supervisors' current activities were judged to be of a certain importance level (full, high, routine, or low), and incoming interruptions were also judged to be of a certain importance level (full, high, routine, or low) that depended on their associated value to the supervisor and the urgency conveyed by the interrupter approaching the administrative assistant for access.

This previous work suggests that senders typically weigh the importance and urgency of their need to communicate against the current status of the receiver.

#### *1.2.1.3 Relationship Factors*

In general, relationship features such as interdependence, reciprocity (Gouldner, 1960), affiliation (Gaertner & Insko, 2000), and status (Pfeffer, 1981) influence the way in which two people interact (Tubbs & Moss, 2003). In initiating a communication, the degree to which senders take into account cost or benefit to the receivers is likely to depend upon the relationship with the receiver—whether they have interdependent goals, common group memberships, personal friendships, and likely future interactions, among other factors.

Kendon (1990) cited several features of relationships that influence the likelihood of interrupting another person's ongoing activity, such as closeness, importance, and status. In particular, he noted that status in the group affected an individual's willingness to interrupt when initiating an interaction, noting, "if *p* is high in status in the gathering, he may be more likely to interrupt *q*, no matter what *q* may be doing, than if he is low in status" (Kendon, 1990, p. 166).

Similarly, Dabbish and Baker (2003) found in their study that administrative assistants classified interrupters into levels of importance depending on their relationships with their supervisors. Full access individuals were typically very intimate family or friends, while high-importance individuals were individuals of higher status, routine contacts were subordinates or close co-workers, and low-status individuals were strangers.

### 1.2.2 Communication Response

The receiver of the communication goes through a similar decision process as the initiator when deciding whether to respond immediately to an interruption or postpone a response. The receivers must determine the possibility of postponing their current tasks (Gruen, 1996), the urgency and importance of the communication interaction (Tan, 2006; Gruen, 1996; Kendon, 1990), and their relationships with the senders (Dabbish & Baker, 2003). As Gruen (1996) noted:

> Determining how to handle an interruption may require a process of evaluation during which the costs and benefits of each way of dealing with the interruption are weighed against the costs of removing resources from the current activity. (Gruen, 1996, p. 35)

#### *1.2.2.1 Current Task State*

The receiver's willingness to postpone ongoing work and attend to an incoming communication is influenced by the value of the receiver's current work, proximity of impending deadlines, and proximity to a reasonable stopping point in the primary task (McFarlane, 2002; Gruen, 1996). As Kendon notes (where *p* in this case is the receiver of an interruption and *q* is the initiator):

> If p is already engaged in a conversation with someone when he sights q, he may have to postpone an initiation of a greeting with him until that conversation is ended. (Kendon, 1990, p. 165)

This influence of the current task state was noted in observations by Gruen (1996) in which participants delayed incoming communication interruptions differentially, depending upon their proximity to a reasonable stopping point in their current activity. He concluded that people take into account the effect on their current activity when determining whether to handle an incoming interruption. Tan (2006) found that expectations about the duration of the interruption task were an important influence on the likelihood of responding to an interruption. In her study, nurses deferred or ignored the interruption if an interruption task was perceived to redirect them from their current activity for too long.

#### *1.2.2.2 Communication Value to the Initiator*

Because responding to a communication interruption can harm ongoing work (Speier, Vessey, & Valacich, 2003; McFarlane, 2002; Perlow, 1999; Gillie & Broadbent, 1989), a receiver may be inclined to postpone communication until the primary task has been completed. However, delaying a response can have negative consequences on the work of the communication initiator (Gruen, 1996), particularly for help-seeking communications (Rennecker & Godwin, 2005). The extent to which the receiver takes into account the value of the communication to the initiator may depend on the conveyed urgency and importance of the communication. Gruen (1996) noted that receivers considered the urgency of the interruption in deciding when to respond. In Dabbish and Baker's (2003) study, administrative assistants did consider the importance of the interruption's content, weighing the urgency conveyed by the interrupter and the perception of the interrupter's need to communicate with their supervisor against their supervisor's current status.

#### *1.2.2.3 Relationship Factors*

The relationship between the sender and the receiver of a communication also influences the extent to which the receiver will take into account the value of the communication to the sender. Similar to the willingness to interrupt, previous work indicates that relative status, affiliation, closeness, and reciprocity influence the willingness to be interrupted (Dabbish & Baker, 2003; Perlow, 1999; Kendon, 1990).

### 1.2.3 Organizational Context

The organizational context of a communication interaction influences both the propensity to initiate a communication and to respond (Tubbs & Moss, 2003). In particular, previous work has noted the potential influence of organizational roles, communication norms, and organizational culture.

Gonzales and Mark (2004) note that accountability or responsibility for certain functions, as dictated by organizational role, affect an individual's propensity to engage in interaction. Kendon (1990) also notes that the role of an individual within a particular setting may influence the individual's ability to defer interruption or willingness to accept an interruption. For example, a greeter whose role is to engage in communication with people as they arrive at a location will be highly willing to accept an interruption because the greeter's organizational role defines this as a responsibility.

In addition, organizational norms and culture can influence willingness to interrupt or to respond to interruption (Ghosh, Yates, & Orlikowski, 2004; Rennecker & Godwin, 2005). A workplace where frequent communication interactions are encouraged and expected should increase individuals' willingness to interrupt each other's tasks as well to respond to interruptions.

### 1.2.4 Coordinating Electronic Communication

As noted in the model of initiation and response presented in Figure 1.1, both senders and receivers must balance their own task constraints against those of the other party in a communication situation. The sender is motivated to interrupt because of a need for information or advice that is associated with an ongoing task, although the sender must balance this need against the availability of the receiver. The receiver, on the other hand, must consider the importance and urgency of the current task activity and the potential effect of the incoming interruption, then weigh this against the interrupter's need for information.

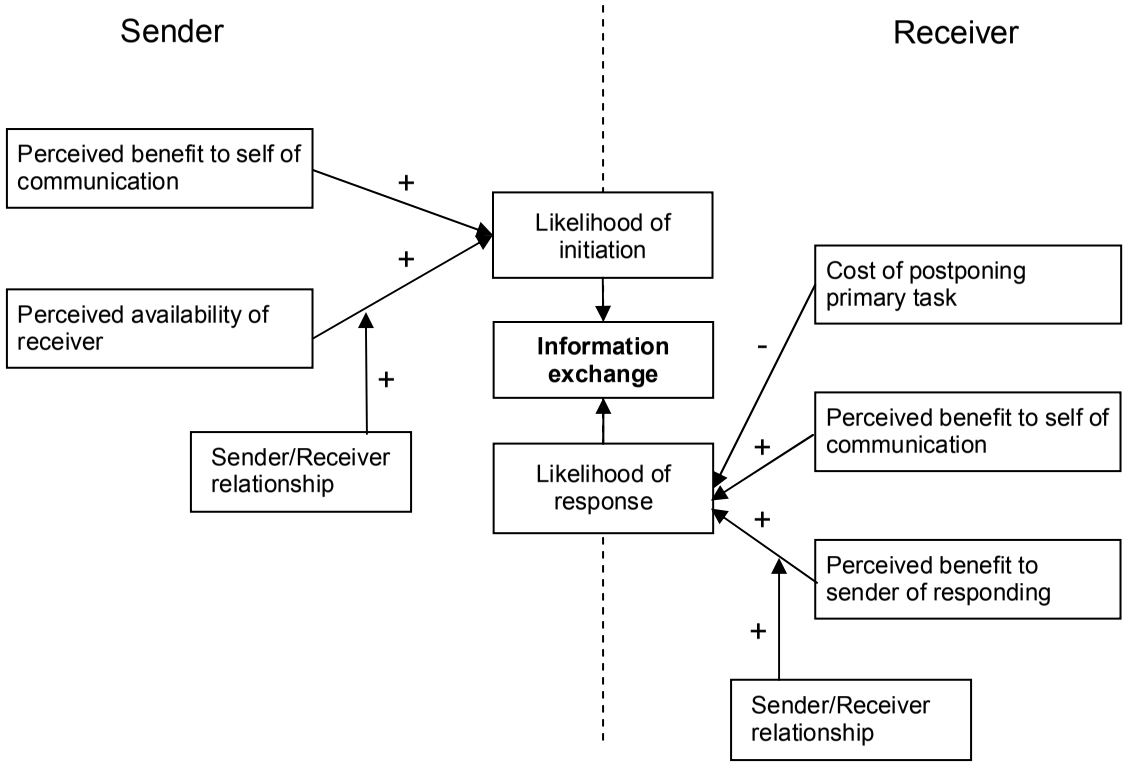


Figure 1.1. Communication initiation and response decision.

When communication is electronically mediated and the initiator and recipient are not co-located, it is more difficult for information to be shared—both for the sender to obtain information about the recipient's current state (Fish et al., 1993) and vice versa. In this context, an initiator's perception of receiver availability depends in part upon the amount of information that the initiator has about the receiver's physical and psychological ability to receive the communication.

Sharing of information about task state is an issue even for co-located individuals, as Gruen (1996) notes:

> The interrupter knows the urgency of the interruption, its importance, and the cost of postponing it to a future time. The interruptee knows the urgency and importance of their current activity and the cost of suspending it. The interruptee may also know of other opportunities to handle the interruption when its detrimental effects would be lower. Even when both parties have common goals, determining how to handle an interruption requires that information be shared. (Gruen, 1996, pp. 239-240)

The central hypothesis behind this thesis is that increasing the mutual visibility of sender and receiver task constraints can improve communication timing to reduce the potentially harmful effects of interruption on ongoing work and can maintain connectivity between individuals.

Relevant to the issue of designing technology for coordinating informal communication interactions is research on workplace communication and interruption as well as previous research aimed at improving coordination. To understand the nature of organizational communication, we look at how people are communicating on the job and what functions communication interactions serve in ongoing work. To understand the impact of different communication timings on ongoing work, we also examine previous work on interruption. The rest of this chapter provides a brief summary of key results in each of these areas as they apply to the current research goals.

## 1.3 Workplace Communication

Communication is a central work activity in most organizations. A recent Gaertner Group survey about communication at work indicated that office workers spend a majority of

their time on the job engaged in communication with co-workers (over 40% on average (Tubbs & Moss, 2003; Wendland, 2001)), and other work indicates that the average office worker participates in over 150 technologically mediated informal communication interactions (via email, cell phone, voice mail, etc.) during a normal workday (Clark, 1999). Studies of managers and professionals, in particular, have shown that these workers engage in multiple, spontaneous communications with many different people over the course of a single work day to scan their environment, to exchange information, to influence, or to request or provide advice—consequently spending a majority of their time in communication with others (up to 80% in one study), much of which in opportunistic, informal, and unplanned communication interactions (Hudson, Christensen, Kellog, & Erickson, 2002; Panko, 1992; Reder & Schwab, 1988, Sproull, 1984; Mintzberg, 1973).

A hallmark of modern managerial and professional work is that it is communication intensive (Panko, 1992). Communication serves important functions in organization, supporting task completion, relationship maintenance, and ambiguity management. Communication allows members of an organization to coordinate action related to interdependent activities (Tubbs & Moss, 2003; Clark, 1996; Flores, Graves, Hartfield, & Winograd, 1988; Winograd, 1986; Conrad, 1985). Organizational members also use communication to create and maintain business and personal relationships with other members of the organization (Holtgraves, 2002; Clark, 1996; Linde, 1988; Brown & Levinson, 1987; Conrad, 1985). Productive relationships are an important aspect of organizational life because these relationships affect job satisfaction, communication efficiency and flow, and compliance with commands (Tubbs & Moss, 2003; Clark, 1996; Whittaker, Frohlich, & Daly-Jones, 1994; Conrad, 1985). Finally, communications help members of an organization deal with ambiguity in facilitating the construction of a socially shared understanding of the uncertainty encountered and in allowing information exchange between participants attempting to make sense of new or uncertain situations (Tubbs & Moss, 2003; Daft & Lengel, 1986; Daft & Weick, 1984).

However, informal, spontaneous communication comes at a cost: interruption. Managers think through important issues in three-minute blocks of time because of interruptions (Reder & Schwab, 1988; Sproull, 1984). Overwhelmingly, studies have characterized managerial work as fragmented and marked by brevity. Seminal studies of managerial work by Panko (1992), Reder & Schwab (1988), Sproull (1984), and Mintzberg (1973)

found that managers engage in an activity for an average of ten minutes before they are interrupted by a communication or interrupt themselves with another task. Reder and Schwab's (1988) study found that managers were continually being interrupted by communication events every three minutes. Sproull (1984) found that, on average, 21% of a manager's activities each day are interrupted and that managers often spontaneously interrupted themselves as often as they were interrupted by others. She noted that a new person entered the manager's field of attention on the average of once every ten minutes. Frequent interruptions to ongoing work reduce the size of time slices available for conducting a task (Reder & Schwab, 1990), resulting in highly fragmented activity and frequent context-switching.

The frequent interruptions and fragmentations associated with high volumes of informal communication is not a problem only for managers. Recent work by Mark, Gonzales, and Harris (2005) on multitasking in information work demonstrates that individuals in a variety of job types experience the same kind of work fragmentation and high level of interruption previously observed in managerial work. Participants in their study of multitasking in an office setting were interrupted by others, on average, every four minutes throughout the work day (Mark, Gonzales, & Harris, 2005; Gonzales & Mark, 2004).

These disruptions to individual work can have effects at the organizational level. Perlow's (1999) fieldwork among engineers at a software company illustrates the trade-offs involved in spontaneous communication. When engineers needed help on a task, they would approach a person in a neighboring office. This would disrupt and set back the helper's own efforts, in turn motivating the helper to approach the first person available when the helper needed help. This norm of frequent interruption led to reductions in productivity for the group as a whole and caused their department to miss important deadlines for shipping a product, costing the company thousands of dollars.

At the individual level, Tetard's (1999) empirical research demonstrates that interruptions disrupt ongoing thought and O'Connaill and Frohlich's research (1995) shows that managers fail to return to the activity that was interrupted almost 50% of the time. This problem of disruption is compounded because of the unequal benefit that the interrupter and the interrupted party receive. Both O'Connaill and Frohlich (1995) and Kraut and

Attewell (1997) demonstrate that typically the interrupter gains most from the communication interruption and incurs less cost.

It is this imbalance between the sender and the receiver of an interruption that we are most concerned with in the work presented in this thesis. How can senders and receivers better take into account the impact that their actions have on the work of the other party in a communication interaction?

In summary, previous work on organizational communication has highlighted the central functions that communication interactions serve for coordinating work, facilitating task completion, maintaining relationships, and dealing with uncertainty. People within organizations, particularly office workers, spend a great deal of time in communication with co-workers. Although these communications are critical for getting work done, they can result in disruption to ongoing work and task fragmentation—and ultimately reduced organizational effectiveness.

## 1.4 Interruption

This section reviews previous work that examines the impact of interruptions on task performance and looks for ways to reduce the potential negative impact of task disruption from communication.

### 1.4.1 Cognitive Psychology and Human Factors

An interruption to a primary task can be thought of as any event or activity that demands attention to be redirected from the primary task toward an interruption task, forcing a task-switch (McCrickard, Catrambone, Chewar, & Stasko, 2003). Interruptions can interfere with primary task completion in several ways: delay, strain on attentional resources, and resumption difficulty.

Switching to an interruption task may result in delayed completion of the primary task activity (McDaniel, Einstein, Graham, & Rall, 2004). Depending on the nature of the primary task, this delay can be differentially problematic (Jackson, Dawson, & Wilson, 2001). For primary tasks that require continuous attention or the aspects of which frequently change, an individual's prolonged absence from the task while attending to an interruption could result in error due to missed cues or lack of awareness of changes in

the task or environment (Weick, 1990). For tasks with a proximate impending deadline, this delay, if longer than the deadline, could mean that the task will not be completed.

Interruptions put a strain on attentional resources because they divide attention between the primary task and the incoming request for attention (Miyata & Norman, 1986). This means that less attention is available to each individual source (i.e., the interruption and the original primary task), causing a decrease in performance on both that is referred to as "dual-task interference" (Behrmann & Geng, 2003). The level of an interruption's interference with a primary task is affected by the similarity between the interruption and the primary task (Gillie & Broadbent, 1989; Hirst & Kalmar, 1987). Tasks that deal with similar types of information are more difficult to multitask (Brooks, 1968) to the extent that similar interruptions may be more difficult to process. Tasks that are complex are also more difficult to multitask than simple tasks (Gillie & Broadbent, 1989; Speier, Valacich, & Vessey, 1999), such that an interruption's higher complexity should cause greater disruption to a primary task than a less complex interruption. This previous research suggests that the nature of the interruption task must be taken into account when considering its potential impact on primary task performance.

Another issue is the difficulty resuming the primary task following the interruption. An interruption requires task switching from the primary task to the interruption and then again from the interruption to the primary task. As stated previously, individuals often forget to return to the primary task following an interruption—more than 50% of the time, according to a study by O'Connaill and Frohlich (1995). Individuals also may have difficulty remembering the state of the task or their position in the task prior to the interruption (McDaniel et al., 2004; Einstein, McDaniel, Williford, Pagan, & Dismukes, 2003; Zacks, Tversky, & Iyer, 2001; Edwards & Gronlund, 1998; Zeigarnik, 1967). This difficulty in task state recall, or prospective memory, can result in errors in executing the interrupted primary task (Tan, 2006; Gruen, 1996; Weick, 1990).

### 1.4.2 Reducing the Disruptive Impact of Interruptions

In human-computer interaction, a stream of work has focused on finding ways to time interruptions to reduce their disruptive impact.[1] McFarlane's (2002) research on

[1] Other work in HCI has focused on the design of notifications signaling an interruption request (McCrickard & Chewar, 2003; McCrickard, Catrambone, Chewar, & Stasko, 2003; McCrickard, Catrambone, & Stasko, 2001; Cutrell et al., 2001). This work suggests that the attentional demand

interruption examined four methods for delivering interruptions and each method's impact on the primary task. In his experiment, participants completed a primary task demanding continuous attention, the video-game-like "jumpers game." Participants were periodically interrupted during the jumpers game by a secondary matching task, thus creating a dual-task situation. The results showed that the interruptions harmed performance on the jumpers game when delivered immediately, but that performance improved when players were allowed to postpone their responses to the interruptions.

Results of McFarlane's studies (2002, 1999) and other previous work (Adamczyk & Bailey, 2004; Cutrell, Czerwinski, & Horvitz, 2001; Zacks & Tversky, 2001; Czerwinski, Cutrell, & Horvitz, 2000; Cutrell, Czerwinski, & Horvitz, 2000) suggests that it is possible to time interruptions appropriately in order to minimize their disruptive impact on the primary task. For example, in Cutrell et al.'s research (2001), experimenters interrupted participants by sending instant messages when they were searching a list. The interruption caused the least disruption if it occurred toward the end of the search task rather than toward the beginning. Other research shows that interruptions will generally be less disruptive if they occur at task and subtask boundaries (Adamczyk, Iqbal, & Bailey, 2005; Adamczyk & Bailey, 2004; Zacks & Tversky, 2001). This idea is based on event perception literature, which suggests that tasks are structured hierarchically and can be broken down into meaningful subtasks with detectable breakpoints (Zacks, Tversky, & Iyer, 2001; Zacks & Tversky, 2001).

The implication of this research is that there are certain points in a task when interruptions are less disruptive than others. Given the correct information, workers can properly time interruptions so that they obtain the information that they need while minimizing the disruption that they cause (Teasley, Covi, Krishnan, & Olson, 2000). With appropriate motivation, they may use this information to improve synchronization of their interruption attempts with receivers' ongoing tasks.

## 1.5 Technology for Controlling Interruptions

Three generic techniques have been applied to control the disruption associated with spontaneous interaction: (1) providing the receiver of the interruption with filtering and

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of a notification design should correspond with the importance of the notification content. We focus in the work presented on the issue of interruption timing versus notification design.

other technologies to control the volume, nature, and timing of incoming communications; (2) imposing norms or providing information displays to synchronize interruption attempts with periods when the receiver is not intensively engaged in a task; and (3) manipulating economic and other incentives in order to reduce the volume of communication sent by interrupters and increase their selectivity. I will concentrate here on the first two of these, which are techniques suited to intra-organizational communication.

### 1.5.1 Filtering and Context-Aware Systems

Answering machines, email filters, and more sophisticated technologies (Hudson, Fogarty, Atkeson, Avrahami, Forlizzi, Kiesler, Lee, & Yang, 2003; Horvitz, Jacobs, & Hovel, 1999) are concrete attempts to increase the control that a receiver of an interruption has over incoming communications. Context-aware systems typically use sensors in the environment to detect features of an individual's current activity (e.g., ambient noise level in a room, keyboard activity, motion, etc.) and translate this sensor data into an assessment of what the individual is doing, the individual's current workload, or the individual's availability for a communication interaction (Bailey, Adamczyk, Chang, & Chilson, 2006; Fogarty, Hudson, Atkeson, Avrahami, Forlizzi, Kiesler, Lee, & Yang, 2005a; Fogarty, Lai, & Christensen, 2004; Hudson et al., 2003; Dey & Abowd, 2000; Horvitz et al., 1999). These systems allow the user to filter communication to arrive during pre-specified activities or when the user is under some interruption threshold as detected by the system (Horvitz, Koch, Sarin, Apacible, & Subramani, 2005; Horvitz, Koch, & Apacible, 2004; Horvitz & Apacible, 2003; Horvitz, Kadie, Paek, & Hovel, 2003; Horvitz, Koch, Kadie, & Jacobs, 2002; Horvitz et al., 1999).

While granting control to the receiver in this manner is likely to help conserve the receiver's attention, it does not honor the often legitimate needs that an interrupter may have for the receiver's time and attention. Receivers (or their software surrogates) are forced to make decisions about communication based on one-sided information. They know how busy they are, but they do not know the nature, urgency or importance of the incoming communication.

### 1.5.2 Mechanisms for Synchronization

Mechanisms for synchronization, which deliver communication when receivers are least busy, can improve productivity and help interrupters without harming communication

receivers. Two mechanisms are discussed here: scheduling communication and displays of recipient availability.

#### *1.5.2.1 Scheduling Communication*

Perlow (1999), in her study of software engineers, conducted a field experiment in which certain times of the day were designated for individual work (when people could not interrupt each other) and for interactive work (when people could interrupt each other). This synchronization mechanism had positive effects on productivity (Perlow, 1999).

While both engineers and their managers appreciated this regime of quiet times and interactive times, they were not able to maintain the regime and gradually reverted to their highly interactive, highly interruptive, crisis-driven pattern of communication. This backsliding may have happened because the temporal grain size was too coarse. The synchronization regime required all engineers in a unit to postpone their communications until the interactive period, even if an individual had an urgent question and a potential receiver had free time.

#### *1.5.2.2 Media Spaces and Awareness Displays*

Other researchers have attempted to build displays that show potential interrupters the attentional states of their receivers. These displays allow individual communicators to time their interruptions to occur during the receivers' idle states, providing for a more fine-grained synchronization than the regime instituted by Perlow (1999).

For example, Hudson and Smith (1996) built visual indicators that showed if someone were engaged in conversation but that did not revealing the interrupter's identity. (also Wiberg & Whittaker, 2005; Isaacs, Walendowski, Whittaker, Schiano, & Kamm, 2002; Tang, Yankelovich, Begole, Van Kleek, Li, & Bhalodia, 2001; Erickson & Kellogg, 2000; Greenberg, 1996.) The notion that the visibility of others' actions is useful for coordinating joint activity has been discussed in previous literature on designing computer systems for distributed collaborative work (Malone, Grant, Turbak, Brobst, & Cohen, 1987). There is, however, no empirical evidence yet that demonstrates that awareness displays help to synchronize communication.

In the early 1990s, for example, the goal of many research projects was to extend the benefits of spontaneous communication, which happens naturally in collocated settings, to distributed work groups (Abel, 1990; Dourish & Bly, 1992; Fish, Kraut, Root, & Rice,

1993; Tang, Isaacs, & Rua, 1994; Whittaker, Frohlich, & Daly-Jones, 1994). An interesting side effect of these types of systems was that they provided communication initiators with fairly low-cost, continuous access to respondents. For example, in the field trial of the Cruiser system (Fish et al., 1993), individuals who wanted to initiate communication would "camp out" in a receiver's office, leaving open the video stream of the receiver's office space so that they could communicate with them as soon as they returned. In fact, the goal in much of the computer-supported collaborative work (CSCW) work of the 1990s was to increase communication through displays that showed someone's availability rather than through regulation of communication (Kraut, Fish, Root, & Chalfonte, 1993).

At the same time, the displays used in media spaces and other awareness systems have the potential to impose considerable attentional cost on the initiator (McCrickard & Chewar, 2003; Hudson & Smith, 1996). The cost that this may have on the performance of primary work tasks may supersede the benefits of connectivity. It would be difficult to imagine a bond trader, for example, watching full video of a co-worker's office terminal instead of attending to continuous changes in the stock market.

## 1.6 Research Approach

The work presented here utilizes a combination of laboratory and field approaches to examine the coordination problem. Studying communication interactions in the laboratory allows us to quantify attention and performance as well as manipulate factors like workload, which are difficult to measure and almost impossible to manipulate in a field setting. In addition to these laboratory studies, we make use of a survey approach to gathering data on email usage. This approach allowed collection of data across large numbers of individuals in a variety of organizations and job types. Studying an established mode of computer-mediated communication (CMC) like email illuminated some basic principles about CMC usage and its role in ongoing work activities. This mixed method lab and field based approach allows for comparison between results found in the lab and those found in the field.

## 1.7 Dissertation Organization

This chapter has illustrated a high-level model of the decision to initiate and respond to communication and has discussed relevant prior work. Subsequent chapters will look at portions of this model in more detail. Here is a road map to subsequent chapters:

**Chapter 2** describes results from a pair of laboratory experiments focused on sender-side decision-making, particularly how a sender takes into account a receiver's current status. Results indicate that awareness displays containing information about a remote collaborator's workload lead to communication attempts that are less disruptive, but only when the interrupter has incentives to be concerned about the collaborator's welfare.

**Chapter 3** describes results from two laboratory studies focused on sender-receiver trade-offs. The first study examines sender prioritization and receiver response behavior, comparing the utility of two methods for delivering incoming communication notifications as well as the use of visibility of a sender's task value to better coordinate response. The second study focuses on receiver decision-making, particularly how current task state and a common social identity with the sender affects prioritization of messages for response.

**Chapter 4** describes results from a survey of email use across a variety of organizations that focuses on receiver-side decisions about attention to email. In particular, we focus on how the receiver's relationship with the sender and the message content affects the perceived work importance of a communication and resulting action on the communication (i.e., speed of response and retention).

**Chapter 5** concludes with a discussion of findings from the studies presented, pointers for future work, and closing remarks.

# Chapter 2

# Awareness Displays and Social Identity*

## 2.1 Overview

Work life is filled with interruptions, most of which benefit the interrupter more than the one who is interrupted. This problem is greatest with remote collaboration because team members interrupt blindly, without contextual information about the potential collaborator's availability. Awareness displays are new technology designed to provide distributed workers with up-to-date status information about their group members. Results from a pair of laboratory experiments indicate that awareness displays containing information about a remote collaborator's workload lead to communication attempts that are less disruptive, but only when the interrupter has incentives to be concerned about the collaborator's welfare. Furthermore, the attentional demand of the awareness displays themselves needs to be taken into consideration because too much detail may distract those viewing the display from their primary task. In this set of studies, interrupters spent significantly more time looking at the most detailed-filled displays, which harmed their task performance. We conclude that a display with an abstract representation of a collaborator's workload is best; it leads to better timing of interruptions without overwhelming the person viewing the display.

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* Parts of this chapter are adapted from Dabbish and Kraut (2004).

## 2.2 Awareness Display Design and Usage

Given the overall model of the factors that influence senders' and receivers' willingness to engage in a communication, as laid out in Chapter 1, we focus in this chapter on the ways in which senders use information about receivers' work activities as well as the designs of displays that can provide this information because these displays influence the sender's perception of the receiver's availability and therefore the potential disruption to the receiver's work. The displays are especially important in distributed work settings, where causal observation is insufficient to assess a receiver's workload. The theoretical framework for this chapter is presented in Figure 2.1.

### 2.2.1 Communication Timing and Performance

Previous work suggests that it is possible to interrupt people at times that minimize the disruptive impact that the interruptions have on a receiver's ongoing work (e.g., Gillie & Broadbent, 1989; Speier, Vessey, & Valacich, 2003). For example, programmers are more productive in debugging if they are not interrupted during periods of peak concentration (Fogarty, Ko, Aung, Golden, Tang, & Hudson, 2005b), and interruptions are generally less disruptive if they occur at task and subtask boundaries (Adamczyk & Bailey, 2004). Thus, it follows that if the sender is attempting to minimize the impact on the receiver, the former should attempt communication at times when the receiver is free (e.g., not deeply engaged in a higher priority task) and that doing so will lead to better performance on the receiver's primary task. The rest of our theory on initiating interaction rests on this assumption, which we validate in the experiments described in this chapter:

> **Assumption 1**: Interruptions that arrive during periods of low workload will lead to higher performance for the receiver than interruptions that arrive during periods of high workload.

### 2.2.2 Design of Awareness Displays

To synchronize communication with a receiver's availability, the sender needs feedback about the receiver's task and attentional state (Figure 2.1). In co-located settings, this information is often obtained by glancing into someone's office (Fish et al., 1993). In a distributed situation, an awareness display showing the receiver's availability could provide similar information. Designers must deal with two problems in creating this kind of awareness display: (1) interpretability and (2) attentional demand.

Communication systems for distributed work during the 1990s often showed a full video stream of a collaborator's office so that those who wanted to communicate could easily understand when others were present and what they were doing before attempting to communicate with the receiver (Tang et al., 1994; Fish et al., 1993; Abel, 1990). Because this level of detail can violate the receiver's privacy and can be distracting to the sender, follow-up research involved displays with a more abstracted view of co-workers' current activities (Cadiz, Venolia, Jancke, & Gupta, 2002; Milewski & Smith, 2000; Hudson & Smith, 1996; Isaacs, Tang, & Morris, 1996; Dourish & Bly, 1992). The experiments in this chapter attempt to establish the relationship between information abstraction, the accuracy of the decision to communicate, and attentional demands in order to understand the trade-offs involved in designing awareness displays.

#### *2.2.2.1 Display Utility*

The sender needs information about the receiver's availability and workload to synchronize the communication request with periods when the receiver has a low workload. A display with no information about the receiver's availability would harm the receiver because the sender would have little basis for making decisions about when to interrupt, as suggested in Assumption 1. In contrast, displays that provide more information about availability should benefit the receiver because this information allows the sender to synchronize interruptions with periods of low workload, also as suggested in Assumption 1, thus minimizing a disruptive impact on the receiver's performance. This suggests Hypothesis 1:

> **Hypothesis 1**: Displays showing the receiver's workload will allow the sender to time the communication so that the communication arrives during a period of low workload in the receiver's task.

However, there are limits to the amount of information that senders can effectively use to assess a receiver's workload. For example, studies have shown that people cannot effectively use more than two information sources when making decisions and that the availability of more than two sources can lead to errors because of the effort required to search and integrate the cues available (Wickens, Gordon, & Liu, 1998; Dawes, 1979). Displays to facilitate information monitoring for decision-making purposes should present only the information specifically required for a decision rather than all possible system cues (Wickens et al., 1998). These previous findings suggest Hypothesis 2:

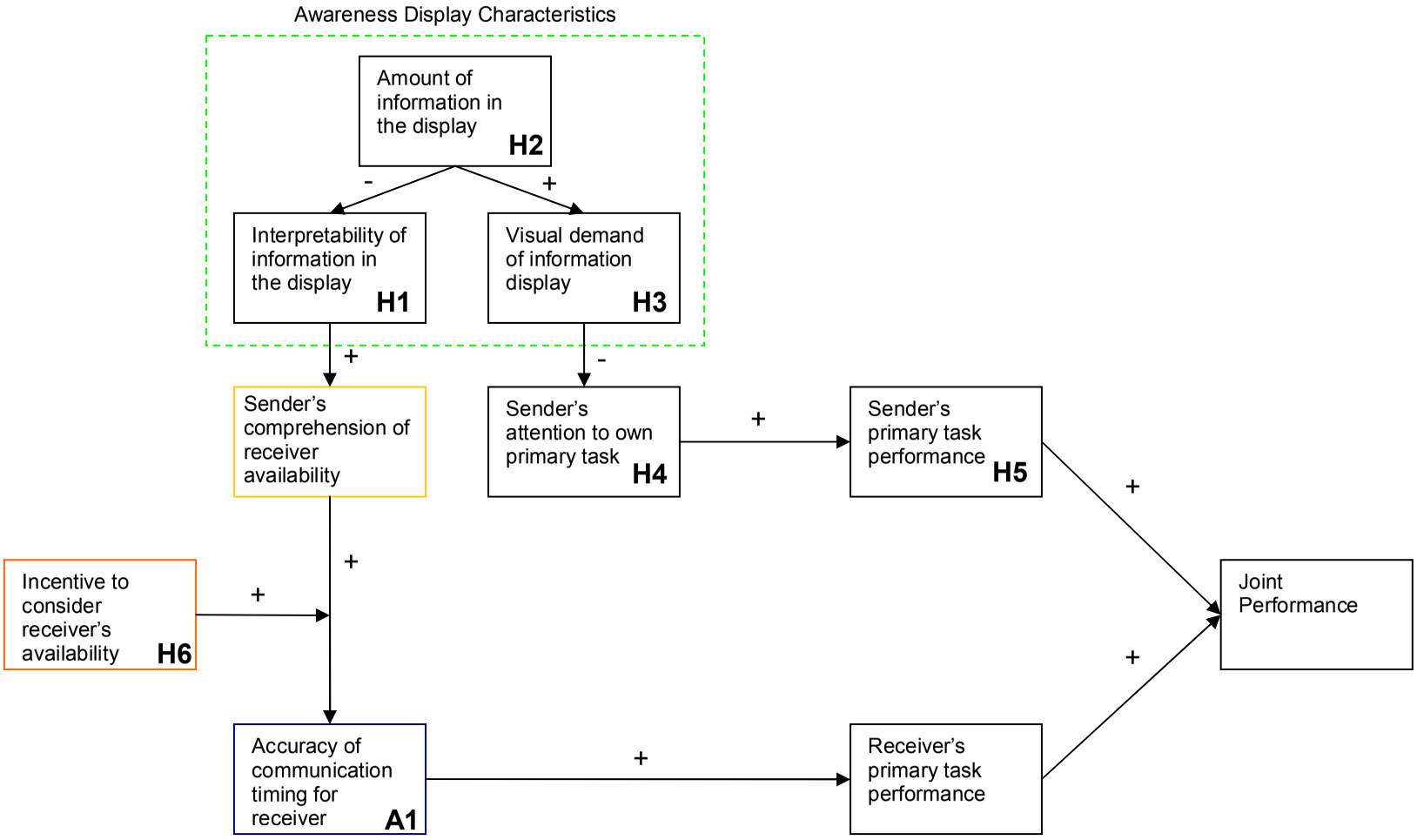


Figure 2.1. Conceptual framework: Awareness display use and performance.

> **Hypothesis 2**: Abstracted information displays that show a simple representation of the receiver's workload should allow the sender to assess availability and time the communication so that it arrives during periods of low workload equally as well as a full video display that shows more information about a receiver's work activities.

#### *2.2.2.2 Attentional Demand*

Studies of attention in perceptual psychology have shown that increases in the number of visual elements and movement (Paschler, 2001; Wickens et al., 1998) make visual stimuli more distracting or attention-grabbing. In addition, large numbers of visual elements increase the visual search time required to filter and process relevant cues (Wickens et al., 1998). These considerations suggest the following hypothesis:

> **Hypothesis 3**: An increase in the amount of information in a visual display (with respect to the number of elements and movement) will increase the amount of visual attention required to attend to the display and obtain information from it.

If abstract displays are sufficient for the sender to make good decisions about when to interrupt (Hypothesis 2) and if movement and large numbers of visual elements in the display distract the sender (Hypothesis 3), then rich awareness displays will cause the sender to divide attention between the display and a primary task, which should in turn harm the sender's performance on the primary task (Wickens et al., 1998) without any added benefit for the receiver.

> **Hypothesis 4:** Increased visual attention demand from an awareness display will significantly reduce the sender's attention to the primary task.

> **Hypothesis 5:** Decreased attention to the sender's primary task should result in decreased primary task performance by the sender on continuous attention tasks.

### 2.2.3 Incentive to Care about Receiver's Welfare

Frequently, senders of communications and their receivers have incompatible incentives (Kraut & Attewell, 1997). The information that receivers can provide is often worth more to the sender than to the receiver. When senders have no stake in receivers' performances, they have no motivation to delay communication attempts to be convenient for receivers. It follows, therefore, that senders will use awareness displays to

time communications to be convenient to receivers primarily when the senders are concerned about disruption to the receivers' work (Figure 2.1).

Previous research suggests that if a sender and a receiver were in a group with outcome interdependence, their common social identity and common rewards could motivate the sender to honor the receiver's needs for both altruistic and self-interested reasons (Gaertner & Insko, 2000; Henry, Arrow, & Carini, 1999). For example, members of self-managed teams are mindful of the activities of their peers and strive to benefit the group as a whole because team membership is emphasized and teams are rewarded based on the overall team performance, rather than on their individual performance (e.g., Van der Vegt, Emans, & Van de Bliert, 1998).

> **Hypothesis 6:** Common social identity and outcome dependence will cause the sender to use awareness displays to time communication so that it arrives during periods of low workload for the receiver.

To validate our assumptions and test each of the six hypotheses as stated above, we designed and performed two controlled experiments. In both experiments, a pair participated in a stylized instantiation of the help-seeking situation between two work colleagues. The experiments varied both the amount and the presentation of information that the sender had about the receiver's workload and whether the sender perceived to be part of a common team with the receiver or to be independent. Even though the tasks used in this laboratory setting were stylized and do not correspond in detail to work done in real organizational settings, the tasks capture many features of organizational work in which one person's attempt to complete an assignment has implications for a colleague's ability to complete other work. The experimental settings and tasks allowed us to independently assess the impact of a workload display on team collaborators' performances by controlling the situation to manipulate only those factors of interest (e.g., display design and social identity).

## 2.3 Experiment 1

### 2.3.1 Procedure

In Experiment 1, two subjects played a stylized game where one (the sender) was informationally interdependent with the other (the receiver). The sender tried to guess the identity of pictures as they were slowly revealed and was allowed to ask the receiver for

hints by sending messages over the computer. Doing so interrupted the receiver, who was engaged in a variant of McFarlane's (2002) jumpers game. The experiment varied the amount of information that senders had about the receivers' workload and whether the senders perceived that they and the receivers were or were not on a team. The experimental design was a 3 (awareness information) by 2 (team manipulation) mixed design, with the awareness information manipulated within subjects and the team manipulated between subjects.

#### *2.3.1.1 Task*

The sender's task was to quickly and correctly guess the identity of a partially obscured picture (640x426 pixels) as it was slowly uncovered (Area D of Figure 2.2a). Small black squares (8x8 pixels) covering the image were gradually removed over four minutes while "clues," or random larger squares of the picture (40x40 pixels), were revealed and then hidden again. The game consisted of three rounds, during each of which the sender had to guess the identity of four different pictures.

The receiver's primary task was the jumpers video game used by McFarlane (2002). (left side of Figure 2.2b.) The receiver attempted to save jumpers as they fell from a building by catching them on a stretcher and bouncing them to the ambulance. The receiver's score was based on the number of saved jumpers. The receiver's workload varied from zero to nine jumpers on-screen simultaneously, with new jumpers arriving at random intervals.

The receivers were given a copy of the pictures that senders were trying to guess and thus became experts with access to information that the senders needed. (See right side of Figure 2.2b.) The senders and receivers were seated in separate rooms, and the senders were able to send the receivers 20 yes/no questions over the computer about the picture they were attempting to identify. The senders were informed that these questions took over the receivers' screens until they were answered, covering their primary task and interrupting the receivers' ability to save jumpers.

This design required both the receivers and the senders to continually attend to their primary tasks in order to achieve optimal performance. Interruptions interfered with the receivers' ability to save jumpers. Distraction on the senders' side prevented them from seeing important clues and thus interfered with their ability to identity the picture.

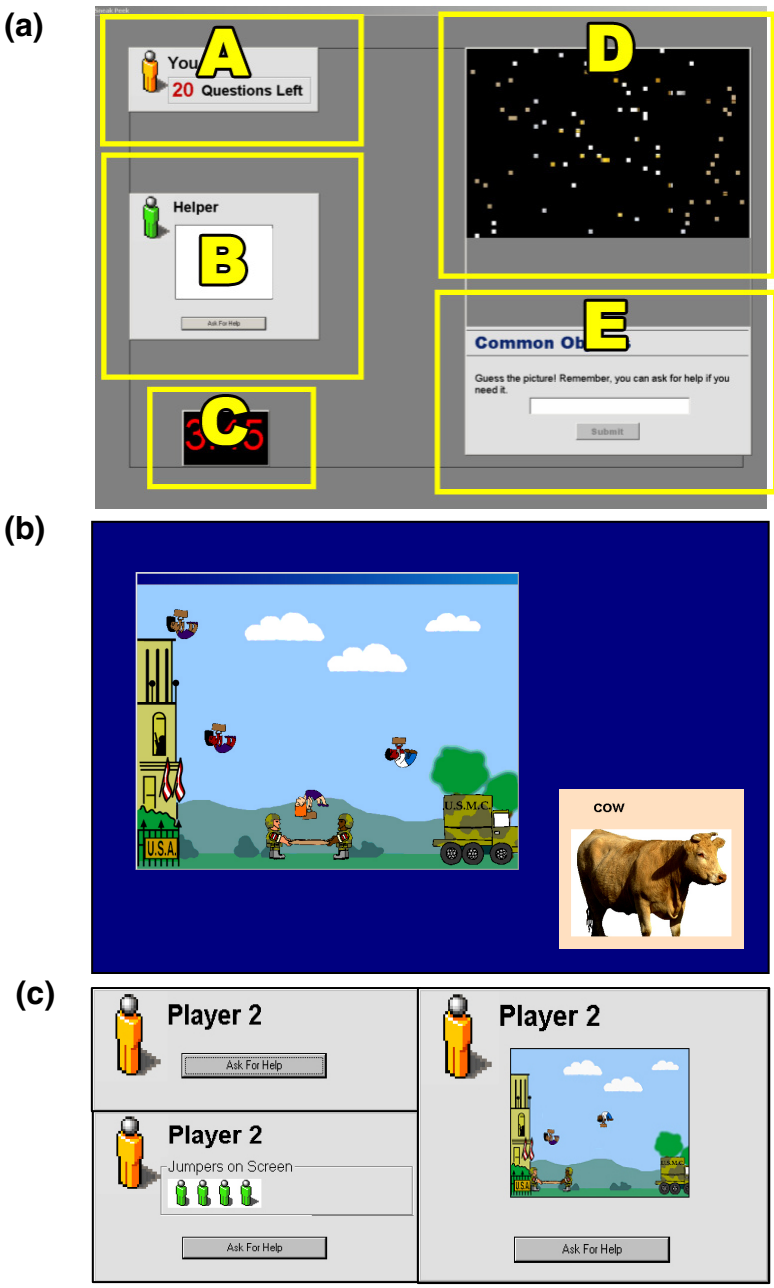


Figure 2.2. From top to bottom: (a) sender's screen in experiment (note: yellow highlights indicate the regions for eye tracking and were not visible to participants); (b) receiver's screen in experiment; and (c) awareness display conditions (counter-clockwise from top left: *no display, abstract, full*).

#### *2.3.1.2 Participants*

Thirty-six sender-receiver pairs (72 individuals) were recruited from local universities. The participants' mean age was 23 years (std. dev. = 5), and 53 percent were male.

#### *2.3.1.3 Awareness Display*

We tested Hypotheses 1 and 2 about the usefulness of awareness displays and Hypotheses 3 through 5 about the attentional demand of the displays by manipulating within subjects both the amount of information that the senders had about the receivers' workload (the number of jumpers currently on-screen) and the presentation of that information. In the **no display condition**, the senders received no information about the receivers' current task. The no display condition was used as a control for comparison purposes. In the **abstract display condition**, the senders saw icons representing the number of jumpers on the receivers' screens. In the **full display condition**, the senders saw a 2.5"x2.5" real-time replicate of the receivers' screens, implemented as a Virtual Network Computing (VNC) (RealVNC, 2002) window on their computers. Both the abstract and full display conditions provided information about the number of jumpers on-screen, the primary determinant of the receivers' workload. However, we expected the full display to be more distracting because it contained more visual elements and movement. Figure 2.2c shows each of the three awareness displays. Each subject saw each of the three awareness display conditions during one round of the game, with display order counter-balanced using a Latin square design.

#### *2.3.1.4 Team Orientation*

To test Hypothesis 6 that common social identity and outcomes with the receiver would cause the sender to use information displays to time interruptions, we manipulated between subjects whether or not senders perceived themselves to be part of a team with the receivers.[2] In the independent condition, senders were rewarded based on their individual performances, were told that they were competing with the receivers for a fifty-dollar prize, and wore a jersey of a different color from the receivers'. In the team condition, senders were rewarded based on the average of their and the receivers' performance, were told that they were on teams with the receivers and that they were competing as a team against other teams for the fifty-dollar prize, and wore jerseys that matched the receivers'.[3, 4]

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[2] In all conditions, the receivers were told that they were on teams with the initiators and that they would be rewarded based on the average of their performances. This was done to control the receiver's motivation to respond to requests.

[3] It is important to note that, in both the independent and team conditions, receivers were blind to the initiators' conditions. They were always informed that they were on a team with the initiators. This was done to control for any effect of team membership on the receivers' behavior in

#### *2.3.1.5 Dependent Measures*

To assess the performance benefits and costs of awareness information, we analyzed the rate and timing of the senders' questions as well as their effect on both players' performances. Because the behavioral measures of question rate and timing directly relate to the research questions, but were not part of the participants' incentive structure, they were examined to reveal the impact of the manipulations of interest. The senders also described their strategies for timing interruptions via open-ended self-report questions, providing insight into the interruption decision-making process.

#### *2.3.1.6 Analysis*

A pair's performance on an individual picture was the unit of analysis. There were 432 pictures (36 pairs x 3 display conditions x 4 pictures per display). Because each pair worked on multiple pictures, we analyzed data using a repeated measure mixed-model analysis of variance, with participant-pairs as a random effect. In analyzing the effects of the display manipulation, we computed two single-degree-of-freedom contrasts. The first compared the abstract and full information display conditions to the no-display condition to test whether simply providing the senders with information about the receivers' workload influenced performance (Table 2.1, "No Display vs. Display"). The second compared the abstract display to the full display to test whether the amount of information differentially influenced performance (Table 2.1, "Abstract vs. Full").

### 2.3.2 Results

#### *2.3.2.1 Manipulation Check*

Senders completed a 12-item survey measure of group identity to check the effectiveness of the team manipulation (Henry et al., 1999). The inter-item reliability for the measure was satisfactory (Cronbach's alpha = .85). Although the senders in the team condition identified more strongly with their partners than did senders in the independent condition (Means: Team = 5.07, Independent = 4.67, SE = 0.16), this difference was only marginally significant with ($t(36) = 2.03$, $p = 0.09$) and with a moderate effect size (Cohen's $d = 0.42$) (Rosenthal & Rosnow, 1991). Follow-up analysis showed that the team involvement manipulation did not influence either the senders' or the receivers'

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answering questions from the initiators. The receivers' goal was to equally weight the importance of the jumpers game task and the importance of the incoming questions.

[4] Previous work in social psychology has used matching jerseys during laboratory experiments to instill feelings of common social identity among participants (Kane et al., 2005).

performances. This suggests that the team manipulation was not successful, so we will not further discuss the results from Experiment 1 with respect to the team manipulation.

Table 2.1. Performance Results for Experiment 1

| Row | Dependent variable | | Display condition means | | | Differences among conditions | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | No Display | Abstract | Full | No Display vs. Display | | Abstract vs. Full | |
| | | N | | | | F(SE) | *p* | F(SE) | *p* |
| A | Initiator Interruption timing (probability of jumpers on screen during interruption) | 432 | 0.75 [a] | 0.43 [b] | 0.42 [b] | 35.7 (0.063) | <0.001 | 1.78 (0.072) | 0.18 |
| B | Initiator Interruptions sent per minute | 432 | 1.046 [a] | 1.042 [b] | 1.036 [c] | 12.5 (0.007) | <0.001 | 8.38 (0.007) | 0.004 |
| C | % Jumpers saved by Targets | 432 | 70.7 [a] | 75.4 [b] | 74.6 [b] | 5.52 (0.018) | 0.02 | 0.04 (0.02) | 0.84 |
| D | Accuracy of Initiators' puzzle performance | 432 | 0.79 [a] | 0.80 [a] | 0.78 [a] | 0.06 (0.042) | 0.8 | 0.24 (0.048) | 0.62 |
| E | Time for Initiators' puzzle performance | 432 | 110 [a] | 105 [a] | 121 [b] | 0.24 (6.69) | 0.62 | 4.06 (7.73) | 0.04 |

### *2.3.2.2 Display Utility*

#### *2.3.2.2.1 Communication Timing*

Hypothesis 1 predicted that awareness displays showing receivers' workload would allow senders to interrupt during periods of low workload for the receiver, resulting in improved receiver performance. To test this hypothesis, we compared the number of jumpers that receivers had on-screen during a communication attempt in the abstract display and full information conditions compared to the no display control condition. The senders in the abstract display and full information conditions attempted communication when the receivers were under less workload than those senders in the no display control condition. The abstract and full display conditions did not differ from each other. For means and statistics, see Table 2.1, Row A.

#### *2.3.2.2.2 Interruption Rate*

We also looked at the number of questions that the senders sent per minute to calculate the interruption rate. As shown in Row B of Table 2.1, the interruption rate significantly decreased as the senders received more information about the receivers' workload. They asked 7% fewer questions per minute in the abstract display condition than in the no information condition and 14% fewer in the full information condition than in the abstract condition. This result suggests that by waiting until a good time to interrupt, the senders sent fewer interruptions as a side effect.

##### *2.3.2.2.3 The Receiver's Performance*

Consistent with Assumption 1, the awareness displays that enabled the senders to send questions during periods of low workload improved the receivers' performance. Receivers were able to save approximately 7% more jumpers when senders were using the abstract display or full information awareness display than in the no display control condition. (See the "Display vs. No Display" contrast in Table 2.1, Row C.) Consistent with Hypothesis 2, there was no significant difference between the abstract display and full information condition for the number of jumpers on-screen when a message was sent (Table 2.1, Row A) and no significant difference in the receiver's performance as the amount of information in the display increased from abstract to full (Table 2.1, Row C).

#### *2.3.2.3 Attentional Demand*

The prior analyses indicated that senders used both types of awareness displays to time their questions in ways that benefited the receivers' task performance and that the abstract and full displays were equivalent in this regard. Were they also equivalent in their effects on the senders' task performance?

##### *2.3.2.3.1 The Sender's Performance*

The sender's performance was measured by the correctness on the picture identification task and the time that it took, in seconds, to identify each picture. As Row D in Table 2.1 indicates, the display conditions had no effect on a sender's ability to correctly identify pictures; however, the displays did influence the senders' speed. Senders took 12.5% longer to guess pictures in the full information condition than in the abstract display condition or the no information condition (Table 2.1, Row E).

##### *2.3.2.3.2 Self-Report Data*

We obtained some qualitative data to get a better sense of the nature of awareness display use. Senders described their strategies for deciding when to send questions to their receivers in response to an open-ended question asked immediately after using each type of awareness display. In the abstract display condition, 60.8% of senders reported using the display to decide when to send questions to their partners. Because the only information that they received during this condition was the number of jumpers on the receivers' screens, all of them reported asking questions when the number of jumpers was below some threshold. For example, they described rules such as "When there was only one person on the jumper indicator," "When there was one jumper. [Otherwise] I tried to

ask as few questions as possible and to figure out the picture on my own," or "When there were two or less [sic] jumpers."

In the full display condition, 67% of senders reported using the display to determine when to send questions to their partners. Senders' strategies were more complex in the full display condition than in the abstract information condition. They reported taking into account more detailed information about the receivers' task states than the number of jumpers as well as using more complex rules. For example, senders reported the following question-sending heuristics:

> "…if the current position of the net was okay or had to be moved soon."
>
> "Whenever she had people at the apex of their bounce or if there was a break in the jumpers."
>
> "Tried to do it when the people were higher in the air so they had time to answer without losing a person."

### 2.3.3 Summary

The results from the first experiment showed that providing an interrupter with information about a remote partner's workload, in the form of an awareness display, benefited the remote partner's performance. Increasing the realism of the workload display did not result in additional benefit for the remote partner. Interrupters used the additional information available in the full display to form more complex strategies to time their interruptions. It was either these complex strategies or the greater perceptual complexities in the full display that harmed the interrupter's own performance without improving the partner's performance.

## 2.4 Experiment 2

The results from Experiment 1 left several open questions, which we sought to answer in Experiment 2. In Experiment 1, the team manipulation was not successful, so we could not test whether incentives influence senders' use of awareness displays to time communication (Hypothesis 6). Experiment 2 was designed to include a more compelling manipulation of team identity and joint outcomes.

In addition, Experiment 1 indicated that the full information display harmed task performance for those using it (corresponding with Hypothesis 5). However, Experiment 1 included no direct measures of attention, preventing us from identifying the root of this performance deficit and testing Hypotheses 3 and 4. In Experiment 2, we used eye tracking to measure the amount of attention required by the various displays. By examining the amount of time spent looking at the various awareness displays, we could test whether the full information display consumed more attention than the abstract information display.

### 2.4.1 Procedure

#### *2.4.1.1 Task*

Experiment 2 utilized the same laboratory task as Experiment 1, but with a modified reward structure. In Experiment 2, senders were rewarded based on the time that they took to guess the contents of each picture being revealed and not simply on whether they identified the picture correctly, as in Experiment 1. By rewarding the senders based on time as well as accuracy, we highlighted the conflict that they might experience between getting help quickly and waiting for a lull in the receivers' workload. We also lengthened the duration of each interruption so that questions stayed on the receivers' screens for at least five seconds. Analysis of the jumpers game showed that a five-second interruption caused, on average, the loss of one jumper, whereas a one- or two-second interruption, which was typical of Experiment 1, often did not cause the loss of any jumpers. The longer interruption allowed us to better observe the effect of senders' interruption timing on receivers' performance.

#### *2.4.1.2 Awareness Display*

Experiment 2 used, within subjects, the same three awareness display conditions used in Experiment 1 (no display, abstract display, and full information display). As in Experiment 1, each subject saw each of the three awareness display conditions during one round of the game; display order was counter-balanced using a Latin square design.

#### *2.4.1.3 Team Orientation*

As in Experiment 1, we manipulated between subjects whether the senders were independent and received individual rewards or were part of a team and received joint rewards. In the team condition, senders were rewarded based on the average of their score with their receivers'; they were told that they were on a team with their receivers, that

they were competing as a team against other teams for a fifty-dollar prize, and that they and their receivers wore matching jerseys. To enhance their feelings of attachment to their partners, we showed senders in the team condition photographs of their partners sitting in front of a computer playing the jumpers game (Walther, Slovacek, & Tidwell, 2001) with the explanation that we wanted them to see what their partner would be doing. Work on CMC has shown that participating in getting-acquainted activities with a virtual partner results in almost the same level of trust development as face-to-face meeting (Zheng, Veinott, Bos, Olson, & Olson, 2002). To increase the likelihood of such a bond developing, senders in the team condition also participated in a structured social chat with confederates whom they believed to be their partners. They were instructed to exchange information with their partner in response to a list of get-acquainted questions such as "What is your major?", "What did you do last weekend?", and "What is your favorite restaurant in this city?" For each question, they first sent the question to their partners, received a response, were asked the question by their partners, and then provided their own answers. Confederates acting as their partners responded by sending back randomly selected answers recorded from the chat logs of naive participants answering the same series of questions.

In the independent condition, senders were rewarded based on their individual performances, were told that they were competing against all other senders for a fifty-dollar prize, and wore a jersey of a different color than their receivers'. To avoid any experimenter effects that would confound the differences between the team and independent senders, participants in the independent condition were shown a picture of a person who had completed the experiment in the past and were told this was to illustrate their partners' task set-up. They also answered the same questions used in the team condition social chat via a static web-based form.[5]

#### *2.4.1.4 Analysis*

Players' performance during an individual picture puzzle was the unit of analysis, except where noted. We recorded participants' actions on 396 puzzles (33 pairs x 3 display

[5] It is important to note that in Experiment 2, as in Experiment 1, during both the independent and team conditions, receiver were informed that they were on a team with the other players. This was done to control for any effect of team membership on the receivers' performance in answering questions from initiators. The receivers' goal was to equally weight the importance of the jumpers game task and the importance of the incoming questions from their partners.

conditions x 4 picture puzzles per display). Again, we used a repeated measure mixed-model analysis of variance to analyze the data and to handle the non-independence of observations. To examine the consequence of awareness displays, we calculated one-degree-of-freedom planned contrasts to compare the condition with no display (No Display) to the conditions where a display was visible (Abstract and Full) (Table 2.2, "No Display vs. Display") and to contrast the abstract display condition with the full display condition (Table 2.2, "Abstract vs. Full").

#### *2.4.1.5 Measuring Attentional Demand*

We calibrated a visor-mounted ISCAN ETL-500 gaze tracking system to record the number and duration of senders' gaze fixations in various regions of their computer screens (see Figure 2.2a) with a fixation threshold of 50 milliseconds (Jacob & Karn, 2003). In particular, we were interested in the amount of time that the senders spent looking at their puzzles (region D) versus the awareness display (region B).

The eye-tracking measures that were recorded were proportion fixations and mean fixation duration. *Proportion of fixations* is the number of fixations on a particular display element of interest relative to the total number of fixations. Because people fixate more often on display elements that they consider important, this measure is generally treated as a measure of the visual importance of an element (Jacob & Karn, 2003). *Mean fixation duration* is the average length of a fixation on an area of interest. It is generally treated as an indication of a participant's difficulty extracting or interpreting information from an interface (Jacob & Karn, 2003).

Eye-gaze data were collected from the senders for an entire round (four puzzles), so the unit of analysis for the eye-tracking data is one round in the game. Due to calibration problems, we excluded gaze data from twelve participants. Thus the results with respect to visual attention come from 19 out of the 33 senders in Experiment 2. The number of rounds analyzed was 57 (19 pairs x 3 display conditions = 57). We used a repeated measure mixed-model analysis of variance to analyze the eye-tracking data, with participants treated as a random effect to control for the non-independence of rounds nested within pairs.

Table 2.2. Performance Results for Experiment 2

| Row | Dependent variable | | Team | | | No Team | | | Differences among display conditions | | Team | Display x team interactions | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No Display | Abstract | Full | No Display | Abstract | Full | No Display vs. Display | Abstract vs. Full | Team vs No Team | No Display vs. Display | Abstract vs. Full |
| | | N | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | F(SE) | F(SE) | F(SE) | F(SE) | F(SE) |
| A | Initiator Interruption timing (number of jumpers on screen during interruption) | 1480 | 1.95 [a] (0.089) | 1.60 [b] (0.093) | 1.69 [b] (0.096) | 1.98 [a] (0.081) | 1.93 [a] (0.085) | 2.02 [a] (0.089) | 4.50* (0.074) | 0.97 (0.089) | 9.71** (0.074) | 7.79** (0.110) | 0.43 (0.132) |
| B | Initiator Interruptions sent per minute | 390 | 1.64 [a] (0.174) | 1.53 [a] (0.174) | 1.36 [a] (0.174) | 2.05 [b] (0.183) | 2.04 [b] (0.180) | 1.80 [b] (0.179) | 2.42 (0.108) | 2.88 (0.210) | 4.67* (0.144) | 1.86 (0.144) | 0.96 (0.168) |
| C | % Jumpers saved by Targets | 390 | 53.2 [a] (2.79) | 59.2 [b] (2.78) | 63.3 [b] (2.79) | 50.3 [a] (2.92) | 53.2 [a] (2.87) | 54.4 [a] (2.86) | 11.03*** (1.75) | 1.76 (1.99) | 3.31 (3.28) | 11.32*** (2.40) | 2.18 (2.76) |
| D | Accuracy of Initiators' puzzle performance | 390 | 54.0% [a] (6.29) | 50.5% [a] (6.25) | 58.2% [a] (6.26) | 43.1% [a] (6.65) | 50.8% [a] (6.49) | 56.4% [a] (6.44) | 1.01 (5.36) | 1.19 (6.11) | 0.54 (5.61) | 0.002 (7.39) | 0.83 (8.51) |
| E | Time for Initiators' puzzle performance | 390 | 149 [a] (10.6) | 160 [a] (10.5) | 141 [a] (10.5) | 165 [a] (11.2) | 156 [a] (10.9) | 143 [a] (10.8) | 0.70 (8.72) | 2.57 (9.94) | 0.18 (9.88) | 0.006 (12.0) | 1.83 (13.8) |

Table 2.3. Eye-Tracking Results for Experiment 2

| Row | Dependent Variable | Element of interest | Team | | | Non-Team | | | Statistics | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | None | Abstract | Full | None | Abstract | Full | Abstract vs. Full | Team vs No Team | Display x Team Interaction |
| | | | | | | | | | F(1,33) | | |
| A | **Proportion of Fixations (percent)** | Awareness Display | 17.0[a] (1.61) | 17.0 [a] (1.61) | 17.8 [a] (1.61) | 16.0 [a] (1.89) | 16.2 [a] (1.89) | 21.2 [b] (1.89) | 5.91* (1.25) | 0.067 (2.02) | 1.9936 (1.65) |
| B | | Primary Task | 66.8 [a] (2.72) | 67.7 [a] (2.72) | 67.8 [a] (2.72) | 65.2 [a] (3.19) | 66.4 [a] (3.19) | 60.1 [b] (3.19) | 4.29* (1.49) | 0.85 (3.82) | 2.854 (1.9643) |
| C | **Mean Fixation Duration (msec)** | Awareness Display | 301 [a] (0.1433) | 288 [a] (0.1433) | 324[a] (0.143) | 332 [a] (0.168) | 275 [a] (0.168) | 343 [a] (0.168) | 1.85 (0.125) | 0.049 (0.1671) | 0.1806 (0.140) |
| D | | Primary Task | 306 [a] (0.149) | 298[a] (0.149) | 376[b] (0.149) | 335[a] (0.175) | 276 [a] (0.175) | 390[b] (0.175) | 4.77* (0.133) | 0.0099 (0.171) | 0.2114 (0.115) |

### 2.4.2 Results

#### *2.4.2.1 Manipulation Check*

Senders in Experiment 2 completed a 12-item survey measure of group identity to check the effectiveness of the team manipulation (Henry et al., 1999). The inter-item reliability for the measure was satisfactory (Cronbach's alpha = 0.82). Senders in the team condition identified more strongly with their partners than did senders in the independent condition (Means: team = 4.24, independent = 3.75, SE = 0.16, with $t(30) = 2.23$, $p<0.05$). Results indicate that the social identity manipulation was substantially stronger in Experiment 2 than in Experiment 1, with a 26% increase in effect size (Cohen's d = 0.53) (Rosenthal & Rosnow, 1991).

#### *2.4.2.2 Display Utility*

##### *2.4.2.2.1 Communication Timing*

Hypothesis 1 predicted that awareness displays showing a receiver's workload would allow a sender to interrupt during periods of low workload. To test this hypothesis, we again compared the number of jumpers that receivers had on-screen during a communication attempt in the abstract and full information conditions compared to the no display control condition. Consistent with Hypothesis 1 and the results from Experiment 1, when senders had awareness displays (either abstract or full), they were more likely to pose their questions during periods when receivers had fewer jumpers to manage (Table 2.2, Row A). However, as also shown in Row A of Table 2.2 and in Figure 2.3a, the effects of the awareness displays depended upon the team manipulation. The awareness displays caused senders to communicate during periods of low workload only in the team condition, but not in the individual condition.

##### *2.4.2.2.2 Interruption Rate*

Senders asked fewer questions per minute of the receivers in the team condition than in the individual condition (Table 2.2, Row B). However, unlike in Experiment 1, senders asked approximately the same number of questions per minute when they had information about the receivers' workload (abstract and full display conditions) as when they did not (no display control condition) (Table 2.2, Row B).

##### *2.4.2.2.3 The Receiver's Performance*

Consistent with Hypothesis 1 and Assumption 1, receivers' performance improved significantly when senders received information about receivers' workload and used that

information (Table 2.2, Row C). They were able to save approximately 10% more jumpers in the abstract and full display condition than in the no display condition. Receivers saved 11% more jumpers in the team condition than in the independent condition (Table 2.2, Row C).

These main effects of the display and team manipulations must be qualified by the significant display-by-team interaction shown in Figure 2.3b. Consistent with Hypothesis 6, the awareness displays improved receivers' performance only when senders believed that they were operating as a team with their receivers (Table 2.2, Row C, last column). Because only senders were exposed to the team manipulation and all receivers believed that they were working as a team with their partners, the team manipulations' influence on the receivers' performance must have been mediated by the changes in the senders' communication rate and timing

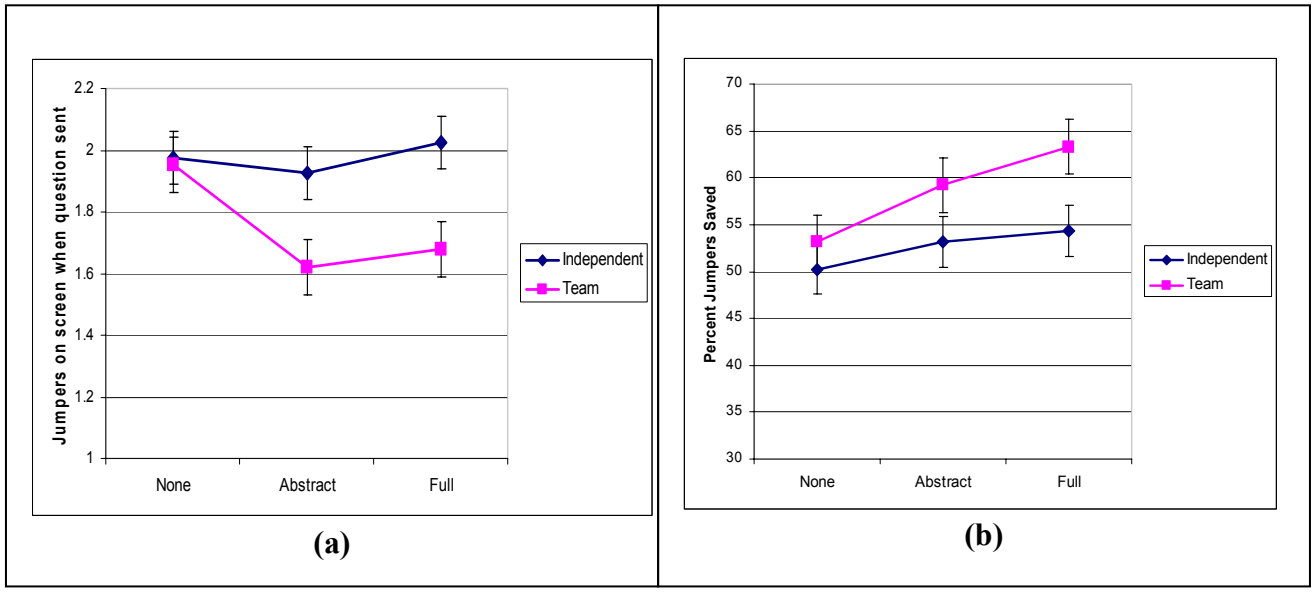


Figure 2.3. (a) Experiment 2 – Jumpers on screen when interruption occurred by display condition; (b) Experiment 2 – Percent of jumpers saved by receiver by display condition.

### *2.4.2.3 Attentional Demand: Gaze*

Overall, from our eye-tracking data we found more attention was directed to the display area of the screen when a display was present and more attention was paid to the display area of the screen with a high-information display versus an abstracted one. There were no main effects for team, or team-by-display interactions, so we do not report the gaze results for the team manipulation.

*2.4.2.3.1 Proportion of Fixations*

Consistent with Hypothesis 3, senders in the full display condition increased their attention to the awareness display compared to senders in the abstract display condition (Area B in Figure 2.2a; see also Table 2.3, Row A). The increased proportion of fixations on the full display indicates its prominence on-screen and its level of visual attention demand. In addition, consistent with Hypothesis 4, senders in the full display condition also dropped their attention to the primary task—guessing the identity of the revealing picture. They fixated significantly less on their primary task area (Area D in Figure 2.3a; see also Table 2.3, Row B). This result suggests that the full information awareness display distracted senders from their primary task even though, in the independent condition, they were not using the display to time their communications.

*2.4.2.3.2 Mean Fixation Duration*

The average fixation duration, or how long each glance lasted on average, in the display area was about 10% longer for the full condition than for the other two conditions (Table 2.3, Row C), but this difference was not significant. Senders had fixations in the primary task area (Area D in Figure 2.2a) that were 36% longer when they were using the full display than in the abstract display (Table 2.3, Row D). These data provide support for Hypothesis 4—that the presence of the full display may have made processing of the primary task more difficult as well. Dealing with the informationally rich full display, whether or not it was being used for communication timing, seems to have increased participants' cognitive load and thus made the primary task more challenging.

*2.4.2.3.3 The Sender's Performance*

The senders' performance was measured by the accuracy in their identifications of the picture puzzles and the time, in seconds, that it took them to identify each picture. There were neither main effects (Table 2.2, Rows D and E) nor interactions of the awareness display condition and team manipulation on the senders' accuracy or speed in identifying pictures. In contrast to Experiment 1, the senders' performance in Experiment 2 was not influenced by the presence of the full information display.

### 2.4.3 Summary

Experiment 2 showed that senders in the team condition used the workload displays to time their interruptions more accurately (when their partners were less busy), while senders in the independent condition did not do so to the same extent. This difference in interruption behavior resulted in a significant performance benefit for receivers during the team condition. The eye-tracking data showed that the full information display consumed substantially more attention than the abstract information display for senders in the independent condition and increased sender cognitive load in both the team and independent conditions.

Table 2.4. Summary of Support for Stated Hypotheses Across Experiments 1 & 2

| | **Hypothesis** | **Supported in Experiment 1?** | **Supported in Experiment 2?** |
|---|---|---|---|
| | **Assumption 1**: Interruptions that arrive during periods of low workload will lead to higher performance for the receiver than interruptions that arrive during periods of high workload. | Yes | Yes |
| **Awareness display design** | **Hypothesis 1**: Displays showing the receiver's workload will allow the sender to time the communication so that the communication arrives during a period of low workload in the receiver's task. | Yes | Yes |
| | **Hypothesis 2:** Abstracted information displays that show a simple representation of the receiver's workload should allow the sender to assess availability and time the communication so that it arrives during periods of low workload equally as well as a full video display that shows more information about a receiver's work activities. | Yes | Yes |
| | **Hypothesis 3**: An increase in the amount of information in a visual display (with respect to the number of elements and movement) will increase the amount of visual attention required to attend to the display and obtain information from it. | Not tested | Yes |
| | **Hypothesis 4**: Increased visual attention demand from an awareness display will significantly reduce the sender's attention to the primary task. | Not tested | Yes |
| | **Hypothesis 5:** Decreased attention to the sender's primary task should result in decreased primary task performance by the sender on continuous attention tasks. | Yes | No |
| **Incentive** | **Hypothesis 6:** Common social identity or outcome dependence will cause the sender to use awareness displays to time communication so that it arrives during periods of low workload for the receiver. | Not tested | Yes |

## 2.5 Discussion

The experiments presented here investigated the utility of awareness displays for coordinating interruptive communication. Table 2.4 summarizes the empirical results and support for the hypotheses presented. We found that, under conditions of shared rewards and common identity, awareness displays showing a partner's workload were beneficial for reducing the disruption associated with interruption. In both Experiments 1 and 2, the targets of interruptions, the receivers, performed better when interrupters, the senders, had information about their workload and, in Experiment 2, when the interrupters had sufficient incentive to use that information. Our results from both Experiments 1 and 2 also indicate that a display focused only on decision-relevant information about a potential communication partner's activity is as useful for coordinating communication as a display showing everything that a partner is doing. In addition, we found that the full information display, showing everything that the partner was doing, was distracting to the person initiating communication. In Experiment 1, the full information display negatively affected interrupters' performance compared to the abstract display, and in Experiment 2, it consumed substantially more visual attention, was more cognitively demanding, and reduced the amount of attention that the interrupter paid to his or her primary task.

### 2.5.1 Implications for the Design of Communication Systems

Results from both of our experiments suggest that showing information about others' task states can help coordinate communication between co-workers. In addition, our results showed that an "abstract" display presenting only decision-relevant information about a co-worker's state was as useful for timing interruptions as a display presenting richer information about a co-worker's current state. Before applying these ideas to real-world awareness displays, we must answer four questions not directly addressed in our empirical research: (1) How can a system gather data about the relevant aspects of a work task to use as the basis of an awareness display? (2) How can a system present the multidimensional data that might be relevant to the decision to communicate with another person in ways that minimize distraction? (3) How can a system influence a user's incentives to take a communication partner's welfare into account before attempting a communication? (4) Under what conditions would these display be useful (i.e., to what settings do these empirical results generalize)?

#### *2.5.1.1 Collecting Relevant Information*

Research suggests that lack of awareness of what others are doing is the cause of at least some of the difficulties in distributed work because the lack of awareness leads both to failures to communicate and to misconstruals of the reasons for behaviors (Cramton, 2001). Although our research showed that providing a display showing a partner's availability and busyness can improve the coordination of communication, we were able to easily assess workload to drive that display only because we controlled the task. This technique cannot apply to the real world.

People announce their availability with varying amounts of explicitness, for example, by making their calendars public (Palen & Grudin, 2003), by varying the crack on their doors (Fish et al., 1993), or by setting the away indicators on an instant message application. These kinds of techniques that rely upon potential communication targets to announce their availability often fail because of forgetfulness and self-interest.

Recent research on automated sensing of availability shows that inexpensive and easily deployable sensors coupled with machine learning techniques can do a reasonable job of assessing an individual's availability in the workplace. (Fogarty et al., 2005a; Begole, Tang, & Hill, 2003; Horvitz, Kadie, Paek, & Hovel, 2003). For example, instant messenger programs use a lack of keyboard activity to set "away" messages and simple sensors already available on a laptop computer can be combined to assess whether managers or research programmers are interruptible with over 89% accuracy (Fogarty et al., 2005a).

#### *2.5.1.2 Displaying Relevant Information*

An important technology design question is how to distill rich, multidimensional information about an individual's current activity into a format that is easy to visually and mentally process. In our experiment this was trivial because the receiver's task was one-dimensional with respect to availability, such that workload equated to a directly measurable aspect of the receiver's task, that is, the number of jumpers on their screen. If awareness displays only needed to signal a potential communication receiver's busyness, the machine learning techniques previously mentioned could map many sources of data onto this single dimension (Horvitz et al., 2003). A future research avenue, then, is investigating how people make use of these one-dimensional assessments of availability

in a field setting to test whether the results found here can be generalized to more complex task domains, such as the tasks of knowledge workers.

#### *2.5.1.3 Motivation to Interrupt Sensitively*

The results from Experiment 2 showed that communication senders timed their interruptions sensitively only in the team condition when they were motivated by a shared team identity. A team identity is only one way to motivate people to interrupt at appropriate times. Friendship, reciprocity, joint history, or anticipation of future interaction may all build relationships among people that motivate them to interrupt sensitively.

With interactions among strangers (e.g., the proverbial insurance salesman calling at dinner), one might induce a similar motivation by pricing interruptions. For example, it could become more costly to interrupt someone the busier they are (Horvitz et al., 2003). Pricing should regulate the timing of interruptions without revealing information that would compromise the receiver's privacy. Previous studies have shown that the concept of pricing can successfully encourage more selective email communication (Kraut, Morris, Telang, Filer, Cronin, & Sunder, 2002). Perhaps this concept can also be applied to more synchronous forms of communication.

### 2.5.2 Limitations: Generalizability

The studies described in this chapter used a highly stylized task to simulate advice-seeking and the kind of interruptive behavior described by Perlow (1999). These results may directly apply to the type of continuous visual attention tasks that, for example, air traffic controllers (e.g., Farley, Hansman, Amonlirdviman, & Endsley, 2000) often encounter, and the logic of the analysis may apply more broadly even if the details of the tasks and displays that we used do not.

Awareness displays to coordinate communication may be especially useful for tasks requiring tight coupling between co-workers in a dynamic environment. For example, air traffic controllers, remote surgery team members, and military command-and-control crews must maintain awareness of their colleagues' activities on a minute-by-minute basis to coordinate communication with them and inform their own actions. Our results indicate that in these settings, where there exists a feeling of common social identity with a team, the use of awareness displays with abstractions representing a colleague's

workload could enable individuals to make informed decisions when timing their communications, minimizing the potential disruption and attention required while maximizing the ability to obtain timely information.

# Chapter 3

# Sender / Receiver Trade-offs

## 3.1 Motivation

Instant messaging has gained increasing popularity as a form of electronic communication for conducting work-related interactions (Poe, 2001). Studies of IM usage in organizations has found that much of the communication is about ongoing work, rather than about social matters, as previously thought (Handel & Herbsleb, 2002; Isaacs et al., 2002). The semi-synchronous nature of IM allows conversations to be interspersed with other work activities, such as solitary work, face-to-face conversation, and phone calls. Communication interruptions from IM make work sociable and interesting, and the increased connectivity supports flexibility and knowledge transfer.

But interruptions from IM messages also delay task completion and lower performance quality (Rennecker & Goodwin, 2003) with negative consequences for organizational effectiveness (Perlow, 1999). Incoming IM messages can constantly interrupt ongoing work activities (Rennecker & Goodwin, 2003) and, because of this, individuals are continuously making decisions about where to direct their attention. Yet we do not have a good understanding of how people direct their attention and prioritize certain incoming communications over others. The studies in this chapter examine how individuals make

decisions when dealing with communications and the resultant effect on their task performance both at the individual and dyadic level.

Obtaining an understanding of how message features and social factors influence attention to communication should help to inform the design of communication technology, such as synchronous chat, to better facilitate these kinds of spontaneous dyadic communications that are so important for the successful completion of knowledge work (Kraut, Fish, Root, & Chalafonte, 1993).

This chapter presents results from two laboratory experiments examining communication decision-making. The first experiment looks at both the decision to initiate a communication and to respond. It illuminates the trade-offs between sender and receiver—interruption decision rules that help the recipient of a message harm the sender and vice versa. The second study focuses solely on the response decision and the influence of the recipient's current task state and social identity with the sender on how messages are prioritized for response. The results from both studies illuminate heuristics used in prioritizing certain communications over others, both on the sending and receiving sides, and present implications for design suggesting important areas for future research.

## 3.2 Previous Work

Communication is a central feature of collaborative work—information is exchanged and activities are coordinated by talking with co-workers (Kraut & Attewell, 1997). When communications are interspersed with ongoing work, as is increasingly the case with instant messaging in the workplace, these communications can interrupt solitary work (Perlow, 1999). Different methods of delivering communication over the computer have differential impacts on the task being interrupted. However, previous work has not examined the influence of different notification methods on both parties in a communication dyad. In addition, responses are influenced by receivers' perceptions of the criticality of their responses. Receivers may be able to improve their decisions about responding to communications if given additional information about the urgency and importance of their response to the senders' tasks.

### 3.2.1 Interruption

There has been substantial previous work in the fields of cognitive psychology, human factors, and human-computer interaction on interruptions and their influence on primary task performance. Most of this previous work has been one-sided, seeking to understand the disruptive impact of interruptions on the person being interrupted (Mark, Gonzalez & Harris, 2005; Gonzalez & Mark, 2004; McFarlane, 2002; Zijlstra, Roe, Leonora, & Krediet, 1999; Gillie & Broadbent, 1982) and to develop technology to protect a receiver from potentially disruptive incoming communications (Horvitz & Apacible, 2003; Horvitz, Jacobs, & Hovel, 1999). Unfortunately, this one-sided and largely negative view of interruptions overlooks their benefits (e.g., knowledge transfer, coordination, and relationships maintenance), particularly for informal communication interruptions, as documented in research on workplace communication interaction (Kraut & Attewell, 1997).

Results of previous work on interruptions and task performance suggest that it is possible to time interruptions in order to minimize their disruptive impact on the task being interrupted (Adamczyk & Bailey, 2004; Zacks & Tversky, 2001; Cutrell, Czerwinski, & Horvitz, 2001). However, this work is focused solely on the receiver of the interruption, with minimal consideration as to how the interruption timing would influence the sender. We consider the implications for both the sender and the receiver of an interruption to ascertain the optimal method of communication timing to maintain connectivity while reducing disruption to ongoing work.

### 3.2.2 Notification Methods

McFarlane (2000) outlined four primary methods of interruption or ways that messages can be delivered in human-computer interaction. In McFarlane's studies, an individual participant completed the jumpers game (pictured in Figure 3.2) as the primary task and was interrupted by the computer according to one of four interruption methods: *immediate*, in which the messages were delivered to the screen directly; *negotiated*, in which a notification flashed on-screen when a message arrived and the participant explicitly switched to the message to attend to it; *scheduled*, in which messages were delivered at preset intervals according to a schedule; and *mediated*, in which messages were delivered based on the participant's current workload in the primary task.

The results of this study showed that performance on the primary task was significantly better during the *negotiated* interruption condition. In this condition, participants had the most control over message timing: they were able to choose opportune moments in their primary task to switch their attention to incoming communications. This ability to defer interruptions to periods of low workload in their task meant that participants performed significantly better on their primary task than in any of the other three interruption conditions (i.e., immediate, scheduled, mediated).

However, it is questionable whether the results from McFarlane's studies carry over to conversations in which messages are sent by another person, rather than by a computer's generation. When interacting with another person, a lack of response could have serious negative ramifications for the relationship between the two people and the performance of the message sender.

For interpersonal communication, negotiated notification in McFarlane's taxonomy can be thought of as *receiver-controlled* in that the receiver controls when to attend to messages. Email is a form of negotiated, or receiver-controlled, interpersonal communication. At the same time, the telephone can be thought of as an immediate, or *sender-controlled*, form of interpersonal communication because the sender has control over when a receiver attends to the communication. We are going to use the terms *sender-controlled* and *receiver-controlled* in the remainder of this chapter to refer to McFarlane's immediate and negotiated notification methods.

Our primary goal in this research is to look at the trade-offs between communication senders and receivers. Our central hypotheses for Experiment 1 were that *sender-controlled* interruptions would provide the fastest response (improving the sender's performance) but would cause the greatest disruption to the receiver's primary task. *Receiver-controlled* interruptions would be least disruptive to the receiver's task because the latter could choose the most opportune moments in the primary task to switch attention to incoming communications. However, waiting for opportune moments would cause the greatest amount of delay or non-response and thus should be associated with a decrease in task performance for the sender.

Thus, based on McFarlane's results, we propose the following propositions with respect to the immediate and negotiated methods of interruption notification as they apply to two-person, or dyadic, communication:

> **Hypothesis 1**: The sender's control of message timing will mean that the receiver will attend to messages immediately, meaning higher likelihood of response and faster response speed.
>
> **Hypothesis 2**: The receiver's faster response to messages should result in better performance for the sender of a communication.
>
> **Hypothesis 3**: The receiver' control of message timing should result in a longer time to respond to messages and a lower likelihood of response.
>
> **Hypothesis 4**: The receiver's ability to defer a response should result in better performance for the receiver.

Previous work has not considered the utility of the primary methods of interruption for mediating human-to-human communication. We extend the previous work to consider both sides of the communication situation. In experiment 1, for the *immediate* and *negotiated* notification methods defined by McFarlane, we ask: What is the impact on the message sender? What is the impact on the receiver?

### 3.2.3 Displaying Task State

Conceptually, receivers could make more informed response decisions if they were aware of senders' task constraints. For example, receivers could improve their message response timing when using receiver-controlled notification if they knew the deadline for senders' tasks. In this section, we look at previous work in displaying task state awareness to improve communication.

### 3.2.4 Information for Negotiation

Prior work has explored different methods for displaying task state between communicating parties in prototype systems designed to coordinate interactions. While current IM is capable of providing certain types of presence awareness (Isaacs et al., 2002; Nardi, Whittaker, & Bradner, 2000), it does not typically provide information on work state, workload, and broader task constraints, such as task deadline and importance.

Tang et al. (2002) have explored the disclosure of contextual information through research prototype IM clients ConNexus and Awarenex. Icons and text are used to show users' most recent activities and locales. Project View IM discloses common project activities and shared file access to partners, and laboratory evaluation showed promise in reducing users' perceived workload (Scupelli et al., 2004). However, this previous work has not found conclusively that displaying co-worker task information would lead to better coordinated communication interactions across all situations.

In addition to displaying senders' task states as measured and observed, self-disclosed task states have also been explored as a way to facilitate task awareness between communicating parties and to better coordinate interaction. In commercial email clients, senders have the option of setting an urgency flag as an indicator for how important an email is. Theoretically, such an indicator is intended to signal the value of the email to the receiver or receivers deciding how to act on it. However, the urgency flags are not widely used in email. While our intuition suggests that the lack of use is mostly due to spam and the "cry wolf effect," it is not clear whether receivers would use this information correctly in a spam-free world in which they could trust these signals. The use of pricing, which can act as a truthful signal for urgency and importance, has also been proposed as a way to improve communication coordination and manage the attention of receivers (Kraut, Sunder, Cronin, Filer, & Telang, 2002). However, more work needs to be done to determine if receivers can understand these signals. Therefore, in Experiment 1, we examine the effects of displaying senders' task states (both the value of their task and the deadline associated with the task) to the receivers. From previous work, we expect the following hypotheses:

> **Hypothesis 5:** Displaying the sender's valuation of the message to the receiver should increase the receiver's likelihood and speed of response for messages with higher value.
>
> **Hypothesis 6:** Displaying the urgency of a message to the receiver will increase the receiver's response speed for messages with short deadlines.

The expected increases in response likelihood and speed should in turn improve the sender's performance, as delineated above in Hypothesis 2.

## 3.3 Experiment 1

Our goal in Experiment 1 was to understand at a basic level how senders and receivers prioritized messages for attention and action. We chose to use a laboratory experiment to isolate the variables of interest and to witness in a controlled way the effects of sender actions on receiver performance and vice versa. In this experiment, participants assumed either the role of a communication sender who needs some information to complete a work task or the role of the communication receiver who has the information that the sender needs but is engaged in a primary task as well. This set-up was designed to mimic the general help-seeking scenario, which has been cited as one of the most common uses of IM in the workplace (Quan-Hasse, Cothrel, & Wellman, 2005). This set-up also had the benefit of allowing us to measure most clearly the impact of the sender's communication behavior on the receiver's task as well as the impact of the receiver's response timing on the sender's task.

### 3.3.1 Procedure

The communication sender in this experiment completed a series of crossword puzzles, each with a six-minute time limit. This task was chosen because it was decomposable into subtasks (each hint and word pair in the puzzle), allowing us to manipulate the urgency and importance of individual subtasks and to see how senders and receivers chose to divide their attention among these subtasks. Senders in the experiment were rewarded based on the value of words in the crosswords that they were able to complete correctly. The crossword puzzle task is shown in Figure 3.1.

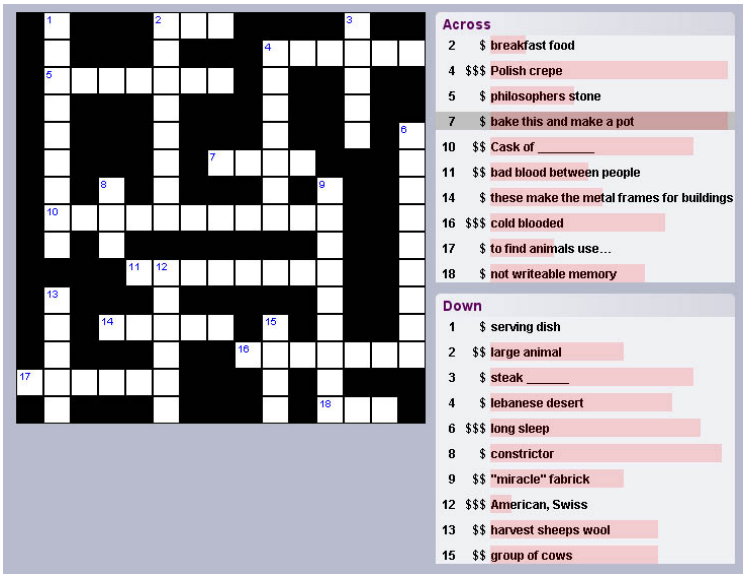


Figure 3.1. Communication sender's task, the crossword puzzle.

The receivers' task in Experiment 1 was the jumpers game (McFarlane, 2002) pictured in Figure 3.2 below, a continuous attention video-game-like task that has been shown to be susceptible to interruption (Dabbish & Kraut, 2004; McFarlane, 2002).


Figure 3.2. Primary task of the receiver, the jumpers game (McFarlane, 2002).

For each of the sender's crossword puzzles, the receiver was given a list of words that were possible answers to the clues in the puzzle. The sender could ask the receiver for

help on a particular word over the computer, and the receiver could respond with an answer chosen from a list (Figure 3.3).


Figure 3.3. Example of open message dialog box.

The receivers' performance was evaluated based on the percentage of jumpers they were able to save in the jumpers game. Receivers were rewarded monetarily based on the average of their performance and the senders' performance in order to provide incentive for them to attend to both the jumpers game and the incoming messages from the sender.

The outcome measures in this experiment were the request and response behaviors of the sender and the receiver and the performance of the sender and the receiver on their respective primary tasks.

Participants in this study were college undergraduates ranging in age from 18 to 23. Data was collected from 24 participants, or 12 pairs of participants, with each participant on the sender side completing four crossword puzzles of approximately 20 questions per puzzle (the first puzzle in each session was a practice puzzle to allow both sender and receiver to learn the game interface, and thus data from only the latter three puzzles were used in the analyses reported here) while participants on the receiver side played the jumpers game. Participant pairs were seated in the same room, but separated by room dividers. They did not know each other and did not talk prior to the experimental session.

To control for any effects of identification or incentive on either partner's behavior, all participants were told that they and their partners in the experiment were part of a team

with a common team name, that they were competing as a team against other teams in the experiment, and that they would be rewarded based on their joint performance in the experiment (the average of both players' performance).

### 3.3.2 Manipulations

#### *3.3.2.1 Deadline*

On the sender side of the experiment, the urgency of an individual subtask or word was manipulated by giving each word in the puzzle a deadline (a set amount of time that the word would be present on screen). Each word was randomly assigned a deadline of two minutes (short), four minutes (medium), or six minutes (long). For example, a word with a two-minute deadline would only be answerable and active in the first two minutes of the crossword puzzle; once its deadline had been reached, the word would become grayed out and the participant could no longer submit an answer. The deadline for each word was indicated by a red bar behind the word's clue, which would slowly disappear as the time left on the word ran out (Figure 3.4).

#### *3.3.2.2 Value*

The value of individual subtasks in the sender's task was manipulated by assigning each word a monetary value that the sender earned for answering the word correctly. Each word was also randomly assigned either a high, medium, or low value, as indicated by the number of dollar signs next to the clue for the word (i.e., high = $$$, medium = $$, low = $; see Figure 3.4). High-value words would result in $1.00 reward if completed correctly, medium-value words would result in a $0.25 reward if completed correctly, and low-value words would result in a $0.05 reward if completed correctly.

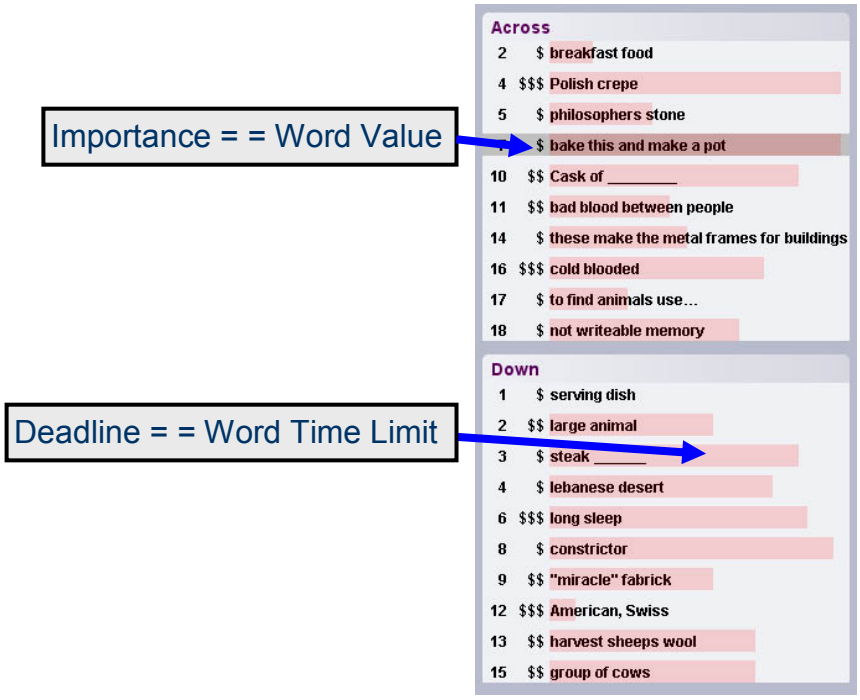


Figure 3.4. Each word in the sender's crossword puzzle was assigned a value (importance) and deadline (urgency).

#### *3.3.2.3 Notification Conditions*

To test Hypotheses 1 through 4 and to better understand sender and receiver decision-making in handling communication of varying importance and urgency, we compared sender-controlled message timing (immediate interruption delivery in McFarlane's taxonomy: the message must be attended to as soon as it is sent) with receiver-controlled message timing (negotiated delivery in McFarlane's taxonomy: the receiver can decide when to attend to the message).

In Table 3.1, we have outlined the interruption conditions used in this study and how each of these conditions was implemented in the experiment.

Table 3.1. Interruption Delivery Conditions

| **Interruption Style (McFarlane, 2002)** | **Sender Side** | **Receiver Side** | **Performance Predictions** |
|---|---|---|---|
| Sender-controlled (Immediate) | No awareness of receiver task state. | Message appears on screen when it is sent. | Sender = High<br>Receiver = Low |
| Receiver-controlled (Negotiated– No information) | No awareness of receiver task state.<br>Delayed message response. | Message goes into a queue after it is sent.<br>Receiver can choose when to attend to the message. | Sender = Low<br>Receiver = High |
| Receiver-controlled (Negotiated— Information) | No awareness of receiver task state.<br>Delayed message response. | Message goes into a queue after it is sent.<br>Details of message value and deadline are displayed.<br>Receiver can choose when to attend to the message. | Sender = ???<br>Receiver = ??? |

Our hypotheses for Experiment 1 were that sender-controlled interruption would provide faster response (Hypothesis 1), in turn improving the sender's performance (Hypothesis 2). Receiver-controlled interruption would be less disruptive to the receiver's task because receivers could choose the most opportune moments in the primary task to switch their attention to incoming communications (Hypothesis 4). However, waiting for opportune moments should cause the greater amount of delay or non-response (Hypothesis 3) and thus should be associated with a decrease in task performance for the sender (Hypothesis 2).

#### *3.3.2.4 Displaying Message Information*

On the receiver side, we were interested in how receivers made decisions about when to attend to incoming messages based on the state of their own task and their perception of message importance and urgency. We hypothesized that displaying a message value would increase response speed for high value messages (Hypothesis 5) and displaying message deadlines would increase response speed for messages with short deadlines (Hypothesis 6). To look at how receivers prioritized messages based on importance and to test our hypotheses, we manipulated whether the receivers saw information about the value and urgency of the words being requested. Between subjects, receivers either had no information about the senders' word value and urgency (no information condition) or

they could see both the value of the word and the deadline or urgency (information condition), as shown in Figure 3.5. Because we were interested in the influence of this information on the receivers' response behavior, and because receivers only had control over their response timing during the receiver-controlled notification condition, the information manipulation was only done during that condition.

No information

| Request |
|---|
| Request #1 |
| Request #2 |
| Request #3 |

Information

| Request | Word Value | Time Left |
|---|---|---|
| Request #1 | $$ | 2 mins 57 secs |
| Request #2 | $ | 0 mins 27 secs |
| Request #3 | $$$ | 2 mins 57 secs |

Figure 3.5. Information manipulation on the receiver side.

### 3.3.3 Results

For communication outcomes on both the sender and the receiver side, the message was the unit of analysis. Because each sender and receiver dealt with multiple messages per crossword puzzle per condition, the data on both the sender and receiver sides was analyzed using a mixed-model analysis of variance with subjects included in the model as a random effect to control for the non-independence of observations across individuals and across puzzles.

#### *3.3.3.1 Message-sending Behavior*

Using individual words in the crossword as the unit of analysis, we examined the sender's likelihood and speed of requesting help on a word.

##### *3.3.3.1.1 Request Likelihood*

The notification condition had a marginally significant effect on the likelihood of requesting help on a particular word, with requests for help on a particular word 48% more likely during the sender-controlled notification condition than in the receiver-controlled notification condition (Table 3.2).

There was a linear increase in the likelihood of requesting help on a word as the word value increased (Table 3.2). In addition, help on long-deadline words was 29% more likely to be requested than help on short- or medium-deadline words (Table 3.2), presumably because senders had more time to deal with them. There was no value by

word deadline interaction on the likelihood of requesting a word ($F(4, 1398) = 1.36$; $p = 0.25$).

#### *3.3.3.1.2 Speed of Request*

To understand whether certain words were prioritized for request before others, we looked at the number of seconds until the first request on a word as the dependent variable. Word deadline significantly affected how quickly words were requested, with a linear increase in time to request as the word deadline increased (Table 3.2). In addition, value significantly affected how quickly words were requested, with high-value words requested significantly earlier than medium- or low-value words ($F(1, 494) = 22.69$; $p<0.0001$).

These main effects of value and deadline on speed of request were accompanied by a value by deadline interaction ($F(4, 487) = 3.76$; $p = 0.005$). Help on high-value words was requested more quickly than help on low- and medium-value words, even as the deadline for the word increased.

Overall, senders prioritized high-value words and words with short deadlines, requesting help on those words earlier than help on lower-value, longer-deadline words. In addition, deadline had less effect on the speed of request for high-value words.

Table 3.2. Sender Request Behavior in Experiment 1 across Conditions

| | **Notification** | | | **Word Value** | | | | **Deadline** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sender controlled | Receiver controlled | Stats | Low | Med | High | Stats | Short | Mid | Long | Stats |
| | M (SE) | M (SE) | F(); *p* | M (SE) | M (SE) | M (SE) | F(); *p* | M (SE) | M (SE) | M (SE) | F(); *p* |
| Likelihood of request | 41.1 (2.21) | 27.7 (1.36) | F(1,72) = 3.25; *p* = 0.076 | 26 (1.47) | 34 (2.10) | 43 (1.62) | F(2,1398) = 31.1; *p*<0.0001 | 31.4 (1.45) | 31.2 (1.86) | 40.5 (1.75) | F(1,1398) = 16.5; *p*<0.0001 |
| Seconds until requested | 140.9 (8.00) | 155.23 (6.56) | F(1,51) = 1.91; *p* = 0.17 | 163.6 (6.47) | 153.27 (7.25) | 127.34 (6.62) | F(2,548) = 12.13, *p*<0.0001) | 82.96 (6.71) | 157.33 (6.75) | 203.9 (6.95) | F(2, 497) = 125.9; *p*<0.0001 |

### *3.3.3.2 Message Response Behavior*

On the receiver side of the experiment, we measured the likelihood of response and time taken to respond. We examined the influence of sender-controlled versus receiver-controlled notification, message information versus no information, word value, and time remaining for a particular word.

In the sender-controlled notification condition, receivers had to respond immediately to all messages received before returning to their primary task. Thus, message response was completely dependent on sender actions. However, in the receiver-controlled condition, receivers had control over their response timing and thus could choose opportune moments in their task to respond to incoming messages from senders. The receiver-controlled condition without information provided a baseline to understand how senders' message orderings behavior affected receiver response and, in turn, the performance of both parties. Comparing receiver behavior during the no information versus the information manipulation in the negotiated attention condition let us see how receiver response behavior changed when receivers had information about the value and deadline associated with each message.

*3.3.3.2.1 Response Likelihood*

Consistent with Hypothesis 1, receivers were 35% more likely to respond to messages when forced to attend to them in the sender-controlled notification condition than in the receiver-controlled notification condition (Table 3.3).

Interestingly, in the receiver-controlled condition, the presence of message information significantly increased the likelihood of responding to a particular message by 39% (Table 3.3).

The presence of value information on-screen also affected likelihood of response, with a significant information by value interaction ($F(1,836) = 7.41$; $p = 0.007$). When the receiver had direct information about the value of the task for the sender, the receiver seemed to differentially ignore the high-value messages. This was an unexpected result and probably is related to senders' behavior in that they send more high-value messages and sent them earlier in the trial, as previously reviewed. This interaction is something to investigate further.

*3.3.3.2.2 Response Speed*

Corresponding with Hypothesis 3, when forced to attend to a message immediately (*sender-controlled notification*), receivers responded 80% more quickly than when they could postpone response (*receiver-controlled notification*) (Table 3.3). When able to postpone response (*receiver-controlled notification*), receivers responded more quickly

when they knew the value and urgency of the requests they were receiving in the information condition versus no information condition (Table 3.3).

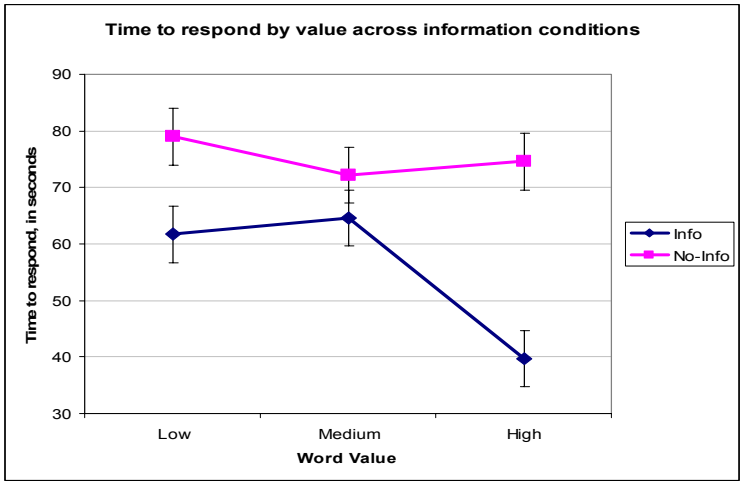


Figure 3.6. Time to respond by value across information conditions.

We also found that there was a significant interaction between information presence and message value consistent with Hypothesis 5 in that receivers responded significantly more quickly to higher-value word requests if they knew the value of those requests to the sender in the information condition (see Figure 3.8 below; $F(1, 607) = 5.18$; $p = 0.02$).

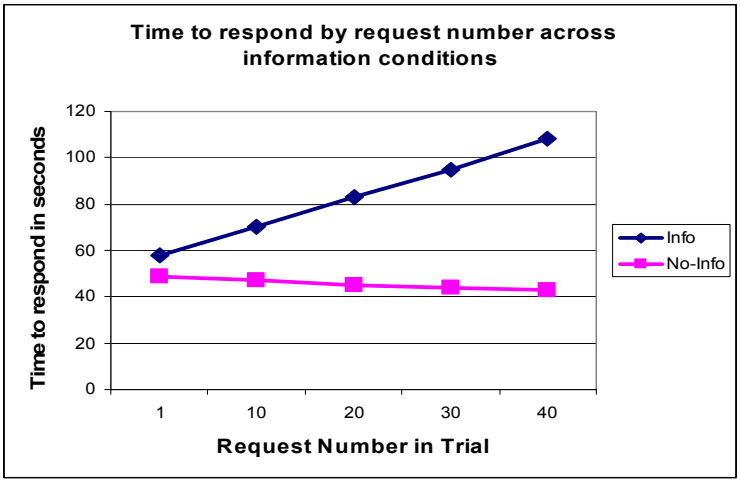


Figure 3.7. Time to respond by question number across information conditions.

There was also a significant interaction between question number in the trial and information condition ($F(2, 574) = 4.98$; $p = 0.0072$). In the no information condition,

questions asked later in the trial (i.e., those with a higher question number) were responded to significantly more slowly, whereas, in the information condition, questions were responded to equally quickly regardless of their number in the trial (Figure 3.7). This result suggests that different response strategies were being used in the no information versus information condition. In the no information condition, respondents did not know the value or urgency of requests and may have simply been responding to requests in the order of receipt; thus, later requests took longer to respond to because earlier requests must be attended to first. However, in the information condition, there was not a significant difference in time to respond across the request numbers. This suggests that receivers in the information condition were using a different response strategy because the order that messages arrived in did not affect their responses.

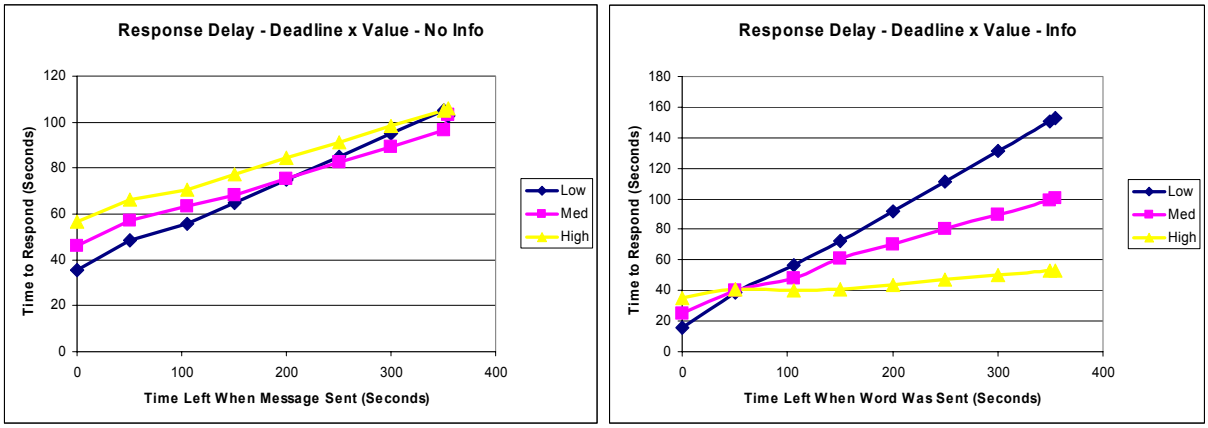


Figure 3.8. Response delay: Value by time left across information conditions.

In addition, there was a significant three-way interaction between word value, time remaining, and the information condition ($F(1, 626) = 8.87$; $p = 0.003$). When receivers did not have information about the value and time remaining on a word request, they responded equally quickly to requests across value conditions (Figure 3.8, left side).

Table 3.3. Receiver Response Behavior Across Conditions

| | Notification | | | Message | | | Word Value | | | | Seconds Left | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sender Controlled | Receiver Controlled | Stats | No Info | Info | Stats | Low | Med | High | Stats | Deadline | Stats |
| | M (SE) | M (SE) | z; *p* | M (SE) | M (SE) | z; *p* | M (SE) | M (SE) | M (SE) | z; *p* | | z; *p* |
| Response delay (seconds) | 11.6 (5.0) | 56.2 (4.4) | -3.63; 0.00 | 40.9 (5.73) | 26.9 (5.31) | -1.43; 0.15 | 30.0 (48.3) | 36.7 (47.6) | 37.1 (46.6) | 0.79; 0.43 | N/A | N/A |
| Probability of a response | 84% (3.7) | 62% (4.9) | 7.34; 0.00 | 51.5% (5.0) | 71.4% (4.5) | 4.37; 0.00 | 75% (4.3) | 72% (4.5) | 69% (4.6) | -1.74; 0.08 | N/A | 4.02; 0.00 |
| Probability of correct response | 61.9% (4.9) | 64.5% (4.8) | -0.51; 0.6 | 61.2% (4.9) | 66.9% (4.7) | 0.68; 0.5 | 66.1% (4.7) | 58.3 % (4.9) | 63.3% (4.8) | -1.60; 0.11 | N/A | 0.23; 0.82 |

#### *3.3.3.3 Performance Results*

To measure performance on the sender side, individual words in the crossword were the unit of analysis. On the receiver side, the entire jumpers game was the unit of analysis. (Performance in the jumpers game was aggregated across six-minute time periods.)

Consistent with Hypothesis 2, the sender performed significantly better with respect to the likelihood of getting an individual word in the crossword puzzle correct during the sender-controlled notification condition than in the receiver-controlled condition (Table 3.4). The sender was 62% more likely to answer a word in the crossword correctly in the sender-controlled condition than in the receiver-controlled condition and was equally as likely to answer a crossword correctly, regardless of whether the receiver was aware of the importance and urgency of the word in the information condition.

There was a significant notification method by deadline interaction in that a sender's likelihood of answering correctly increased as the word deadline increased in the receiver-controlled notification condition. However, in the sender-controlled notification condition, deadline had no effect on the likelihood of answering a word correctly. This interaction supports the results thus far, indicating that receivers postponed responses and answered messages in a sequential manner in the receiver-controlled response condition. This means that words with longer deadlines were more likely to receive a response and in turn helped the sender complete the word in the crossword.

Furthermore, senders earned significantly more money per puzzle in the sender-controlled timing condition than in the receiver-controlled timing condition (Table 3.4). However, presence of information about word deadline and value on the receivers' screens did not affect money earned (Table 3.4); thus, we find no support in the

performance data that visibility of message characteristics improves communication response coordination and, in turn, the performance of the message sender.

On the receiver side of the pair, the notification condition (sender- vs. receiver-controlled) had no effect on the percentage of jumpers saved in their primary task. This means we find no support for Hypothesis 4. Interestingly, the number of messages sent also had no effect on the receiver's performance, suggesting that the jumpers task as implemented in this experiment may not have been as susceptible to interruption as originally expected. In addition, the presence of additional on-screen information had no influence on the receiver's performance ($z$=0.34; $p$=0.73).

Table 3.4. Performance Results for Sender and Receiver Across Notification and Word Deadline Conditions

| | **Notification** | | | **Task State Visibility** | | | **Deadline** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sender Controlled | Receiver Controlled | Stats | No Info | Info | Stats | 180 | 270 | 360 | Stats |
| **Sender** | M (SE) | M (SE) | z; *p* | M (SE) | M (SE) | z; *p* | M (SE) | M (SE) | M (SE) | z; *p* |
| Correct answer? | 44.8% (50%) | 28.5% (45%) | 3.04; 0.00 | 28.8% (45.3) | 28.3 (45) | -1.2; 0.23 | 32% (47) | 34% (47) | 37% (48) | 0.99; 0.32 |
| Money earned per trial | 3.25 (0.55) | 1.78 (0.38) | 2.03; 0.67 | 1.98 (1.58) | 2.28 (1.84) | 0.40; 0.69 | N/A | N/A | N/A | N/A |
| **Receiver** | M (SE) | M (SE) | z; *p* | M (SE) | M (SE) | z; *p* | M (SE) | M (SE) | M (SE) | z; *p* |
| Percent jumpers saved | 44.8% (14) | 41.1% (15) | -0.05; 0.96 | 44.8% (9.4) | 44.9% (16.7) | -0.23; 0.82 | N/A | N/A | N/A | N/A |
| Money earned per trial | 2.39 (0.92) | 1.64 (0.87) | 1.94; 0.05 | 3.09 (1.48) | 3.40 (1.94) | 0.34; 0.73 | N/A | N/A | N/A | N/A |

### 3.3.4 Summary

The data from Experiment 1 begins to illuminate the trade-offs between sender and receiver in a communication interaction that is dependent upon the notification condition and sheds light on the prioritization decisions made by both parties. In the experiment, senders prioritized words with a high value and proximate deadline for requests over others.

On the receiver side, the response to messages was significantly slower in the receiver-controlled notification condition (supporting Hypothesis 3) than in the sender-controlled notification condition (supporting Hypothesis 1). In turn, sender performance on the crossword puzzle tasks was significantly lower in the receiver-controlled condition than in the sender-controlled condition (supporting Hypothesis 2). We had expected that being able to defer answering messages in the receiver-controlled condition would help the

receiver's performance (Hypothesis 4). However, this did not happen, perhaps due to the nature of the sender's task.

Providing receivers with information about the senders' task states helped them better take these constraints into account and prioritize certain messages for attention. When receivers could see the information about word request deadlines and value, they responded more quickly to high-value words (supporting Hypothesis 5) and words with a close deadline (supporting Hypothesis 6). Without value and deadline information, receivers used a simple serial response strategy. Although the visibility of message information did not improve the sender's performance, the receiver's attention to this information indicates that visual representation of the sender's task constraints may be a useful way to coordinate response and should be explored further.

### 3.3.5 Limitations

Several questions were raised by the results of Experiment 1. In addition, there were some issues with the design of Experiment 1. We looked to address these open questions and limitations from Experiment 1 in a second experiment.

#### *3.3.5.1 Reciprocal Causation*

In Experiment 1, pairs of senders and receivers interacted simultaneously in the lab. We developed an understanding of sender prioritization using the sender's likelihood of requesting particular words and speed of request. The sender's requesting behavior in turn had effects on the receiver's response behavior. Senders requested high-value words with short deadlines earlier in the game and, in turn, receivers had more time to respond to these messages. These messages were higher in the queue on the receiver's screen and thus a large part of the reason that they responded to those messages more quickly than other messages was because of the order in which the sender requested them. It was difficult to identify the receiver's prioritization and decision criteria in responding to questions because the receiver's actions were not independent from the sender's asking behavior.

In Experiment 2, we removed the influence of the sender to obtain a clearer picture of the receiver's response decisions independently from the sender's actions. We used a receiver only task with a simulated sender, meaning that our results could be attributed entirely to the actions of the receiver.

#### *3.3.5.2 Message Priority Indication*

In Experiment 1, both message value and urgency had relatively the same direction of effects on the receiver's decision to respond. It may be that people have difficulty distinguishing these two features of a message in real settings, and they are correlated highly in people's minds. To simplify our manipulation of message features, we condensed our representation of message deadline and value into a one-dimensional binary representation of "priority". Based on our results from Experiment 1, our expectation was that messages marked as "high priority" would receive faster response than "normal" messages and, in turn, these messages would be more likely to receive a response.

> **Hypothesis 7:** Receivers will respond to messages marked "high priority" faster than "normal" messages and, in turn, will be more likely to respond to "high priority" messages than "normal" messages.

#### *3.3.5.3 Receiver's Task Trade-offs*

Previous work on interruption has shown that the current state of a task greatly affects the disruptive impact of an interruption (Czerwinski et al., 2001) and that when senders have control of interruption timing they can reduce the disruptive impact of an interruption by postponing it until their workload drops (McFarlane, 2000). In Experiment 1, we saw that receivers took longer to respond when they could delay responses (immediate vs. negotiated response condition). However, we were unable to record how busy receivers were at the moment that a message arrived in Experiment 1 due to a software error. This meant that we did not know if the differences in response behavior were because of how busy receivers were at the time that a message arrived, lack of incentive to respond, difficulty noticing that a message had arrived, etc.

We wanted to know how the state of the receiver's game affected how the receiver dealt with messages. In Experiment 2, we controlled receivers' busyness in the game over time so that we could see how their choices to attend to messages were affected by their game state. Based on our results from Experiment 1, we expected that the more jumpers that were on-screen in the game, the less likely a receiver would be to respond to a message and the longer a receiver would delay response.

> **Hypothesis 8:** If the receiver's workload is higher, the receiver will take longer to respond and be less likely to respond to a particular message.

#### *3.3.5.4 Relationship with the Sender*

In Experiment 1, all participants were told that they were on a team with a partner and would receive joint rewards based on the combination with their partners. This was done to hold constant their feelings of identity with the other person as well as incentive to attend to communication from that person. However, it is important to understand the impact of identity and incentive on attention to communication. In a real-world work situation, people respond to and choose among communications from many different individuals. Previous work on email and IM response behavior has found that certain senders are more likely to receive a response than others and receive responses more quickly than others (Avrahami & Hudson, 2006; Dabbish et al., 2005). The relationship between a sender and receiver may play an important role in whether a particular sender's messages are given priority (Avrahami & Hudson, 2006).

Having a common social identity with the sender may influence response decisions. In one study, members of the same organization received a faster response than people external to the organization (Dabbish et al., 2005). Previous work on interruptive communication has found that individuals better take into account the task constraints of someone with a common social identity when interrupting (Dabbish & Kraut, 2004). Based on this previous work, we expected that receivers would prioritize messages from team members over all other messages.

> **Hypothesis 9:** Receivers will be more likely to respond and will respond more quickly to messages from a sender with a common team identity.

> **Hypothesis 10:** Receivers will be more likely to respond and will respond more quickly to messages marked "high priority" from senders with a common team identity.

Thus, in Experiment 2, we manipulated team identity with the sender of a message to examine whether people differently prioritize messages from members of the same team versus others as well as how team identity interacts with level of busyness in the primary task and message priority.

## 3.4 Experiment 2

Experiment 1 suggested an imbalance between sender and receiver in terms of notification method in that sender-controlled communication timing resulted in better performance for the sender but not for the receiver. Experiment 1 also found that response behavior was influenced by the information provided on message value and deadline, such that receivers focused on deadline and then value in prioritizing messages for response.

Experiment 2 focused solely on receiver behavior and their prioritization decisions in message response. Because of this, we used only receiver-controlled communication timing (negotiated notification) so that we could measure receiver actions on a message independently of the sender. As described above, we also aimed to test an additional research question: Does having a common identity with the sender of a message affect the decision to respond to messages?

### 3.4.1 Procedure

Because we were primarily interested in receiver behavior in Experiment 2, we isolated the receiver portion of Experiment 1 and constructed a stand-alone receiver set-up which used a simulated "sender." In the task, all participants played the role of the receiver and believed that they were receiving and responding to messages from other participants. In fact, the messages in the task were generated by the computer to control for message timing and for distribution of message types across the experimental conditions.

Participants were told that the six participants in the room were divided into two teams and that, within each team, one player was playing the role of the receiver (with the jumpers game as the primary task; see Figure 3.2) and two players were playing the role of the sender (with the crossword puzzle as the primary task; see Figure 3.1) and that the roles were randomly selected. In reality, all participants played by themselves as receivers with pre-programmed computer teammates and non-teammates.

The participants were told at the beginning of the experiment that they would be rewarded based on how many jumpers they saved and whether they answered requests for help correctly. Each jumper saved was worth one point, and providing correct help on a request was worth three points. In reality, all participants earned the same amount of money ($15) at the end of the study.

### 3.4.2 Manipulations

In order to test our hypotheses regarding the influence of message priority and social identity on response behavior, we compared receivers' responses to different types of messages under varying game conditions. The message types were: from either a teammate or an opponent (team vs. other), with or without a priority flag (high priority vs. normal), and could occur anytime during the receivers' jumper's game (across varying level of busyness). This was a completely within-subjects experiment, with team by priority by busyness manipulated on a message-level basis. Participants received a total of 67 messages during the experiment, distributed evenly across these conditions.

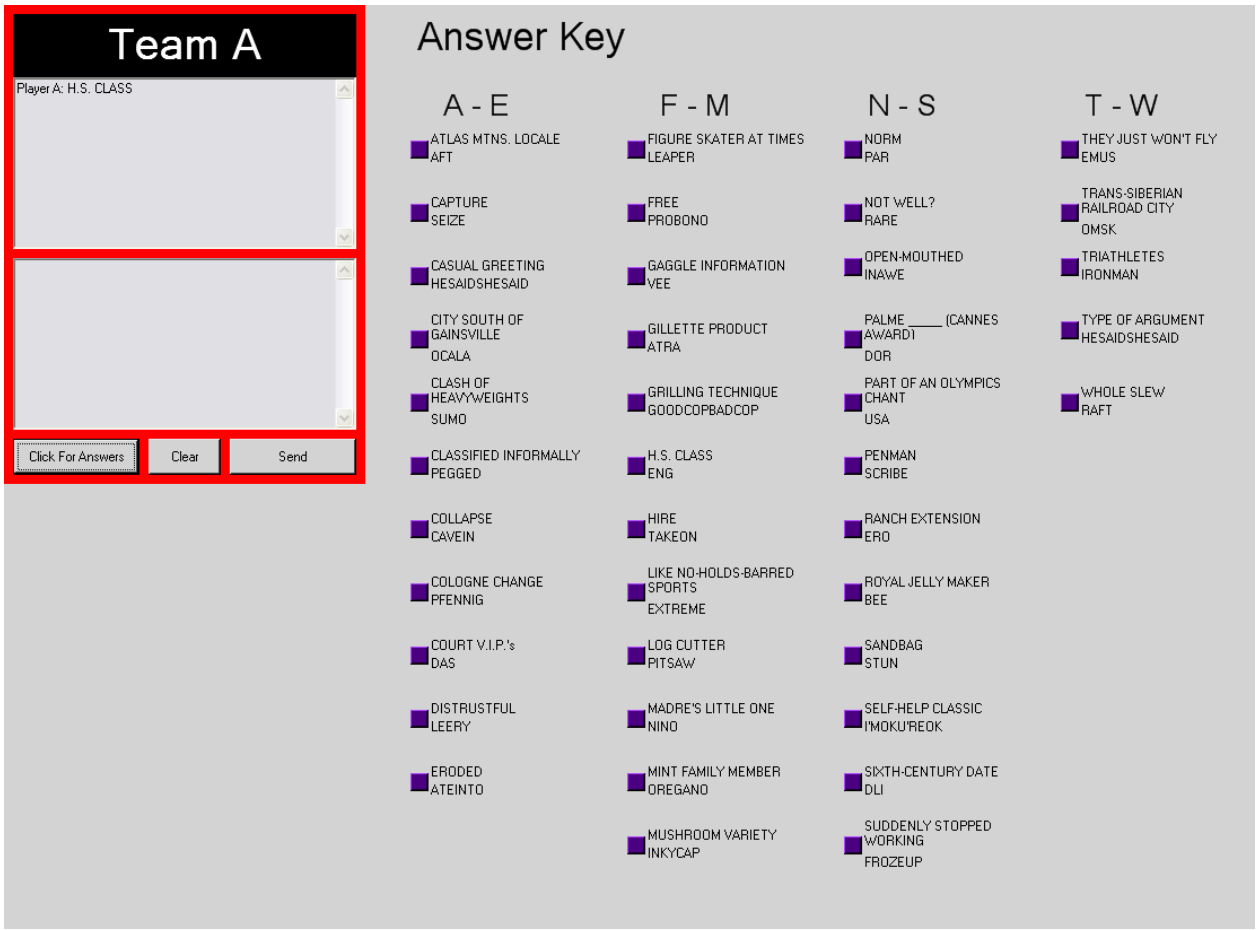


Figure 3.9. Opened message screen. Clue was listed on the left and a response was selected from the answer key list of clue-word pairs on the right.

Message response was similar to the receiver-controlled notification condition in Experiment 1. Messages appeared next to the jumpers game (up to six at a time), and the

receiver had to select a particular message to open it. When the message was open, it covered their screen until they responded (Figure 3.9).

#### *3.4.2.1 Priority Manipulation*

Participants in the experiment were told that senders could mark a message as "high priority" or normal. Messages marked as high priority appeared on the receiver's screen with a red border (as shown below in Figure 3.10), and normal priority messages appeared with a gray border (as shown below on the left side of Figure 3.10). Participants were also told that the senders' crossword puzzles had bonus words, which are randomly selected, unanswered words on the puzzle that are worth a bonus (three points) if solved within 30 seconds. This change was made to provide a plausible explanation as to why senders might flag certain messages as high priority. This priority manipulation allowed us to test Hypothesis 7.


Figure 3.10. Priority manipulation. Red border indicated a "high priority" message.

#### *3.4.2.2 Busyness Manipulation*

Busyness level was defined as on the average number of jumpers on the receiver's screen when the message first arrived until it disappeared due to the sender's cancellation or due to the receiver's response. In order to test Hypothesis 8, we used a pre-determined schedule to control busyness level during the session. A 20-minute session was divided into 30-second segments, evenly distributed between either low (0-3 jumpers on-screen), medium (4-6 jumpers on-screen), or high busyness level (7-9 jumpers on-screen) according to a pre-defined schedule.

#### *3.4.2.3 Team Manipulation*

Participants in the experiment were split into two teams: the Safari Team and the Arctic Team. They were told that the two teams were competing against each other and that members on the team with more points at the end of the study would each receive $20 in

compensation, while the losing team would only receive $10 per member. The team identity of a message sender was indicated at the top of each incoming message, as shown in Figure 3.11.

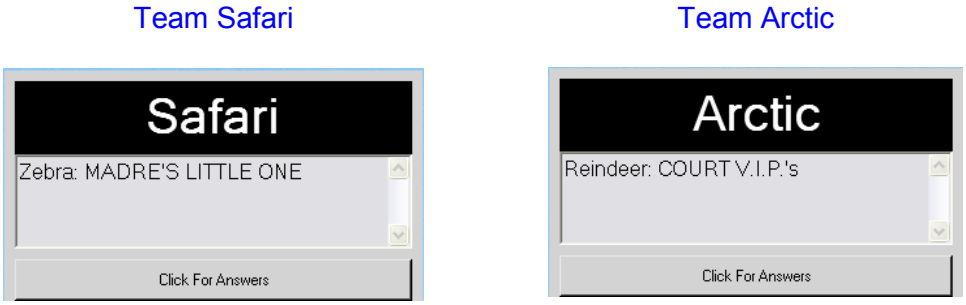


Figure 3.11. Team manipulation. Name of the sender's team was presented at the top of the message box.

We reinforced the team effect by telling participants that we were seating people on the same team together and by using the game interface's background to reinforce team membership (Team Safari was shown a picture of a safari and Team Arctic was shown a picture of the Arctic). The common social identity and financial incentive with some players and not others allowed us to test Hypotheses 9 and 10.

### 3.4.3 Results

Data was collected from 19 participants across five experimental trials. Participants in the experiment used IM fairly frequently (3.84 out of 5, where 1 is never and 5 is all the time). Since six participants were required per session to maintain the appearance of two three-person teams, confederates were used when scheduled participants did not show up to the study. Each participant received 67 messages during the experiment. The messages were split evenly between team/non-team and high priority/normal conditions.

#### *3.4.3.1 Analysis*

With a message as the unit of analysis, we conducted a repeated measures regression with team (same team/different team), priority (high priority/normal), and busyness level (the number of jumpers on-screen when a message appeared), two-way and three-way interactions included in the model, and participant included as a random effect to control for the non-independence of messages answered by the same participant (each participant responded to 67 messages). Our qualitative manipulation check[6] indicated that

[6] This consisted of participant interviews following each experimental session.

participants may not have understood the meaning of the priority condition, and in fact there were no differences in response likelihood and response speed for high priority versus normal messages. Thus, we do not present any further results from the priority condition, but include priority in our analyses to control for the visual salience difference between high priority and normal messages as presented to participants.

#### *3.4.3.2 Response Likelihood*

Using a probabilistic regression analysis, we looked at the likelihood that an individual message would receive a response. Our outcome in the analysis was a binary variable set to "1" if a message received a response and set to "0" if the message timed out before a response was received (after 30 seconds). Receivers were significantly less likely to respond to messages as their busyness level increased, supporting Hypothesis 8. Consistent with Hypothesis 9, receivers were significantly more likely to respond to a message if it was sent by a teammate than if it were sent by the opposing team (Table 3.5). These main effects must be qualified by a marginally significant interaction effect between team and busyness ($Z = 1.68$; $p = 0.09$). If a message was from a teammate, busyness did not affect likelihood of response. However, if a message was from a non-teammate, a higher level of busyness decreased the likelihood that the receiver would respond (Figure 3.12).

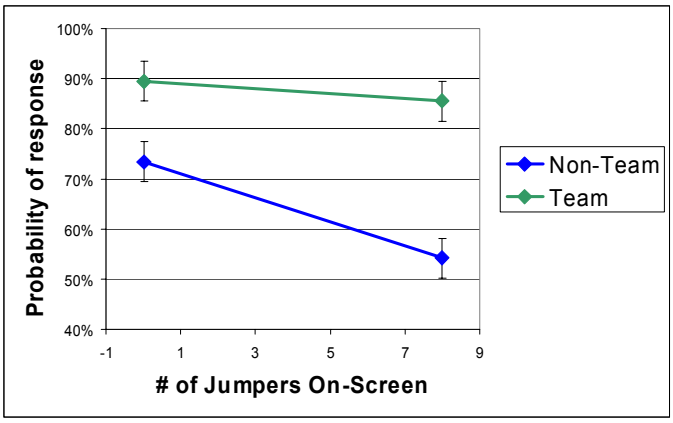


Figure 3.12. Response likelihood across receiver level of busyness (# of jumpers on-screen) for team versus non-team messages.

#### *3.4.3.3 Response Delay*

In Experiment 2, messages disappeared after being on screen for 30 seconds without a response. This meant that our message response speed data was truncated at 30 seconds.

To account for this truncation, we ran a Tobit model of response speed using team, priority, busyness level, and the two-way and three-way interactions as independent variables, including participant as a random effect to control for individual differences in message response. Our analysis indicated that team was a significant factor in determining the amount of time until a message was answered. Messages from team members were responded to significantly more quickly than messages from non-team members (Table 3.5). In addition, busyness had a significant main effect on response speed in that higher workload significantly increased the time that a participant took to respond to a message.

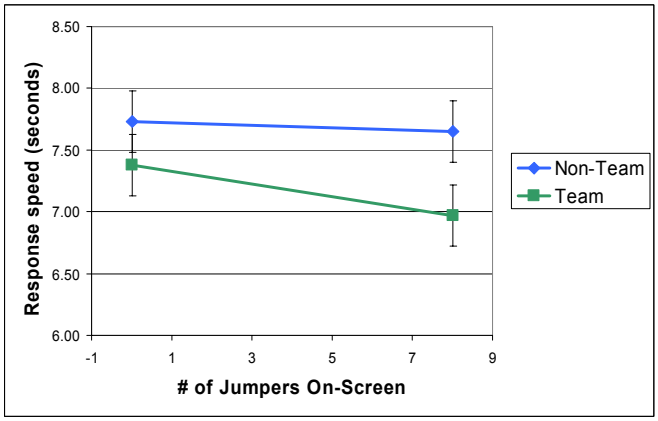


Figure 3.13. Response delay in seconds across receiver busyness level (# of jumpers on-screen) for team versus non-team messages.

Finally, there was a significant team by busyness interaction ($Z = -2.94$; $p = 0.003$) for response speed, shown in Figure 3.13. Messages from team members were answered more quickly, the busier the receiver was, while messages from non-team members were postponed equally as long regardless of how busy the receiver was when the message arrived.

Table 3.5. Response Behavior in Experiment 2, Means and Statistics

| | **Team** | | | | **Busyness** | | | | | **Priority** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Non-Team | Team | Stats | | Low | Med | High | Stats | | Norm | High | Stats | |
| | M | M | z | *p* | M | M | M | z | *p* | M | M | z | *p* |
| Response likelihood | 0.69 | 0.90 | 3.36 | 0.001 | 0.81 | 0.77 | 0.83 | -2.07 | 0.04 | 0.79 | 0.79 | 1.50 | 0.13 |
| Response delay (seconds) | 7.36 | 6.80 | -2.00 | 0.05 | 7.55 | 6.63 | 7.22 | 3.37 | 0.001 | 7.54 | 6.55 | -0.02 | 0.98 |

### 3.4.4 Summary

The data from Experiment 2 provide quantitative support that both team identity and the receiver's task state are important factors influencing likelihood and speed of response to incoming messages. The results from Experiment 2 suggest that being on the same team decreases the effect of the receiver's busyness on both response likelihood and speed. This result suggests a model of response where receivers' behavior is strongly influenced by the relationship with the person sending a particular message. This finding maps to previous empirical results (Avrahami & Hudson, 2006; Dabbish & Kraut, 2005; Dabbish & Baker, 2003; Quan-Hasse et al., 2002) as well as anecdotal evidence that attention is directed to communication differently depending on the relationship with the sender.

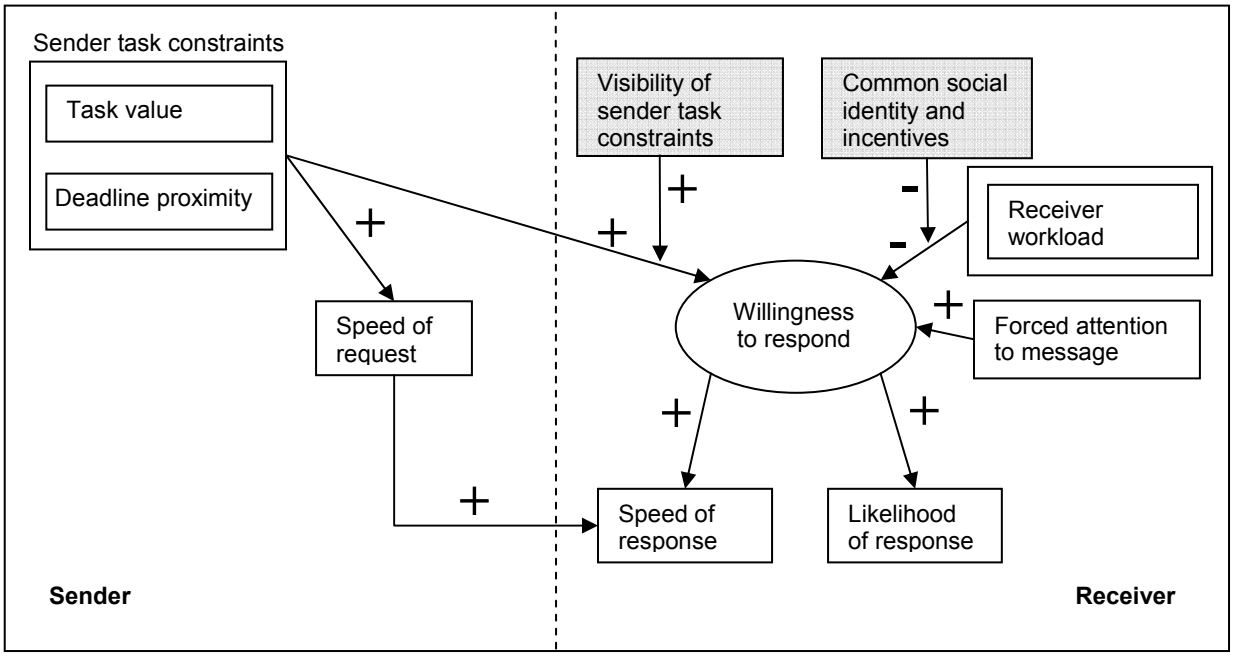


Figure 3.14. Summary of results from Experiments 1 and 2 with respect to message-sending behavior.

## 3.5 Discussion

Both Experiments 1 and 2 focused on help-seeking communications in a dual-task scenario. Experiment 1 examined the effect of notification methods varying communication control between the sender and the receiver as well as message value and deadline indicators on sending and receiving behavior, while Experiment 2 examined the effect of the receiver's task state and social identity on receiving behavior only. The

results indicate a set of basic heuristics used by both parties in the communication interaction when prioritizing messages. Figure 3.14 summarizes the results from Experiments 1 and 2 in diagram format.

### 3.5.1 Notification Methods

Previous work has considered how the different notification methods for delivering incoming communications affect the receiver of communication and the receiver's ability to complete a primary task (McFarlane, 2002). In the work presented here, we explored the effect of these notification methods on both sides of the communication dyad. The results from Experiment 1 provide support for our hypothesis that giving the sender control of communication timing (what McFarlane (2002) terms *immediate notification*, that is, messages received immediate attention) improved the sender's performance. Giving the receiver control of communication timing (what McFarlane (2002) terms *negotiated notification*, that is, messages went into a queue) harmed the sender's performance because the sender did not get the help needed because the receiver's responses were delayed and the receiver ignored messages. Experiment 2 suggests that this delay occurred because receivers postponed messages when their task workload was high (many jumpers on-screen). This result highlights the importance of designing communication technologies that consider potential impacts on both parties of the communication. Failure to consider both sides would result in a potential mismatch in communication benefits, helping one party at the cost of the other.

### 3.5.2 Visibility of Sender's Task State

As expected, the sender's messaging behavior was strongly affected by the demands of the sender's primary task. In Experiment 1, the likelihood of requesting help increased significantly for higher value subtasks with shorter deadlines. Correspondingly, having information about sender subtask value and deadline also affected receiver behavior: receivers responded more quickly to messages with earlier deadlines and to messages of high value. Despite the effect on receiver response actions, providing information about the sender's task to the receiver (Experiment 1's information condition) had no influence on either sender or receiver performance. Such information should have improved coordination by directing the receiver's attention to help requests that the sender needed most urgently and would benefit from the most. We do not know why this was not the case. It may have been an issue with the design of our experimental task or an issue with the particular representation chosen; regardless, this certainly merits future investigation.

#### *3.5.2.1 Message Priority Indicator Design*

In Experiment 1, during the information condition, receivers could see the deadline and value associated with a word request and in this condition used both parameters to determine whether or not to respond as well as how quickly to respond to a message. This result suggests that concrete representations of sender task constraints may be useful in guiding receiver behavior. In Experiment 1, we chose to display deadline and value of the sender's task in the information condition. Presentation of the time remaining in a sender's task helped the receiver in deciding when to respond to a particular message because the receiver could weigh the constraints in the receiver's primary task against the precise time remaining on the message and would be more likely to respond to messages in a timely fashion, versus ignoring messages when not aware of an impending deadline. However, presenting an indication of message priority did not affect the receiver's behavior in Experiment 2, perhaps because combining time and value into a single-dimension indicator made it difficult for the receiver to translate priority into the action that should be taken. Providing a receiver with a very specific representation of the sender's task state as it relates to the action that the receiver should undertake may better direct the receiver's behavior in alignment with the sender's task goals.

Future work must be done to examine across different tasks what types of indicators of the sender's task state are more useful for a message receiver. Particularly, the dimensions of comprehension, ambiguity, expressiveness, and trust must be taken into account when designing these kinds of indicators, and the trade-offs between these indicator features must be examined in greater depth.

### 3.5.3 Social Identity

In Experiment 1, when team identity was held constant and receivers and senders were always on a team with joint incentives, receivers attended to information about the sender's needs and responded to a high proportion of messages from the sender. In Experiment 2, we varied team identity and found that the relationship with the sender strongly affected the receiver's response behavior. Not only did identity with the sender determine whether or not a receiver would respond to a message, it also strongly affected the speed of response. Messages from team members were responded to more quickly than non-team messages. Receivers may have used the identity of the sender as a selection heuristic when choosing between messages on their screen.

Helping common team members was also prioritized over primary task constraints. In Experiment 2, receivers were equally likely to attend to messages from members of the same team regardless of how busy they were in their primary task, the jumpers game. However, messages from non-team members were more likely to be ignored the busier receivers became.

Team identity in Experiment 2 involved both a common social identity with team member senders as well as a joint monetary incentive with those senders. Thus, an interesting issue to explore in future work is whether common identity alone is sufficiently strong motivation to prioritize team members over other individuals requesting attention and help. Social identity involves both cognitive identification with team members (e.g., mentally viewing oneself and team members as a unit, referring to the unit as "we," etc.) as well as an increase in liking for common team members. It would be interesting to also explore whether liking is a sufficient motivator for increased attention to communication or whether a common fate and perception of oneself and others as a unit are necessary components to achieve similar results as those in our study. In addition, it would be interesting to investigate how receivers prioritize different senders when other social factors are added to the equation. For example, is there an interaction between common social identity and status or reciprocity? Finally, it is unclear how these results might differ if receivers had membership in multiple teams and had to weigh these teams against each other, prioritizing certain teams over others. Competing social identities, such as between multiple project groups, may be another interesting issue to examine in future work.

## 3.6 Conclusion

The studies presented in this chapter have attempted to shed light on the trade-offs between sender and receiver in a computer-mediated interaction. In particular, we have aimed to examine the impact of notification condition, visibility of sender's task state, and social identity on interaction behavior, and we have looked at the consequences for performance of the pair as a whole. We have presented design considerations for electronic communication system developers based on the results from our studies. With the studies in this chapter, we have begun to develop a picture of how attention is directed when balancing ongoing work and communications on the computer.

# Chapter 4

# Response in Context: Understanding Email Use*

## 4.1 Introduction

Email consumes significant time and attention in the workplace. This chapter presents an organizational survey conducted to understand how and why people attend to incoming email messages. We examined people's perceptions of message importance and the actions that they took on specific email messages, based on message characteristics as well as characteristics of receivers and senders. In our sample, respondents kept a quarter of their new messages in the inbox and replied to about a quarter of all messages. They rated messages as important if they were about work and required action. Importance, in turn, had a modest impact on whether people replied to their incoming messages and whether they saved them. The results indicate that factors other than message importance (e.g., a person's social nature and a person's relationship with the sender) also determine how people handle email. Overall, email usage reflects attentional differences due to personal propensities, work demands, and relationships.

* Parts of this chapter are adapted from Dabbish, Kraut, Fussell, and Kiesler (2005)

## 4.2 Motivation

The studies in the previous two chapters were conducted in a laboratory setting, with communication over the computer using both asynchronous and synchronous forms of notification. However, the results and theory developed apply to computer-mediated communication more generally. In this chapter, we examined the interaction between social ties and work demands on communication behavior in a more naturalistic work setting and across individuals in a variety of jobs, using email as our focus mode of computer-mediated communication.

Email is by far the most popular form of computer-mediated communication. Because it has been so widely adopted for communication within organizations, people are receiving an increasing amount of email on the job. To inform the design of technology that may alleviate the communication overload problem, we conducted an empirical study to understand decision rules and strategies that people use to reply to, file, or delete email messages.

To help people deal with the deluge of communication, application designers have been developing more efficient search engines, advanced interfaces for navigating contacts (Nardi, Whittaker, Isaacs, Creech, Johnson, & Hainsworth, 2002), and interfaces designed around task management (Belotti, Ducheneaut, Howard, & Smith, 2003; Neuwirth, Morris, Regli, Chandok, & Wegner, 1998). In addition, researchers have attempted to characterize and develop tools to combat unsolicited commercial email, known as spam (Boone, 1998; Sahami, Dumais, Heckerman, & Horvitz, 1998).

Most previous empirical research on email management describes at a general level the functions that email serves and the problems associated with email overload. For example, several studies have focused on how people save their email, what purposes it serves for them, and its importance as a tool for coordination in the workplace (Dabbish, Venolia, & Cadiz, 2003; Ducheneaut & Bellotti, 2001; Kraut & Attewell, 1997; Mackay, 1988; Sproull & Kiesler, 1991; Sumner, 1988; Venolia, Dabbish, Cadiz, & Gupta, 2001; Whittaker & Hirschberg, 2001; Whittaker & Sidner, 1996).

In this chapter, we build on this previous work by looking carefully at the decision rules that people use in dealing with particular email messages. Few previous studies have examined, using behavioral data, how people choose to reply to email messages or save or delete them. Analysis of email-related behavior as a function of message and user characteristics is important both for

understanding this communication technology and for the development of automated tools to help people manage their email.

In the next section, we review the previous literature on email usage. We then review theory on the main functions of email in current organizational contexts and put forth a set of hypotheses on how these functions relate to important characteristics of email messages and, in turn, the likely action on a message. In the remainder of the chapter, we describe an email survey to examine these hypotheses in which participants reported the characteristics of new email messages in their inbox and their actions on those messages. We use regression techniques to model message characteristics that influence recipients' perceptions of message importance and subsequent actions on messages.

## 4.3 Previous Work

Because email is one of the oldest uses of networked computers and one of the most popular, social scientists have long examined how people use it. Sproull and Kiesler (1991) provide a summary of much of the early work on the social and organizational aspects of email. Here we will focus on work about email and information management strategies as well as research dedicated to alleviating the problem of "email overload."

### 4.3.1 Email as a Task-Management Tool

As early as 1988, Sumner examined how email was being used in organizations by interviewing and surveying users at an organization with an electronic mail system in heavy use. She found that email was displacing previous communication modalities and warned that access to electronic mail systems might lead to information overload (Sumner, 1988).

Mackay (1988) observed that people used email in highly diverse ways, and Whittaker and Sidner (1996) extended this work. They found that in addition to basic communication, email was "overloaded" in the sense of being used for a wide variety of tasks—communication of new information, reminders, contact management, task management, and information storage.

Ducheneaut and Bellotti (2001) performed a more recent study of email usage in three organizations and found, as had previous authors, that email was being used for a wide variety of functions. In particular, they noted that people used emails as reminders for tasks that they had to do and for task management more generally.

### 4.3.2 Individual Differences in Email Handling

Mackay (1988) also noted that people fell into one of two categories in handling their email: *prioritizers* or *archivers*. Prioritizers managed messages as they came in, keeping tight control of their inbox, whereas archivers archived information for later use, making sure they did not miss important messages.

Whittaker and Sidner (1996) also examined how people responded to the abundance of electronic mail that they received. According to them, people fell into one of three categories, depending upon the strategy they used for handling email: *frequent filers*, who constantly cleaned their inboxes; *spring cleaners*, who cleaned their inboxes once every few months; or *no filers*, who did not clean up their inboxes and used search tools to manage it. Research to identify and compare different strategies for email management has continued.

Extending Whittaker and Sidner (1996), Bälter (2000) developed a mathematical model using keystroke-level analysis to examine the time necessary to use each organizational strategy. Tyler and Tang in a recent interview study identified several factors that may influence likelihood of response (Tyler & Tang, 2003). These previous empirical studies were qualitative, generally based on 10 to 30 interviews. The current research extends this work, using a larger sample and statistically examining users' decision rules. Venolia et al. (2001) also used a large sample quantitative survey technique in examining patterns of email usage; however, because of the wording in their questionnaire, their results represented people's theories about their personal email habits and not data on specific user behaviors and actions in email, which the current study presents in the results below.

### 4.3.3 Technologies to Facilitate Email Handling

Implementation-oriented research has attempted to design and deploy email systems that help people deal with the deluge of email and better support the tasks email serves (Boone, 1998; Malone, Grant, Turbank, Brobst, & Cohen, 1987; Nardi et al., 2002). Much of this work has focused on intelligently categorizing messages and determining what is important to the user. For example, researchers at Xeroc PARC (Bellotti, Ducheneaut, Howard, & Smith, 2003) designed TaskMaster, a system that supports the use of email messages as task reminders. TaskMaster (Bellotti et al., 2003) allows users to group their email specifically by its relationship to active tasks. Malone et al. (1987) experimented with the "Information Lens," an intelligent information-sharing system that focuses on informational aspects of content that is important to users. Even

though particular features of these systems appear valuable, attempting to combine the elements from them may increase the overload problem.

Machine learning and artificial intelligence techniques have also been applied to the problem of email overload. Intelligent agent-based systems have been created to extract content information from email and create meaningful summaries for users (Abu-Hakima, McFarland, & Meech, 2001; Boone, 1998). Machine learning techniques have been used to filter out spam (Sahami, Dumais, Heckerman, & Horvitz, 1998). Horvitz et al. (1999) have developed a system aimed at inferring the criticality of messages and prioritizing email received. The goal of these systems is to facilitate dealing with large numbers of emails in a short amount of time.

None of the intelligent systems discussed here, save spam filters, have been widely adopted. Although much of this implementation research has collected quantitative data on email usage, it typically involves small samples of users and does not provide general models that contribute to our understanding of users' actions on email.

## 4.4 Conceptual Framework

Communication is conducted to serve both task-oriented and relationship maintenance functions (Clark, 1996), thus, action on email communication should be influenced both by task considerations and social or relationship factors. Based on this perspective, we posit that both the relationship with the sender of a message and the task-oriented content of the message itself comprise the exogenous factors that influence a recipient's perception of individual message importance to the recipient's own work and to the sender's work. These perceptions of importance should in turn influence the attention given to individual messages in terms of response behavior and retention. Figure 4.1 below presents this general conceptual framework guiding the data collection performed in this study.

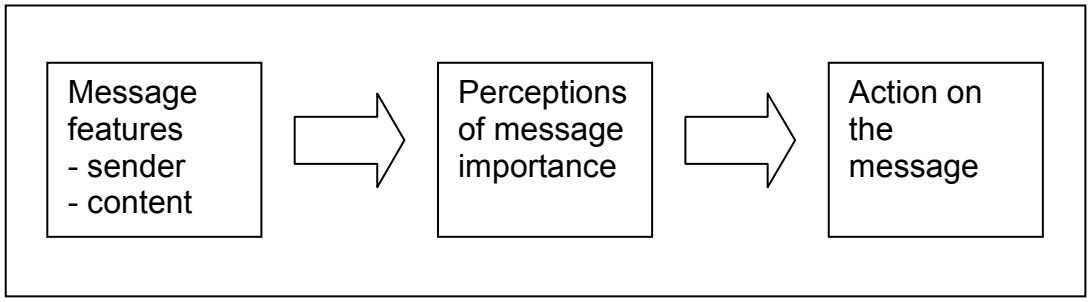


Figure 4.1. General theoretical framework for this study.

### 4.4.1 Message Importance

It is plausible that the perceived importance of email messages influences how quickly people respond to, delete, store, or file them. However, studies have not examined what aspects of a message influence a user's evaluation of its importance. Systems such as Priorities (Horvitz et al., 1999), which organizes messages based on inferred importance, make assumptions as to what constitutes an important message. Currently, there is little evidence about the characteristics that make a message important. One of the primary goals of this chapter is to assess what makes an email message important and how importance influences the way that people act on the message.

Previous researchers, as well as the designers of commercial email systems, such as Outlook or Eudora, have assumed that the inclusion of a priority field in email messages allows users to more effectively manage their email by attending to important and critical messages first. However, email users often ignore the priority field (Whittaker & Sidner, 1996). The problem with this approach is that senders must assign priority to a message manually, a tedious process. In addition, the priority field reflects only the senders' priorities, giving recipients little reason to attend to it. An intelligent system that could accurately infer the importance of a message to the receiver should help users efficiently attend to critical messages. To understand how a user evaluates the importance of a message, we look to see which message characteristics were associated with users' assessments of messages' importance. We differentiate between sender and receiver importance as well as between importance and urgency associated with a message. Our expectation is that sender and receiver importance will be influenced by different features of a message and by urgency.

### 4.4.2 Sender Characteristics

The relationship maintenance function of conversation suggests that social factors should influence attention to communication (Clark, 1996). Previous work has shown that certain senders are attended to and are responded to more quickly than others (Avrahami & Hudson, 2006; Dabbish & Kraut, 2005; Dabbish & Baker, 2004) because of relationship features such as relative status, tie strength, and common social identity. In the previous two chapters, we found this to be the case in an experimental setting as well. Therefore, we expect senders of email messages to be differentially important and, in turn, receive differential attention on the part of the receiver.

In particular, we expect individuals with stronger ties to have higher levels of importance and thus be prioritized for response and attention. We are interested in communication frequency as

an indicator of tie strength, and we expect higher communication frequency to increase importance of a message and response speed.

> **Hypothesis 1**: Higher communication frequency with the sender of a message will increase the perceived importance of a message and the speed of response.

In addition, we expect relative status with the sender to influence perceptions of message importance and action on a message. Messages from higher-status senders should be perceived as more important for work, should receive a faster response, and should be more likely to be retained than messages from senders of the same or lower status than the recipient.

> **Hypothesis 2**: Messages from higher-status senders will be perceived as more important for work, will be responded to more quickly, and will be more likely to be retained than messages from equal or lower-status senders.

Finally, we are interested in the differing influence of work versus that of family or friends. Studies on relationship types and their influence on privacy and communication decision-making have shown that people are able to group their contacts into levels of importance, placing work contacts in a separate category from family or friends (Davis & Gutwin, 2005; Dabbish & Baker, 2003; Lederer, Mankoff, & Dey, 2003).

In the current study, we considered work versus personal relationships and their effect on response speed as well as communication frequency with the sender (one indicator of closeness and tie strength) and the number of recipients included on the message. Our expectation is that having a work relationship with the sender (versus a social relationship, e.g., friend or family) will increase the work importance of a message. However, the impact of the type of relationship with the sender on the likelihood of response is not clear, and thus we cannot make any direct predictions about it. We expect that a work relationship (versus a social relationship) will increase the likelihood of message retention and filing because email acts as repository and record for on-the-job communications. These considerations suggest the following hypotheses:

> **Hypothesis 3**: Having a work relationship with the sender (versus a social relationship) will increase perceived importance of a message for both the sender's and the receiver's work.

> **Hypothesis 4a**: Having a work relationship with the sender (versus a social relationship) will increase the likelihood of message retention.

**Hypothesis 4b**: Having a work relationship with the sender (versus a social relationship) will increase the likelihood of filing a message versus leaving it in the inbox.

### 4.4.3 Email Content as Action-Oriented

Previous work on email and organizational communication has conceptualized the content of email messages as speech acts (Cohen, Carvalho, & Mitchell, 2004; Flores et al., 1988; Winograd, 1986) or communication actions based on Speech Act Theory (Austin, 1962; Searle, 1975). Winograd (1986) and Flores et al. (1988) developed a speech-act protocol based on a study of the recurrent use of language acts inside organizations, as applied in the Coordinator system. Their perspective views conversation as action-oriented, meaning that the goal is to do something, i.e., to complete a task, meet in a particular location, etc.

By considering email from a speech act perspective, we identified four key groups of message content, adapted from the categories presented by Cohen, Carvalho, and Mitchell (2004) and Flores et al. (1988). These four groups are requests, follow-ups, deliveries of information or reminders, and social content. In addition, we made specific predictions about how these types of content should relate to the perceived importance of a message to both the sender and the receiver as well as the actions taken on a message.

#### *4.4.3.1 Task Delegation and Requests*

Requests for action, information, or an opinion, in Speech Act Theory, are the starting points for action-oriented conversations (Flores et al., 1988). Because email is used for task and project management, in many job roles it is a common way that work is assigned. Email is often used to ask questions, request a document or web link, etc. Requests are initiated by the sender of an email, and thus the sender should receive primary benefit from a request. This suggests that messages containing requests will be perceived to be of greater importance to the sender's work than messages without request content.

**Hypothesis 5a**: Messages containing a request will be perceived as more important to the sender's work than messages without request content.

Requests for information, action, or an opinion also can require work or communication outside of the email itself to obtain the necessary information or complete the action requested. We were thus also interested in request messages requiring action or communication outside of email. Because of the work associated with the message, there is a potentially high impact on the

receiver's work from such a request, and thus it should be perceived as more important for the receiver's work than a message without request content.

> **Hypothesis 5b**: Messages containing a request will be perceived as more important to the receiver's work than messages without request content.

In Flores et al.'s (1988) taxonomy, requests elicit a response from the receiver committing to, refusing, or amending the original request. Thus, we hypothesize that requests will be more likely to receive a reply and to receive a faster reply than messages not containing the request.

> **Hypothesis 6**: Messages containing a request and requiring action will receive a faster response than messages without a request that do not require action.

As Whittaker and Sidner (1996) and Ducheneaut and Bellotti (2001) found, users often treat their inbox as an external memory store, with messages in view serving as reminders for actions that need to be taken (Bellotti et al., 2003). This previous research suggests that messages likely to contain an open task or a to-do item—e.g., requesting an action and requiring work or communication outside of email—will be retained and are likely to be left in the inbox rather than filed or deleted in order to serve as a reminder for the work they represent.

> **Hypothesis 7a**: Messages requesting an action or requiring action or communication outside of email are more likely to be retained than deleted.

> **Hypothesis 7b:** Messages requesting an action or requiring action that are retained are more likely to be left in the inbox instead of filed.

#### *4.4.3.2 Modifications to Requests: Coordinating Work*

As noted above, a request by Person A must be followed by a response from Person B that contains a commitment to perform the action requested, a response suggesting a change to the request, or a refusal to perform the action requested (Flores et al., 1988). These messages comprise how work is coordinated and, as Sumner (1988) noted, email from the beginning has been used for these planning and mutual adjustment purposes to coordinate ongoing work.

These messages follow a previous interaction: a prior request or response on the part of the receiver. Thus, they should be more important for the receiver's work than a message thread that is initiated by someone else or that is not part of a previous interaction.

> **Hypothesis 8:** Messages following a previous interaction should be considered of higher importance to the receiver's work than messages that are not a follow-up.

The sender of a follow-up is responding to the receiver's original request and, in the case of a commitment, is also agreeing to complete some action. Follow-ups refusing to complete a request absolve the sender of responsibility and further ties to the original request and thus should be less important to the sender. Finally, messages suggesting an alteration to the original request (amendments) are negotiating how the request is executed and thus should be perceived as both important to the receiver and the sender. Amendments affect the outcome of the receiver's original request and invest the sender in acceptance of the receiver's suggested changes.

> **Hypothesis 9a:** Messages containing a commitment should be perceived as of higher importance to the sender than messages without commitment content.

> **Hypothesis 9b:** Messages containing refusals should be of lower importance to the sender and of higher importance to the receiver than messages without refusals.

> **Hypothesis 9c:** Messages containing amendments should be of higher importance to the sender and the receiver than messages without amendments.

Follow-up messages are preceded by a previous communication on the part of the receiver, meaning that receivers have already made an investment of time and attention to the conversation. Previous actions on the thread of communication (e.g., sending the initial message) should predict future action, and thus follow-up messages such as those continuing a previous interaction or committing, amending, or refusing to perform an action associated with a previous request should be more likely to receive a response. Such messages should also receive a faster response than messages that are not a follow-up to a previous interaction.

> **Hypothesis 10:** Messages following a previous interaction should receive a faster response than messages that are not a follow-up from a previous interaction.

#### *4.4.3.3 Information Exchange, Storage, and Retrieval*

Requests specifically for information or an opinion are typically followed by a response delivering that information or opinion (Flores et al., 1988). This delivery signals the endpoint of the communication interaction unless clarification or additional information is required. This means that messages delivering a piece of information should be less likely to receive a response, particularly an immediate response, because no action is associated with the message.

> **Hypothesis 11**: Messages delivering information or an opinion will be less likely to receive a response and will receive a slower response than messages without delivery content.

One type of message content that delivers information is a reminder. Messages containing reminders, which relate to action to be performed or events outside of the messages itself, should be treated differently than messages containing static pieces of information. In particular, these reminders are more likely to require action and thus should be perceived as more important to the receiver's work and should be more likely to receive a response acknowledging the receipt of the response.

> **Hypothesis 12**: Messages containing a reminder will be responded to more quickly than messages without reminder content.

Previous research also shows that the ability to archive information is one of the primary reasons that users save messages (Whittaker & Hirschberg, 2001; Whittaker & Sidner, 1996). People are likely to store messages containing important information for later retrieval. This informational use of email suggests that the informational content of messages will influence the importance that people attach to a message and the actions that they take on messages. We predict that messages delivering information or opinions will be less likely to be deleted by the user and will be more likely to be left in the inbox or filed. Messages containing reminders should be more likely to be retained than deleted until the action or associated event has been completed, but may not be needed afterwards. Thus, we cannot make a specific predication for the likelihood of retention for reminder messages.

> **Hypothesis 13a**: Messages delivering information or an opinion will be more likely to be retained than deleted.

> **Hypothesis 13b**: Messages delivering information or an opinion will be more likely to be filed than left in the inbox.

#### *4.4.3.4 Social Communication*

Although email communication is asynchronous, in many firms, employees read and respond to their email throughout the day, and exchanges can be almost as rapid as one might expect from instant messaging communication. The proliferation of email in combination with longer working hours mean that people now use work email accounts to communicate with family and friends as

well as work contacts. Thus, we should also consider messages containing purely social content. These messages may be more important for a recipient's life outside of work, although they may have lower importance than a message for work.

> **Hypothesis 14**: Messages containing social content will be perceived as less important for the receiver's work than messages without social content.

Previous findings have shown that social content within a message may increase the speed of response (Dabbish & Kraut, 2005).

> **Hypothesis 15**: Messages containing social content will be responded to more quickly than messages without social content.

## 4.5 Method

There are several ways to build models of user behavior in any domain. One is the machine learning approach, which builds statistical models from records of users' interactions with their messages, as per Horvitz et al. (1999). Another approach is statistical analysis of interviews or surveys. The advantage of the first approach is that models are based on observed behavior and that a great deal of data can be obtained from each respondent, both cross-sectionally and over time. The disadvantage is that machine learning models are often black boxes that provide little insight into the cognitive and work processes that email supports. They might show, for example, that a user saves messages from a certain sender, but not why this sender is important. We chose to use a survey approach to collect data on individuals' actions on their email because the results provide us with general models of human behavior and allow us to see, in human-understandable terms, how work processes mediate between message features (e.g., the number of addressees on a message) and the actions that the recipients may take on a message. In addition, machine learning techniques typically use small samples of users (e.g., Lashkari et al.'s research is based on two users (Lashkari, Metral, & Maes, 1994)) because such techniques are often intrusive. The non-intrusive survey approach allowed us to obtain a larger sample of respondents, increasing the generalizability of our results.

### 4.5.1 Participants

Survey participants were recruited from across the United States using a survey sampling service. Invitations to participate were sent via email to 3900 individuals randomly selected from the sampling service database and stratified by organizational size and job type (managerial,

professional, and sales). Participants were given five dollars as compensation for completing the survey and were entered into a weekly raffle to win 200 dollars. Seven hundred people attempted to complete the survey, resulting in a response rate of 18%. Of these, we screened out 150 respondents as ineligible because they did not have a job or did not use email for their work. A total of 484 individuals usably completed the survey (12% of the initial mailout).

Participants ranged in age from 20 to 81, with an average age of 43.5. Respondents were more likely to be female (65%) and were more likely to have a higher income than the sample as a whole. Forty-five percent of the respondents indicated that they were in a professional occupation, 26% in managerial occupation, and 18% in sales. Participants' tenure in their current positions ranged from less than one year to 46 years, with the average number of years in the current position being 8.4 (Std. Dev. = 8.4 years). Respondents in our sample worked an average of four days per week (Std. Dev. = 1 day), an average of 10 hours per day (Std. Dev. = 3 hours), and used a computer for an average of 6 hours per day to do their work (Std. Dev. = 3.6 hours).

Respondents were fairly well distributed across organizational sizes, with 47% of the sample coming from organizations smaller than 500 employees, 20% of the sample coming from organizations with 500 to 2499 employees, and 29% of the sample from organizations larger than 2499 employees.

### 4.5.2 Survey

The survey itself was web-based, i.e., completed over an Internet browser, and was divided into three sections. The first section collected information about the work context, focusing on the nature of the respondent's job (e.g., the number of projects that the respondent works on, the number of the respondent's subordinates, and the respondent's feelings of time pressure at work). The second section asked questions about the respondent's general patterns of email use (e.g., the number of email messages sent and received, the number of messages in the email inbox, and general email habits).

The third section of the questionnaire asked for detailed information about five new non-spam messages in the respondent's email inbox. For each of the five email messages, the respondent indicated the nature of the content (Table 4.1), the importance of the message, the characteristics of the sender, and the action taken on the message (replied, plan to reply later, do not plan to reply), and what they did with the message (deleted, filed, or left in inbox). We will describe

these measures in more detail below. Appendix A contains the survey in its entirety as it appeared when participants viewed it via the Internet using a web browser.

#### *4.5.2.1 Message Importance to Receiver*

We hypothesized that people draw on certain characteristics of the email messages received (i.e., sender and content) to determine a particular message's importance for their work and that this importance in turn influences their action on a message. To assess the importance of a message to a recipient's work, we constructed a four-item measure index of message importance for this survey. Respondents rated each of the following questions on a five-point Likert scale. These questions were meant to assess the relation of the incoming message to the receiver's work as a whole:

1. How important is the content of this message for doing your work? (on a scale of 1 to 5) Scale: 1 - Not important, 2 - Slightly Important, 3 - Somewhat Important, 4 - Moderately Important, 5 - Extremely Important

2. How long into the future will you keep this message? Scale: 1 - A day or less, 2 - A few days, 3 - A few weeks, 4 - A few months, 5 - A year or more

3. How soon are any deadlines for the project or task associated with this message? Scale: 1 - Within the day, 2 - Within the week, 3 - Within the next few weeks, 4 - Within the next few months, 5 - Within the year

4. How much of your time at work is spent on the project or task associated with this message? Scale: 1 - Little or no time, 2 - A fair amount of time, 3 - Half of my time, 4 - Over half of my time, 5 - Almost all of my time

This scale was highly reliable with an alpha of 0.85. Correlations for the scale items are featured in Table B.1 of Appendix B. The mean for this scale was 2.38 with a standard deviation of 1.20.

#### *4.5.2.2 Message Importance to the Sender*

We measured the participant's perception of importance of the message to the sender's work using a single item: "How important is this message for the sender's work?" (on a scale of 1 to 5 where 1 = Not important, 2 = Slightly Important, 3 = Somewhat Important, 4 = Moderately Important, 5 = Extremely Important). The mean for this item was 3.67 with a standard deviation of 1.94.

#### *4.5.2.3 Urgency of Response*

We measured the participant's perception of message urgency using a single item: "How quickly do you need to reply to this message?" (on a scale of 1 to 5 where 1 = Immediately, 2 = Within the hour, 3 = Within the day, 4 = Within the week, 5 = Within the month, 0 = Never). For ease of interpretation, this scale was reversed in our analyses such that higher urgency indicated that a faster response was required.

#### *4.5.2.4 Amount of Work required*

Finally, we measured the receiver's perception of the amount of work a message required using a single item: "How much work does this message require of you? (in terms of time required) (on a scale of 1 to 5 where 1 = Less than 15 minutes, 2 = 15 minutes to 1 hour, 3 = 2 to 3 hours, 4 = 4 to 5 hours, 5 = More than 6 hours).

### 4.5.3 Sender Characteristics

Because we hypothesized that the sender of the message was important in determining likelihood of response, survey respondents described their relationship with each message sender. To evaluate whether the sender was a work contact or not, we had respondents select the sender's role from a list: "direct supervisor," "direct subordinate," "direct co-worker (e.g., member of the same group, working on the same project, etc.)," "other member of the same organization," "external work contact or client, social contact (e.g., family member, friend outside of work, etc.)," "I do not know the person who sent this message," and "Other." These responses were then coded into a binary variable with 1 for a work-related contact and 0 for non-work-related contacts such as family, friends, etc. Respondents also indicated how frequently they typically communicate with the sender as well as the number of other recipients on the message (Appendix A for the wording of these survey items).

### 4.5.4 Message Content

We hypothesized that certain action-oriented message content, particularly requests for action, follow-ups coordinating ongoing work, delivery of information and reminders, and social communication, would change a message's importance to the sender and the receiver. These content categories were obtained by examining the Speech Act Theory (Searle, 1985) adapted by Flores et al. (1988) for organizational context and in turn by Carvalho & Cohen (2005) more recently for email messages. In the survey, respondents coded the content type of each message using the categories in Table 4.1. Content types were not mutually exclusive, e.g., a message could contain both a request and a delivery.

Table 4.1. Message Content

| **What was the content of this message? Select 'yes' for all that apply:** |
|---|
| - Requesting, or proposing, or requiring action, or requiring communication |
| - Follow-up to a previous message |
| - Committing |
| - Amending |
| - Refusing |
| - Delivering information, file, or opinion |
| - Reminding |
| - Social |
| - Other |

### 4.5.5 Message Actions

Finally, respondents described how they acted on the message. For each message, respondents indicated whether they replied immediately or planned to reply later to the message as well as whether they deleted it, left it in the inbox, or filed it. Through these questions, respondents acted as classifiers, providing detailed categorization of messages in their inbox. We used these data to predict user action on specific messages as a function of message characteristics such as importance, relationship to sender, and message content.

## 4.6 Results

Sender characteristics and message content influenced users' perceptions of message importance. Importance, in turn, influenced how people responded to a message. However, people also responded to messages that they did not consider important, suggesting that other sender and message characteristics play a role. In this section, we first present general statistics describing the population with respect to job characteristics and email usage and then discuss our models of perceived message importance to the sender, receiver, and perceived message urgency. We next propose a model of message response incorporating users' perceptions of message importance and message characteristics. Finally, we examine influences on where messages end up and the role of individual differences.

Table 4.2. Summary of General Email Usage Statistics

| Measure | Mean | Median | Min | Max |
|---|---|---|---|---|
| Number of inbox messages | 311 (1115) | 40 | 0 | 12000 |
| Number of folders | 17 (28) | 8 | 0 | 265 |
| Email times checked | 16 (13) | 8 | 2 | 42+ |
| Messages RECEIVED | 41 (32) | 41 | 6 | 121+ |
| Messages READ | 35 (28) | 21 | 6 | 121+ |
| Messages SENT | 18 (19) | 6 | 6 | 121+ |
| Number spam / last 20 | 5.71 | 2 | 0 | 20 |
| Percent spam | 24% (29%) | 10% | 0 | 100 |

### 4.6.1 Basic Email Statistics

Respondents in our sample received an average of 41 email messages per day, read an average of 32 messages per day, and sent an average of 21 messages per day. These numbers are overall means (presented in Table 4.2), but email usage varied based on job role. The managerial and sales portion of our sample reported reading significantly more messages per day than other job types ($F [4,463] = 2.47$, $p<0.04$; Managerial M = 46 (SD = 34) and Professional M = 38 (SD = 31), and Sales M = 46 (SD = 33), Clerical M = 28 (SD = 15), Other M = 31 (SD = 4)).

The mean number of messages in the inbox was 311. Only 10% of the sample had an inbox larger than 600 messages. There was an extremely wide spread for the number of messages in the inbox, with 50% of individuals having 105 messages or fewer in their inboxes, 25% of individuals having 1050 or more messages in their inboxes, and 2.5% of individuals having 10,000 or more messages in their inboxes. The majority of individuals (75%) had fewer than 1000 messages in their inboxes. This may be due to storage limitations in the environment. However, the small size of the inbox and the high number of email folders suggests that many people are filing their messages in folders.

Although participants came from many different organizations across the nation, the overwhelming majority of our respondents (76%) reported using Microsoft Outlook as their primary work-related email client (client distribution: Lotus Notes (7%), Novell GroupWise (6%), Mozilla Thunderbird (2%), and other clients (10%)). Table 4.2 summarizes general statistics about email usage in this sample.

#### *4.6.1.1 Email Habits*

We gathered data on general email habits, particularly filing behavior. Our results are similar to Whittaker and Sidner's (1996), who indicated that their sample of 11 individuals fell into three categories: frequent filers, spring cleaners, and no filers. In our survey, participants were asked about email behaviors on a five-point scale ranging from never (1) to always (5). Table 4.3 shows the percentage of respondents who report performing each behavior often or always.

Table 4.3. Percent of Respondents Reporting *Often* or *Always* for Email Habit Items and Correspondence to Categories in Whittaker & Sidner (1996)

| Email Habits Item | % | Classification |
|---|---|---|
| "I try to keep my inbox size small." | 65% | Frequent filers |
| "I file my messages into folders as soon as I have read them." | 49% | Frequent filers |
| "I leave messages in the inbox after I have read them" | .39% | Spring cleaners and no filers |

### 4.6.2 Message Level Data

Respondents entered data on each of five email messages in their inbox for a total of 581 messages. Data for each email included sender, content, and action on the message.

#### *4.6.2.1 Message Content Distribution*

Figure 4.2 summarizes the distribution of messages among the various content types. It is important to note that messages could contain more than one type of content. A high proportion of messages contained requests for action (64%), which highlights the task delegation function of email. An equally high proportion of messages delivered information, file attachments, or opinions (61%), which points to the key role of email for information exchange and storage.

Forty-two percent of messages were a follow-up to a previous interaction via email, IM, phone, or in person. Content that coordinates work and makes adjustments to ongoing tasks was present in about a quarter of messages, with 25% of messages containing a commitment to do something, 20% of messages making an amendment to an ongoing task or idea, 34% of messages containing a reminder, and only 4% of messages containing a refusal to perform an action. Finally, only 14% of messages contained social content.

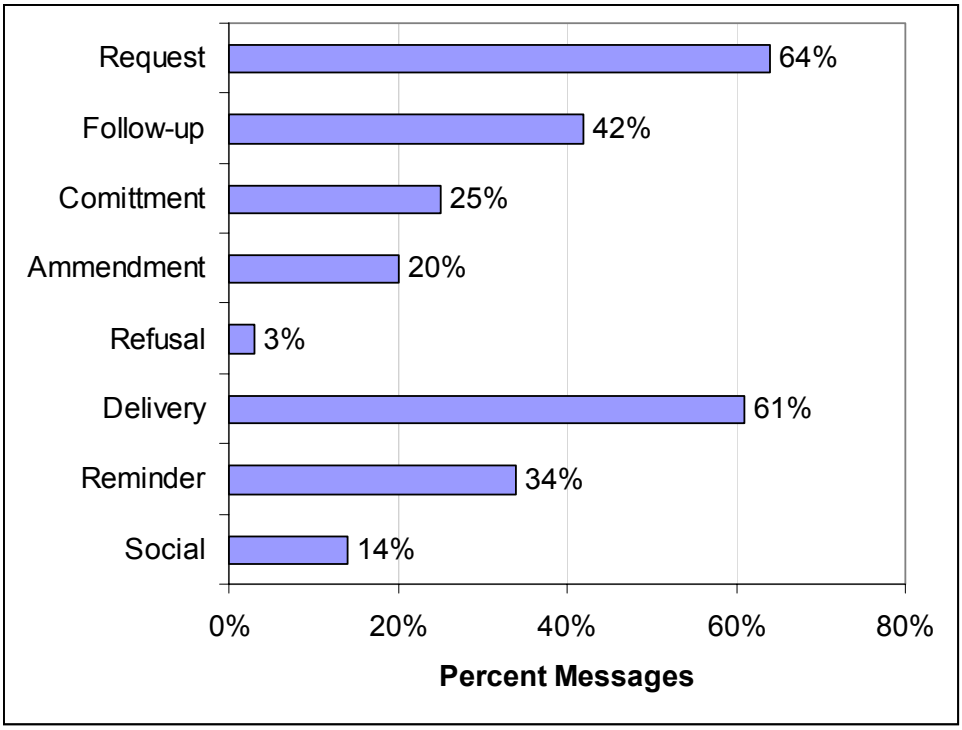


Figure 4.2. Distribution of message content across types (content types are not mutually exclusive).

### 4.6.3 Effects on Importance of a Message

We measured message importance to the receiver using a four-item scale (reliable with alpha = 0.78). Correlations between scale items are shown in Table B.1 of Appendix B. Using single items, we also measured the receiver's perception of message importance to the sender, urgency of a message response, and the amount of work that a message required. Table 4.4 shows the correlations between the receiver's importance scale and the single-item measures of message perceptions (importance to sender's work, urgency of response, and work required).

Table 4.4. Correlations and Means for Message Perception Measures

| | Measure | Mean (SE) | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| **1** | Importance to receiver | 2.56 (0.03) | * | | | |
| **2** | Importance to sender | 3.67 (0.05) | 0.58 | * | | |
| **3** | Urgency of response | 2.65 (0.05 | 0.71 | 0.29 | * | |
| **4** | Work required | 1.95 (0.03) | 0.66 | 0.39 | 0.42 | * |

As shown in Table 4.4, our measures of message perceptions are all highly positively correlated, meaning that our single-item measures of importance to the sender, urgency, and work required are not conceptually distinguishable from our measure of importance to the receiver. It may be that receivers are unable to distinguish between the importance of a message to the sender versus themselves and between importance, urgency, and work required by a message—or our items may not have captured the differences between these concepts. Another possibility is that these measures were subject to common method bias because all the items were in close proximity in the same section of the questionnaire and thus may have been answered in a similar way.

Because these items measuring message perceptions were all highly correlated with importance to the receiver, we could not use them as distinct outcome variables. Thus, for the remainder of our analyses we considered only the receiver's perception of the importance of a message to the receiver's own work because this measure utilized a four-item scale and because receivers were likely to be most accurate in assessing their own perceptions of importance.

We were interested in the relationship between the perceptions of message importance for work and the characteristics of the message itself (sender and content) and actions taken on a message. Table 4.5 shows the correlations between our receiver work importance scale, message characteristics, and actions on a message (reply speed and likelihood of saving a message).

Interestingly, importance to the receiver's work was highly positively correlated with the sender's likelihood of being a work contact, the request message content, and the likelihood of saving a message.

Table 4.5. Correlation of Importance, Content Types, and Action on a Message

| | **Measure** | **M** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Importance | 2.58 | * | | | | | | | | | | | | | | | |
| **2** | Relative Status | 1.22 | 0.25 | * | | | | | | | | | | | | | | |
| **3** | Work Contact | 0.73 | 0.45 | 0.63 | * | | | | | | | | | | | | | |
| **4** | Friend of Family | 0.11 | -0.25 | -0.36 | -0.56 | * | | | | | | | | | | | | |
| **5** | Num Recipients | 2.89 | -0.22 | 0.02 | 0.04 | -0.18 | * | | | | | | | | | | | |
| **6** | Comm Frequency | 3.09 | -0.28 | -0.26 | -0.34 | -0.01 | 0.16 | * | | | | | | | | | | |
| **7** | Request | 0.64 | 0.52 | 0.16 | 0.28 | -0.20 | -0.07 | -0.16 | * | | | | | | | | | |
| **8** | Follow-up | 0.42 | 0.37 | 0.11 | 0.20 | -0.02 | -0.36 | -0.25 | 0.22 | * | | | | | | | | |
| **9** | Commitment | 0.25 | 0.30 | 0.06 | 0.13 | -0.08 | -0.06 | -0.08 | 0.29 | 0.25 | * | | | | | | | |
| **10** | Amendment | 0.20 | 0.30 | 0.05 | 0.15 | -0.10 | 0.05 | -0.11 | 0.23 | 0.18 | 0.18 | * | | | | | | |
| **11** | Refusal | 0.03 | 0.16 | 0.04 | 0.06 | 0.00 | -0.03 | -0.06 | 0.13 | 0.16 | 0.22 | 0.18 | * | | | | | |
| **12** | Delivery | 0.61 | 0.12 | 0.11 | 0.19 | -0.15 | 0.13 | -0.04 | 0.01 | 0.08 | 0.12 | 0.11 | 0.03 | * | | | | |
| **13** | Reminder | 0.34 | 0.13 | 0.07 | 0.12 | -0.11 | 0.18 | -0.09 | 0.18 | 0.08 | 0.16 | 0.18 | 0.09 | 0.19 | * | | | |
| **14** | Social | 0.14 | -0.11 | -0.09 | -0.13 | 0.26 | -0.03 | -0.07 | -0.08 | 0.08 | 0.05 | 0.07 | 0.25 | 0.00 | 0.01 | * | | |
| **15** | Speed of Response | 0.27 | 0.28 | 0.09 | 0.15 | -0.04 | -0.13 | -0.12 | 0.23 | 0.15 | 0.13 | 0.11 | 0.16 | 0.02 | 0.00 | 0.02 | * | |
| **16** | Likelihood of Saving | 0.51 | 0.45 | 0.03 | 0.13 | -0.05 | -0.12 | -0.10 | 0.19 | 0.17 | 0.12 | 0.12 | 0.03 | 0.03 | 0.04 | -0.13 | 0.16 | * |

#### *4.6.3.1 Sender's Relative Status*

We were very interested in how status influenced the perceived work importance of a message and the response speed. In the survey, we asked respondents to specify their relationship with the sender of a message as well as the relative status for senders in the same organization. Table 4.6 reports mean importance and speed of response by relative status with the sender.

Using an ANOVA, we examined the differences across sender status (higher, same, and lower) in perceived work importance of a message, likelihood and speed of response, and likelihood of saving a message. Surprisingly, we found that the status of the message sender did not have an influence on any of these factors (Table 4.6 below). This was completely counter to our initial expectations that higher-status senders would be prioritized for response and messages from these senders would be perceived as more important for the receiver's work (Hypothesis 2).

Table 4.6. Means, Standard Deviations, and Results of ANOVAs Comparing Perceived Importance of a Message and Actions on a Message Across Sender Status Levels

| | **Relative Status of Sender** | | | | | **Stats** | |
|---|---|---|---|---|---|---|---|
| | **Higher** | **Same** | **Lower** | **Not sure** | **Diff Org** | **F(2, 815)** | ***p*** |
| **Measure** | n = 305 | n = 268 | n = 188 | n = 34 | n = 463 | | |
| Importance to receiver | 3.04 (1.23) | 3.01 (1.15) | 2.83 (1.18) | 2.60 (1.31) | 2.01 (1.12) | 2.10 | 0.12 |
| Likelihood of response | 0.24 (0.43) | 0.28 (0.45) | 0.32 (0.47) | 0.14 (0.36) | 0.18 (0.39) | 2.04 | 0.13 |
| Response speed | 0.29 (0.62) | 0.35 (0.63) | 0.35 (0.61) | 0.18 (0.52) | 0.21 (0.50) | 0.80 | 0.45 |
| Likelihood of saving | 0.58 (0.49) | 0.53 (0.50) | 0.54 (0.50) | 0.49 (0.51) | 0.47 (0.50) | 0.89 | 0.41 |

Because sender status did not appear to have an influence on the perceived importance of a message and the action on a message, we did not include it in our subsequent analyses.

#### *4.6.3.2 Importance to the Receiver's Work*

Using characteristics of the sender and message content as independent variables, we performed a standard least squares regression to predict the following outcome variables: importance to the receiver and importance to the sender. Because each respondent provided data on several email messages, we used a random effects model in Stata to account for the non-independence of messages within respondents by including respondent ID as a random effects variable.

Table 4.7 presents standardized beta coefficients for the regression of message characteristics on survey participants' ratings of message importance to their work. Individual differences accounted for 35% of the variance in the perceived importance of a message for the receiver's own work, indicating that some people rate their email messages as more important on average than other people do. Table B.1 in Appendix B presents all models in the regression analysis of importance to the receiver.

Our results showed that sender characteristics significantly affected how much work importance people assigned to their messages. Respondents perceived messages with fewer recipients to be more important for their work; these messages may be perceived as more directed and personal. Higher communication frequency with the sender reduced perceived work importance of a message, counter to our expectations stated in Hypothesis 1. Messages from family or friends were rated as less important for work, as expected, because these messages are less likely to be relevant to the receiver's work. In contrast, having a work relationship with the sender increased the perceived work importance of a message (Hypothesis 3). If we had measured the importance of a message for life outside of work or life in general, we may have seen the opposite results in that friend or family senders are important in general. It would be interesting in future work to look at whether importance to work and general importance are distinct concepts or whether importance to work is simply a component of general importance. Thus, tie strength alone is not sufficient to understand the work importance of a message. The nature or context of the relationship (work vs. friend or family) must also be taken into account.

Messages requesting or requiring action were all perceived as significantly more important to the receiver. This result corresponds with our expectations stated in Hypothesis 5. The influence of requests for action on a message's perceived importance shows the impact of others' demands on how people direct their attention on the job. Requests for action (e.g., proposals and other messages requiring action or communication) were a significant proportion of all message content (64% of messages; see Figure 4.2) and significantly increased importance ratings of a message ($\beta = 0.64$; $p<0.001$). Messages initiating a new activity may cause people to shift gears and to add new tasks to their current workload.

Follow-ups and coordination content also had a positive impact on the importance of a message to the receiver. Messages following up a previous interaction, committing to do something, or amending a previous request had significantly higher importance ratings (supporting Hypotheses 8, 9a, and 9c), while refusals contained within a message did not affect a message's importance for the receiver (no support for Hypothesis 9b). Messages delivering information or opinions were perceived to be more important to the receiver than messages without delivery content, while the presence of social content in a message significantly decreased the importance of a message for the receiver's work (supporting Hypothesis 14).

### 4.6.4 Actions on a Message

There were several possible actions that people could take on a message. Primarily we were interested in two types of actions: *reply actions* (e.g., whether the user had already replied to, planned to reply to, or did not plan to reply to a message) and *location actions* (e.g., whether a user stores a message after processing or deletes or leaves the message in the inbox).

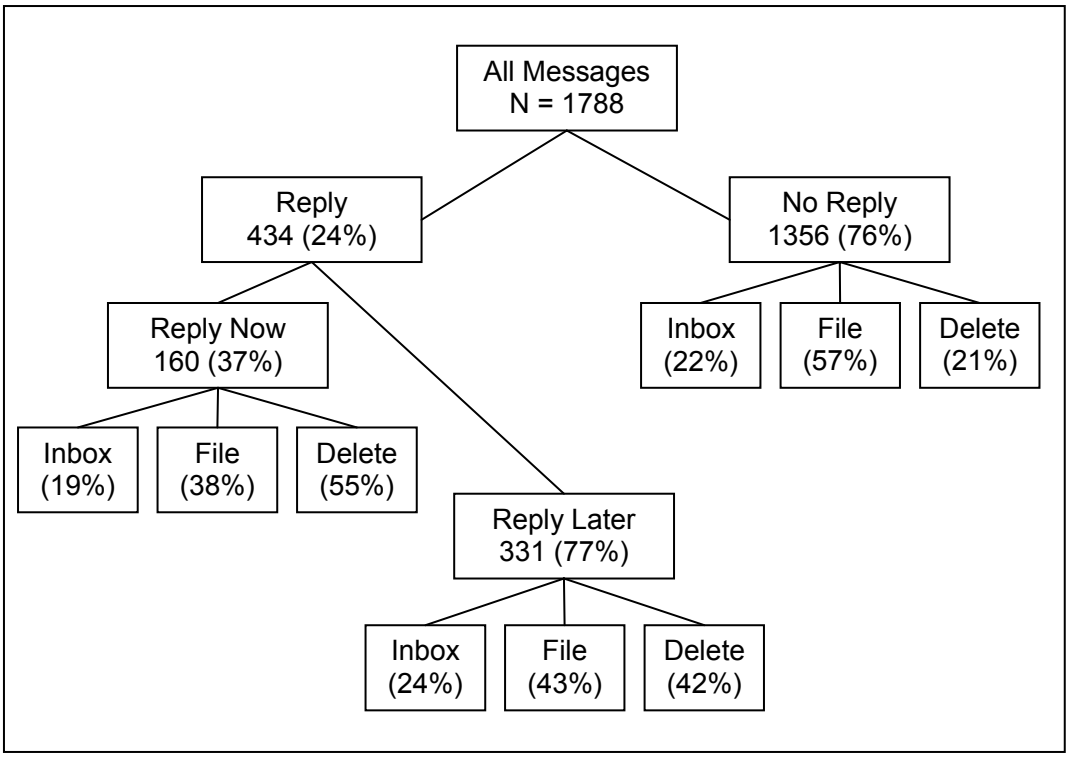


Figure 4.3. Distribution of messages across reply and location action.

Out of the 1788 messages, respondents felt that 64% did not require any reply, 23% required an immediate reply, and 13% required a reply that they postponed (Figure 4.2). There may be message characteristics that differentiated the messages that respondents felt required a reply and messages that respondents did not feel required a reply. We consider the characteristics that predict message response in detail below.

There were three possible resting places for a message: users could file a message in a folder, delete it, or leave it in the inbox. Figure 4.3 shows the breakdown of locations by reply action. Overall, respondents deleted 54% of their email, filed 27% into folders, and kept 23% in their inbox. It is notable that, for messages where a response was postponed, only 24% were left in the inbox. This is counter to previous work that has found that people tend to leave the majority of messages in the inbox (Dabbish et al., 2005) and the previous literature that suggests that individuals use the presence of email messages as a reminder to respond (Bellotti et al., 2003; Ducheneaut & Bellotti, 2001; Whittaker & Sidner, 1996). At the same time, people were only slightly more likely to delete messages that did not need a reply (57%) than those that did (47%). Regardless of reply action, in this sample, people were more likely to file or delete messages than leave them in the inbox; a high percentage of messages were deleted in this sample (54%). We examine factors associated with retaining a message and leaving a message in the inbox in a subsequent section.

#### *4.6.4.1 Effects on Message Reply*

We were interested in influences on email behavior, particularly response speed. Recall that respondents indicated that only 24% of the messages that they received required a reply and that only 13% required an immediate reply. We created a continuous variable for message reply speed set to "0" if the respondent reported not replying to the message, "1" if the respondent reported planning to reply to the message later, and "2" if the respondent reported planning to reply to the message immediately.

To test our conceptual framework illustrated in Figure 4.1, we looked at the extent to which the perceived message importance to the receiver mediated the influence of message characteristics on response speed. We performed mediation analysis using

standard least squares regression[7], regressing message characteristics (our independent variable) on response speed (our dependent outcome variable), and then regressing message characteristics on our mediating variable, which was message importance to the receiver. These results are reported below in Table 4.7.

Table 4.7. Path Analysis of Message Characteristics, Perceived Importance of a Message, and Response Speed

| Outcome Variable | Importance to Receiver | Response Speed | Response Speed | Response Speed | Percent of Effect Mediated? |
|---|---|---|---|---|---|
| | β | β | β | β | β |
| Intercept | -0.96*** | -0.39*** | -0.01 | 0.04 | |
| **Sender Relationship** | | | | | |
| Number of recipients | -0.17*** | -0.07** | | -0.05 | 39%*** |
| Communication Frequency | -0.06** | -0.01 | | -0.00 | 59%** |
| Is Work contact? | 0.52*** | 0.11 | | 0.03 | 66%*** |
| Is Friend of Family? | -0.15** | 0.07 | | 0.10 | 37%* |
| **Request** | | | | | |
| Requesting action | 0.64*** | 0.33*** | | 0.21*** | 35%*** |
| **Follow-up** | | | | | |
| Following prev. interaction | 0.25*** | 0.16** | | 0.10 | 31%*** |
| Committing | 0.15*** | 0.08 | | 0.05 | 34%** |
| Amending | 0.22*** | 0.07 | | -0.02 | 58%*** |
| Refusing | 0.20 | 0.39* | | 0.36* | |
| **Deliver** | | | | | |
| Delivering Info or Opinion | 0.17*** | -0.01 | | -0.04 | 100%** |
| Reminding | -0.00 | -0.04 | | -0.04 | |
| **Social** | | | | | |
| Social Content | -0.26*** | 0.09 | | 0.13 | 66%*** |
| **Perceptions of Message** | | | | | |
| Importance to Receiver | | | 0.26*** | 0.18*** | |
| **Model R-squared** | 0.46 | 0.08 | 0.07 | 0.10 | |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

We hypothesized that response speed might be differentially influenced by the importance of a message to the sender's work versus the receiver's work. However, we

[7] This controlled for individual differences using the cluster command in stata

were unable to test this hypothesis because our importance variables were highly correlated and collinear.[8]

We performed a regression of the importance to the receiver (our mediating variable) on response speed. Finally, we performed a regression with both our independent variables (message characteristics) and our mediator (perceived message importance) in the model to look at the influence of the mediator on the independent variable's regression coefficients. The results of these regressions are reported in Table 4.7. The importance of a message to the receiver significantly increased the speed of response, but accounted for only a small percentage of the variance in response speed (7%). In addition, messages containing requests, refusals, and social content received faster responses (supporting Hypotheses 6 and 15). Follow-ups to previous interactions did not affect response speed once work importance to the receiver was taken into account, which means that we do not find support for Hypothesis 10's statement that previous action on a conversation should influence subsequent actions. In addition, delivery and reminder content did not influence response speed as expected (no support for Hypotheses 11 and 12).

We tested mediation of importance to the receiver on response speed for each of the independent variables using the Sobel test. The results are reported in Table B.6 of Appendix B. This testing indicated that perceived work importance of a message to the receiver fully mediated the influence of certain content types on message response (i.e., follow-ups, commitments, amendments, deliveries, and social content) and fully mediated the influence of certain sender characteristics (i.e., the number of recipients, communication frequency, having a work relationship, and having a friend or family relationship). In addition, importance partially mediated the influence of requests. This means that part of the reason that these types of messages receive a response is because of their perceived importance to the receiver's work, but a significant part of their response speed is a direct result of the nature of the content itself, beyond its importance for work. Interestingly, messages containing a refusal received a faster response than messages without a refusal, even though refusals do not influence the perceived work importance of a message.

[8] This means that both importance to the sender and importance to the recipient were conveying essentially the same information and it would not make sense to include both in a regression analysis. See correlations included in Table 4.4.

#### *4.6.4.2 Effects on Message Retention*

We next looked at whether particular message characteristics were associated with retaining a message versus deleting it. A binary variable "Saved" was set to "0" if a user deleted or planned to delete a message and "1" if a user retained the message. We analyzed the likelihood of retaining a message using logistic regression with "Saved" as our binary outcome variable, controlling for individual differences using the xtlogit command in Stata and including individual in our model as a random effect.[9] The analysis looked at the relationship between sender characteristics, message content, perceived message importance, and likelihood of message retention versus deletion. Results of our analysis are reported below in Table 4.8. The odds ratios reported may be interpreted as the effect of the independent variable on the likelihood of saving a message, holding all other message features at their average value for continuous variables and at 0 for binary variables. An odds ratio higher than one means that the independent variable increases the likelihood of retaining a message, while an odds ratio lower than one means that the independent variable decreases the likelihood of retaining a message. For our binary message content variables, this means that the presence of a certain type of message content within a particular message increases or decreases the probability of saving that message by the odds ratio reported.

Note that individual differences accounted for 43% of the variance in likelihood of retaining a message versus deleting it, indicating strong patterns or tendencies across individuals. For example, some people are inclined to save everything and others delete messages immediately after reading them (Whittaker & Sidner, 1996).

Sender characteristics did not significantly affect the probability of retaining a message (no support for Hypothesis 4a). Counter to our expectations, request content also did not affect likelihood of retention (no support for Hypothesis 7a). This was surprising, given the previous work that shows that messages are often saved to serve as reminders for the tasks that they represent—in this case, delivering the information or performing the action requested. Messages with social content were significantly less likely to be retained (0.65 times or about two-thirds as likely). This was to be expected since these messages may be less likely to contain information or need action. Surprisingly, delivery

[9] Participants in our sample provided data on 3 to 5 messages in their inbox; thus, we needed to control for the influence of participant characteristics in our model.

of information or opinion within a message did not influence the likelihood of message retention, as posited in Hypothesis 13a.

Finally, perceptions of message importance for the receiver's work strongly affected whether messages were saved. A standard deviation increase of one in the receiver's work importance score of a message related to the receiver being five times more likely to retain the message. Thus, receivers were much more likely to hold onto messages perceived as important to their work.

Table 4.8. Logistic Regression of Saving vs. Deleting and Filing vs. Leaving a Message in the Inbox

| **Outcome Variable** | **Save vs Delete** | | | **File vs Leave in Inbox** | | |
|---|---|---|---|---|---|---|
| | β | SE | Odds Ratio | B | SE | Odds Ratio |
| Constant | 0.34 | 0.26 | | -1.27** | 0.40 | |
| **Sender Relationship** | | | | | | |
| Number of recipients | -0.06 | 0.09 | 0.94 | 0.19 | 0.14 | 1.21 |
| Communication Frequency | 0.14 | 0.09 | 1.15 | -0.01 | 0.13 | 1.00 |
| Is Work contact? | -0.30 | 0.23 | 0.74 | 0.39 | 0.37 | 1.48 |
| Is Friend of Family? | 0.40 | 0.27 | 1.49 | 0.07 | 0.47 | 1.08 |
| **Request** | | | | | | |
| Requesting action | -0.26 | 0.18 | 0.77 | 0.14 | 0.30 | 1.15 |
| **Follow-up** | | | | | | |
| Following prev. interaction | 0.26 | 0.17 | 1.29 | -0.02 | 0.26 | 0.98 |
| Committing | -0.09 | 0.19 | 0.91 | 0.18 | 0.27 | 1.20 |
| Amending | -0.20 | 0.21 | 0.82 | 0.30 | 0.29 | 1.35 |
| Refusing | -0.03 | 0.44 | 0.97 | 1.62* | 0.70 | 5.06* |
| **Deliver** | | | | | | |
| Delivering Info or Opinion | 0.26 | 0.16 | 1.30 | 1.21*** | 0.26 | 3.34*** |
| Reminding | -0.04 | 0.17 | 0.96 | -0.45 | 0.26 | 0.64 |
| **Social** | | | | | | |
| Social Content | -0.75** | 0.22 | 0.47** | 0.50 | 0.39 | 1.64 |
| **Perceptions of Message** | | | | | | |
| Importance to Receiver | 1.63*** | 0.13 | 5.09*** | 0.81*** | 0.16 | 2.25*** |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

#### *4.6.4.3 Predicting Message Location*

As Figure 4.3 shows, a proportion of messages in our study were left in the inbox (23%) rather than filed into folders. We were interested in whether respondents were deliberately leaving certain email messages in their inboxes versus filing them into folders, as the practice of using the inbox as a to-do list has been commonly cited in previous qualitative research and potentially contributes to overload in email use (Bellotti et al., 2003; Ducheneaut & Bellotti, 2001; Whittaker & Sidner, 1996).

We expected that certain types of messages, messages from work senders, and messages perceived as work-critical would be more likely to be filed than to be left in the inbox. Again using random effects logistic regression on the sub-set of messages retained, we modeled the likelihood of filing a message (versus leaving it in the inbox) as a function of sender, content, and importance, controlling for individual differences by including the participant in our model as a random effect. Table 4.8 above presents the results of our analyses.

It is interesting to note that individual differences accounted for a large portion of the variance in the probability of a message being left in the inbox (43%), suggesting stable differences among respondents. For example, some people keep messages in their inbox, regardless of message content, as an overarching strategy (Whittaker & Sidner, 1996).

Interestingly, sender characteristics did not affect the likelihood of filing a message. Thus, we find no support for our hypothesis that messages from work senders would be more likely to be filed for future access (Hypothesis 4b).

We hypothesized that messages requesting an action and reminder messages would be left in the inbox as a memory aid (Hypothesis 7b), but the results of our logistic regression did not support these hypotheses.

Messages containing refusals were significantly more likely to be filed away versus left in the inbox (5.06 times more likely to be filed than left in the inbox). Messages delivering information or opinions were also more likely to be filed into a folder than left in the inbox (3.34 times more likely to be filed). This supports our initial expectation that delivery content would be filed into folders corresponding with the archival function of email folders (Hypothesis 13b).

Other types of message content, such as requests, reminders, follow-ups, and commitments, did not significantly influence whether a message was filed or left in the inbox.

Finally, people in our sample were significantly more likely to keep the messages that they considered important for their work in their inboxes, with higher work importance of a message increasing the likelihood of leaving in the inbox by 1.56 times (and decreasing the likelihood of filing by 0.64 times, or almost two-thirds).

Only refusal and delivery content impacted where a message ended up, suggesting that most message content only influences message retention in a mediated fashion through its effect on message importance.

### 4.6.5 Results: Summary

The analyses presented above revealed that almost all message content types had a significant influence on the importance of an email message to the receiver. Request, follow-up, and delivery content all increased the importance of a message to the receiver, supporting Hypotheses 5b, 8, 9a, 9b, and 9c. In addition, messages from work contacts were more important for the receiver's work (supporting Hypothesis 3), while more recipients, a friend or family sender, higher communication frequency, and social content decreased the work importance of a message. Because of the collinearity between our measures of message perceptions, we were unable to examine influences on other perceptions of a message: importance to the sender, perceived urgency of response, and amount of work required by the message. These concepts may be directly associated with a receiver's perception of importance of a message to their own work, or require more items per measure.

By performing a path analysis on message response speed, we saw that a majority of message content factors indirectly affected message response through their influence on the respondent's perception of message importance for the respondent's work. Many of these factors—action requests, follow-ups, and reminders—relate directly to email's function as a task management and delegation tool. At the same time, certain types of message content had a direct effect on speed of response even though they did not influence perceived work importance of a message—in particular, messages containing a refusal received a faster response even though refusals did not increase perceived

importance of a message. Finally, request content had both a mediated and direct effect on speed of response. It may be that request and refusal messages elicit a response simply due to social protocol and politeness, regardless of their impact on ongoing work. It would be perceived as rude to ignore a direct request or to simply ignore a direct refusal to do something, and perhaps this is what motivates reply to these kinds of message content.

We also examined the influence of message features on the retention of email messages. The results suggest that where a message ends up is largely a factor of the recipient's personal habits and perceived message importance, as individual differences accounted for a large percentage of the variance on message retention and as perceptions of work importance of a message also had a strong impact. Although we could not perform a path analysis on retention action because the data was binary, our analysis suggests that perceived message importance may mediate the influence of content and sender on message retention. Only social content directly influenced the likelihood of saving a message or deleting it when perceptions of message importance were included in the regression model.

## 4.7 Discussion

Much of the defining work on email usage in organizations was conducted around ten years ago, just as email started to become prevalent in the workplace (Whittaker & Sidner, 1996; Kiesler & Sproull, 1991; Mackay, 1988; Sumner, 1988). Although new communication media, such as instant messaging, are increasingly used at work, email remains a principal means of organizational communication and information transfer. A main goal in our survey was to understand email behavior in today's workplace and to define areas of interest for further study. To do so, we obtained general information about email usage and data on how people differentially attend to particular messages. The message level data allowed us to examine how characteristics of individual email messages significantly relate to the action taken on that message.

In this work, we sought to identify features of email messages that influenced attention to the message. One interesting result from our data was that the perceived importance of a message was only one of the influences on the likelihood of replying to it. People responded to requests beyond their importance, perhaps because these were easy to attend

to. At the same time, refusals, which are not considered important to the receiver's work, receive a faster response and are more likely to be left in the inbox for later viewing.

Very important messages may have required a lot of work, so they were retained and more likely to be left in the inbox. It may be that messages considered important are valued for their content and retained to refer to later. One type of important message, such as deliveries, might not need a reply, but are retained in the inbox for later reference.

### 4.7.1 Limitations

There are limitations to the study in this chapter that should be taken into account when applying the results presented here to practice or design. These limitations include the nature of the population sampled, data collection method, contextual factors that we did not study, and the representativeness of messages included in our sample.

#### *4.7.1.1 Generalizability*

The data reported here come from a sample of 482 people across a variety of organizations and job types. Even though the sample is larger and more diverse than those used in other studies of email, coming from a wide variety of organizations, there is still an issue of potential selection bias in the sample. In particular, we must consider potential occupational influences on respondents' email usage and the role of email in their work. Because this survey was distributed across a large variety of organizations, we were able to collect data from participants in a wide variety of job types. However, because of limited information about the nature of their work and the nature of the organizations that they belong to, we cannot make statements about the boundary conditions within which these results apply.

Our sample may be biased in terms of time-demand on the job. Because our survey was 30 minutes long, this may have precluded individuals with high workloads or time demands from taking the survey. In addition, people in routinized jobs in which their time and attention allocation are controlled would not be able to participate in our survey, thus our sample may also be biased in terms of job latitude. Finally, our survey participant request was delivered to potential participants via email and may mean that our respondents are biased toward heavy email users or individuals who are highly responsive to email requests.

#### *4.7.1.2 Self-Report Bias and Controlling for Context*

We think a more serious problem with the data collected is that it is based on respondents' self-reports about the characteristics of their own messages and their expected actions on these messages. By asking respondents to reflect upon messages in their inboxes, our survey technique approximated the think-aloud protocols common in the HCI community. However, talking about what one has done or will do with a particular message is not the same as actually performing the action. Similarly, asking respondents for their judgments about the content of messages is not the same as capturing the text of messages and coding its contents. The accuracy of our results may be subject to our respondents' abilities to interpret the content of their email messages in a consistent way. While one respondent may interpret an email from her manager asking for a document as a request, another may interpret it as a proposal. We attempted to reduce the influence of misinterpretation on our results by grouping content into major categories of action types (e.g., request, follow-up, delivery, social) and by piloting the survey with a large number of individuals to improve the clarity of the wording.

Merely asking respondents to reflect on messages in their inbox may have taken them away from their natural use of email. Finally, our questions may have insufficiently specified the context in which the messages were produced. For example, while we asked respondents to describe their position in the organization and their general workload, we do not have information about the state of the task relevant to particular messages (e.g., the number of people involved in a project, approaching deadlines, and similar contextual issues).

Despite these issues, our research method has allowed us to gather more detailed information about email messages and actions toward them than has earlier research based on general interviews.

### 4.7.2 The Role of Individual Differences

Differences among individual respondents accounted for 26% of the variance in message importance assessments and almost half of the variance in the probability of retaining a message and leaving a message in the inbox. It may be the case that people have widely different replying, filing, and deletion strategies, and previous research may have only documented a sub-set of these (Mackay, 1988; Whittaker & Sidner, 1996). Factors such

as variations in the design of email clients and differences in email account space limitations can influence user action on messages.

Baseline statistics on email usage support Whittaker and Sidner's (1996) categorizations of email users as no filers, spring cleaners and frequent filers. This result, along with the finding that the respondent's identity explains most of the variance in where a message ended up (43% of variance in whether a message was left in the inbox was accounted for by individual differences), suggests that there may be no general *best* solution in terms of placing messages in the proper place. Rather, there are strong individual preferences in filing strategies that are independent of the characteristics of the message or its sender.

Notably, individual differences factored much less into the decision to respond. Only 15% of the variation in decision to respond was explained by differences among respondents. Replying is the most public of the behaviors that we studied. External social factors having to do with communication norms and relationships as well as organizational structure may be a much stronger influence on replying than internal factors such as perceived message importance.

### 4.7.3 Implications for HCI

One of our objectives in this data collection was to distill models of people's email behavior that could inform the direction of future research in Human-Computer Interaction. Our findings relate to the areas of intelligent techniques for email handling and email interface design.

Contrary to our expectations, the message-level data showed that an overwhelming majority of messages were retained (73% were either filed or left in the inbox). The high proportion of messages that people retain suggests that technology to aid in the location and viewing of messages is an important area of future research for electronic mail. People may have difficulty finding the messages they need, a problem that was cited in our interviews and in previous work (Bälter, 2000; Bellotti et al., 2003; Ducheneaut & Bellotti, 2001; Venolia, Dabbish, Cadiz, & Gupta, 2001; Whittaker & Sidner, 1996).

Interestingly, message importance mediated the influence of most types of message content on the speed of response to a message. Our results suggest ways that design can more efficiently direct user attention in dealing with email. A user interface that makes the importance of a message visible may be more useful to help people find archived

messages than to identify messages that require action. The statistical model that we presented can be used as a starting point for developing message importance scores. The message features that we identified as influencing perceived importance could be used in conjunction with information about sender-receiver relationships, as in Horvitz et al. (1999), to prioritize messages for viewing or to allow messages to be sorted by perceived importance.

# Chapter 5

# Conclusion

## 5.1 Discussion

Communication is central to accomplishing work in information organizations. It supports both task coordination and relationship maintenance, and it helps organizational members deal with ambiguity (Tubbs & Moss, 2003; Kraut & Attewell, 1997; Daft & Lengel, 1986; Daft & Weick, 1984; Conrad, 1985). Previous work on the nature of communication in the workplace has found that, particularly in office settings, individuals spend a majority of their time in communication with others (Mark et al., 2005; Gonzales & Mark, 2004; Perlow, 2002; Wendland, 2001; Perlow, 1999; Clark, 1999; Panko, 1992; Reder & Schwab, 1990).

However, frequent communication interaction can fragment ongoing tasks and harm productivity, consequently resulting in a negative impact at the organizational level (Perlow, 1999; Sproull & Kiesler, 1993; Panko, 1992; Reder & Schwab, 1990; Sproull, 1984). Opportunistic communication in particular is useful for sharing information, coordinating work tasks, and building cohesion, among other things (Kraut et al., 1993; Fish et al., 1993; Kraut, Egido, & Galegher, 1988). New communication technology, such as instant messaging, Blackberries, and cell phones, have increased connectivity and

opportunities for these kinds of interactions, but they have also increased the potential for interruption, fragmentation of attention, and disruption to ongoing work (Clark, 1999).

Electronic mediation of communication provides a unique opportunity to better coordinate communication interactions in order to increase responsiveness and reduce potential disruption. By examining the decision to initiate and respond to a communication, and interventions to promote communication at more opportune times, we may be able to increase connectivity while reducing the strain on an individual's attention and the level of disruption to the individual's ongoing work.

Thus, the goal of this thesis was to address the following research questions:

- What information does a communication sender use in deciding when to request attention for a communication interaction?
- What information does a communication receiver use in deciding when to respond to a request for attention?
- What effects do these initiation and response actions have on the task performance of the sender-receiver pair?
- How can information technology improve human performance in the communication process?

Chapter 1 proposed a theoretical model of communication initiation and response based on previous work that observed individuals in face-to-face situations. This model suggested that, on both sides of a communication, the sender and the receiver consider the importance and urgency of what they are doing in conjunction with the importance and urgency of the other person's task. For help-seeking interactions in particular, the sender may need some information or advice, and the sender's willingness to interrupt is influenced by the importance and urgency of the task for which the information is needed. The receiver, on the other hand, may be engaged in ongoing work (solitary work tasks or communication with other people), and the receiver's willingness to respond is directly impacted by the ability to postpone ongoing work tasks and the importance and urgency associated with the ongoing task.

When making these decisions to initiate and response, the model proposed posits that senders and receivers also take into account the effects of their communication decision on the other party. For the sender, this means that the willingness to interrupt the receiver is directly influenced by the perception of how busy the receiver currently is and by the potential impact that the interruption will have on the receiver's ongoing work. For the receiver, this means the perception of the importance and urgency of the sender's request.

The model in Chapter 1 also has proposed that the sender and the receiver take into account the other party in the communication interaction differentially based on the nature of their relationship with the other party. If both parties have joint incentives, then what is important and urgent for the sender is also important and urgent for the receiver—and vice versa. If both parties have a common affiliation or a close friendship, they may be more conscious of the effects of their actions on the other person. If one party has a higher status than the other in a particular context, the higher-status party may be more willing to interrupt or less willing to respond a request for attention.

This thesis has focused on empirically investigating two aspects of the communication situation and their effects on communication timing in an effort to better coordinate interaction: assessment of the other party's task constraints and the relationship between the sender and the receiver.

In an electronic context, communicators have limited information about the other party and reduced awareness of their task activities. This makes it more difficult to assess the impact of communicating or not communicating with the other person.

Chapter 2 focused on the sender's decision to interrupt, using awareness displays to make the receiver's current workload more visible to a distributed sender with a potential request for attention. We compared the value of a high-information display showing all details of a receiver's work task to the value of an abstracted display showing only workload information. The results showed that both the full information and abstracted awareness displays were used by the senders to time communication to arrive during periods of low workload for the receiver, but only when the sender and the receiver were part of a team with joint incentives.

Chapter 3 focused on the visibility of message constraints on the receiver side and the influence on response behavior. Results showed that, under conditions of a joint incentive

and common social identity, receivers prioritized messages of high value with proximate deadlines. In addition, receivers prioritized communication from senders who shared a common social identity. These receivers responded to a higher proportion of team member messages and responded more quickly to messages from team members, consequently discounting their own primary tasks to attend to messages from common team members regardless of how busy they were at the time those messages arrived.

Finally, Chapter 4 focused again on the receiver, examining in particular the response decision for email messages and how the relationship of messages to ongoing work affected the speed of response and likelihood of saving a message. Results showed that message content related to ongoing work increased receivers' perceptions of the importance of a message for completing work. In addition, co-worker senders were perceived as more important. Surprisingly, the relative status of the sender of a message did not affect perceptions of message importance for work or response time to a message.

### 5.1.1 Major Empirical Results

In summary, the significant empirical results from the work presented in this thesis are:

- Awareness displays that show a communication sender a potential receiver's workload are useful for timing communication to correspond with periods of low workload in a receiver's task.

- Awareness displays are only useful under conditions of shared social identity and joint incentives between the sender and the receiver of a communication.

- Abstract representations of a receiver's workload are equally as useful as full information about a receiver's workload for timing a communication to correspond with periods of low workload during continuous attention task completion.

- Sender-controlled message timing results in faster message response than receiver-controlled message timing and, in turn, better performance for the sender in a deadline-driven task.

- Receiver-controlled message timing results in slower message response than sender-controlled message timing and, in turn, lower performance for the sender in a deadline-driven task.

- On-screen visibility of an incoming message's importance and urgency to the sender is used by the receiver in timing a response under conditions of common identity and joint incentive.

- The receiver's joint incentives and common social identity with a sender increase the receiver's likelihood of response and speed of response to a message.

- Higher levels of workload when a message arrives decrease the likelihood of the receiver's response to a message and speed of response to a message.

- Receivers are more likely to respond to messages from senders with a common team identity and will attend to those messages more quickly, regardless of their current workload.

- Email message content associated with requesting an action, following up to a previous request, and delivering a reminder are associated with a positive increase in an email message's perceived importance to the receiver's ongoing work.

- Email messages from co-worker senders, from low communication frequency individuals, and sent to fewer recipients are perceived as more important for ongoing work.

- Email messages from friends or family or with other social content are perceived as less important to the recipient's ongoing work.

- The perceived importance of a message for work is associated with a positive increase in the speed of response and likelihood of message retention.

- Messages that are perceived as more important for work are more likely to be filed than deleted.

The results of the work presented here support the model of communication initiation and response presented in Chapter 1. In addition, these results suggest that technological interventions in the form of on-screen information about a communication partner's task constraints are useful for better coordinating communication interactions around ongoing work.

## 5.2 Future work

### 5.2.1 Organizational Context

By studying communication behavior in the laboratory in the studies presented in Chapters 2 and 3, we effectively controlled for the influence of organizational context. However, factors such as organizational norms and organizational culture have a major influence on communication behavior (Ghosh, Yates, & Orlikowski, 2004) and the willingness to interrupt or respond to interruption (Mark et al., 2005; Rennecker & Godwin, 2005; Gonzales & Mark, 2004). In future work, we hope to examine the different kinds of organizational norms surrounding interruption and how positive, coordination-oriented norms can be developed in an electronic context.

### 5.2.2 Relationship Type

The work presented in Chapters 2 and 3 found that communication initiators are more considerate of a communication partner if they have a social tie with that person, e.g., joint group incentives or common social identity (Dabbish & Kraut, 2004). These two types of motivations—incentives and social identity—have been found to increase likelihood of cooperation in prisoner's dilemma situations (Pruitt, 1988) and to increase the likelihood of helping by increasing potential rewards of pro-social behavior (Penner, Dovidio, Piliavin, & Schroeder, 2005). In the studies presented in this thesis, we combined the use of social identity and joint group incentives in our manipulation of relationships. In reality, social identity and shared incentives may affect communication behavior in different ways.

#### *5.2.2.1 Economic Exchange Motivation*

Our experimental manipulation of incentive (individual versus group) relates to an economic view of human behavior. Previous work has theorized that people make cost-reward analyses when deciding whether to help another person or to cooperate in a dilemma situation (Penner et al., 2005). Under this model, individuals are motivated to maximize their rewards and minimize their costs in any situation.

Considered with respect to the communication situation, initiators want to maximize their reward and obtain the information that they need from the target of the communication. However, they are also motivated to reduce the potential harm to the target to the extent that it will also harm them as a member of the group (Pruitt, 1988).

#### *5.2.2.2 Common Social Identity*

Manipulation of common social identity was the other factor that we used to encourage pro-social or cooperative behavior with respect to a communication partner in the studies presented in Chapters 2 and 3 (Dabbish et al., in progress; Dabbish & Kraut, 2004). Work on cooperation and helping have found that people are more likely to help and cooperate with people whom they perceive as sharing a common group membership, above and beyond interpersonal similarity or attraction (Penner et al., 2005; Pruitt, 1988). There are several possible explanations for this.

One explanation is that feelings of unity and attraction associated with common identity enhance the incentive value of the other party's or the group's success (Pruitt, 1988). Another explanation is that these feelings of unity or "we-ness" promote empathy for the other person, thus producing more pro-social behavior (Penner et al., 2005).

#### *5.2.2.3 Communal versus Exchange Relationships*

These two types of motivations discussed above correspond with the two endpoints of the relationship continuum, ranging from exchange relationships to communal relationships. In exchange relationships, members assume that benefits are given with the expectation of receiving a benefit in return (Clarke & Mills, 1979). This thinking also drives the positive influence of reciprocal behaviors on helping and cooperation. People are more likely to help those who offer help (Penner et al., 2005), and people are more likely to cooperate with those who have cooperated with them (Pruitt, 1988).

In contrast, in communal relationships, members assume that each person has a concern for the welfare of the others (Clarke & Mills, 1979). In these kinds of relationships, members can request help without having helped and can provide benefit with no expectation of a benefit in return. Previous work on helping has proposed that having a common group membership may produce these kinds of relationships, promoting a sense of "we-ness" in which self and other merge and facilitating a sense of empathy that leads to more pro-social behaviors.

In future work on the nature of relationships and communication behavior, we look to understand how the type of relationship between two people differentially influences interruption behavior. Under what conditions does an exchange relationship produce

more optimal behavior than a communal relationship? Under what conditions does a communal relationship produce more optimal behavior than an exchange relationship?

We expect that, under an exchange relationship, initial unmotivated benefit from the target prior to task-based interaction will promote more sensitive interruption timing on the part of the initiator during the task. A communal relationship with the target (in the form of common social identity) established prior to task-based interaction should promote a less sensitive interruption timing on the part of the initiator during the task.

With respect to interface design, we plan to examine if making reciprocity more salient in the interface reduces altruism in a communal relationship as well as if making common identity more salient in the interface engenders altruism in an exchange relationship.

### 5.2.3 Roles, Status, Power, and Empathy

As noted in our introduction, and by Kendon (1990), particular roles and expectations associated with those roles may influence an individual's willingness to interrupt or to be interrupted and may give individuals special license to interrupt or ignore another person. The example that Kendon (1990) presents is the greeter at a party, whose role in the situation is to be interrupted by each incoming person. Simply having this role significantly increases the greeter's willingness to be interrupted.

Willingness to respond may be more a function of role than of status. Interestingly, in our study of email response behaviors, we found that relative status did not have an influence on perceptions of a message's importance to work, speed of response to an email message, or likelihood of message retention. Thus, we are interested in examining the influence of role on perceptions of others' task constraints.

Specifically, we would like to make use of video data collected in previous studies focused on sensing interpretability (Fogarty et al., 2005a; Hudson et al., 2003). In these studies, along with the video recording of a participant's current work activity, participants provided their assessments of their willingness to accept an interruption at particular times. We plan to have participants view these videos and assess a person's availability for communication when assigned to different role conditions. When assigned to the role of manager, we expect that individuals will perceive others as more available for interaction than when assigned to the role of co-worker or subordinate. In addition, using this manipulation of status, we plan to look at the influence of power on

empathy and perceptions of availability as well as the interaction between power and empathy in assessing others' availability. Previous research has shown that feelings of power reduce an individual's ability to empathize with others or to take another person's perspective. Thus, we expect that individuals placed in a high-power role should have lower empathy for others and, in turn, perceive individuals as more available than they actually are.

### 5.2.4 Individual Differences

In analyzing the results for the studies presented in Chapters 2 and 3, we controlled for individual differences between participants in our experiment with respect to their interruption timing, response speed, response likelihood, and task performance. In Chapter 4, again we controlled for individual differences and the impact on perceptions of message importance and action on a message.

In fact, the differences between people with respect to their communication behavior are fascinating. A great deal of research on email communication has been focused on understanding and documenting the nature of these differences (Bellotti et al., 2003; Ducheneaut & Bellotti, 2001; Whittaker & Sidner, 1996; Mackay, 1988; Sumner, 1988). These individual differences may have varying effects on productivity and well-being. A study of email use found that individual differences in email management tactics can affect feelings of email overload and, in turn, the ability to coordinate work (Dabbish & Kraut, 2006).

Particularly for the management of communication interruptions, individuals have inherent differences in their ability to divide attention, multi-task, and recover from interruption (McDaniel et al., 2004; Edwards, 1993; Kahneman, 1973). This may mean that technology should be tailored to account for these individual differences, rather than develop a one-size-fits-all solution for managing interruptions and coordinating communication between individuals.

In future work, we are interested in examining different strategies for coordinating communication and dealing with constant interruption. Although qualitative work has captured some of the unique behaviors that people employ to both enable communication with co-workers and get their work done (Mark et al., 2005; Gonzales & Mark, 2004; Perlow, 2002; Perlow, 1999), additional work is needed to understand broad patterns in

dealing with interruptions and to understand how our physical differences in attentional resources and memory affect our ability to complete tasks and how technology can take these differences into account.

## 5.3 Closing Remarks

The results of this thesis have practical implications for the way that information technology can be used to coordinate communication, especially in distributed-work settings. In addition, they illuminate a response to recent critiques of the disconnect between information systems research and practice (e.g., Benbasat & Zmud, 2003; Orlikowski, 2001) by showing a way to use empirical research to drive the design of important information technology, as opposed to solely documenting its organizational impact.

### 5.3.1 Implications for IS Research

Although we conducted this research to examine ways to coordinate workplace communication, this paradigm has broader implications for conducting information systems research. In part, it represents one response to recent critiques of the relationship of information systems research to practice and the call for information systems research to focus more directly on the study of technology (Benbasat & Zmud, 2003; Orlikowski, 2001).

Part of the problem with information systems research is that the dominant theories are descriptive rather than prescriptive and therefore do not provide explicit guidance for managers and information systems developers. Consider the Technology Adoption Model (TAM), one of the most highly cited information theories in the information systems field (Davis, Bagozzi, & Warshaw, 1989). Although the Technology Adoption Model identifies utility, ease of use, and local norms as predictors of technology adoption within an organization, it does not delineate features of technology that make it either useful or easy to use.

The theory that we have used and developed in this research was directed in the service of designing an information systems intervention. Our approach consists of four steps. First, we mined research and theory in organizational behavior, especially on management communication and on distributed teams, to better understand the needs that communication technologies must support in organizations. Prior research had taken a

one-sided view of informal communication in the workplace, seeing either the benefits derived from rich communication (Mintzberg, 1997) or the costs associated with interruptions (Perlow, 1999). A similar dichotomy existed in the technology-design literature, with researchers focusing on ways to provide informal communication in distributed settings (Abel, 1990) or ways to shield receivers from interruptions (Horvitz et al., 2003). Our chief insight was to develop a theory to inform a design that manages the trade-offs between communication and interruption.

Second, the task analysis that we conducted caused us to focus on two components of a system to manage these trade-offs: information about co-workers' task environments as well as incentives that would cause co-workers to care about each other's welfare. In developing hypotheses about designs that might help to coordinate communication, we again mined the already existing research literatures, this time the human-factors literature on distraction (Gillie & Broadbent, 1989; McFarlane, 2002) and information displays (Wickens et al., 1998) and the social psychological literature on team identity (Henry et al., 1999). This led to the design of a minimalist display that showed a co-worker's engagement with a task (Chapter 2) and the relative importance of a communication to a co-worker (Chapter 3), which we predicted would cause people to effectively coordinate their communication only when shared team-identity or other factors caused them to care about the welfare of their partner.

Third, we conducted empirical tests, presented in Chapters 2 and 3, which showed that at a conceptual level the features of an information display that shows a co-worker's workload and task constraints, which we identified, combined with appropriate incentives indeed does improve communication coordination without overwhelming users of the display.

What is missing from this research program is the fourth stage—namely, translating the abstract design principles that we have developed and tested into actual information system applications to be deployed and evaluated in real-word settings. We have suggested above how our ideas might be applied. We acknowledge, however, that we have presented only a sketch of an application design, and substantial research, engineering, and iterative design and testing will be needed before this sketch is a reality.

# Appendix A

# Email Questionnaire Web Version

This appendix shows the full version of the online survey on email use. The survey was taken via the web, so each page of the appendix corresponds with a page of the survey itself. Note the page on an individual email message was repeated five times.

Carnegie Mellon

email @ work

# Carnegie Mellon University: Email at Work Survey

HCII Human-Computer Interaction Institute

**What is the survey about?**

This survey asks you about your work and the way you use email. Understanding how people use email is essential to making it better.

**How do you participate?**

Please click here to read the consent form before continuing. Enter your email address below and click the "Start Survey" button to indicate your consent and begin the survey. It takes around 30 minutes to complete.

*NOTE: Please try to complete the entire survey at one sitting. The survey will timeout if you leave the browser inactive for longer than 40 minutes.*

**Confidentiality**

Your responses will be completely anonymous and both your email address and responses will be kept confidential. Your email address will ONLY be used to contact you regarding the results of the cash contest.

**Who do I contact with questions?**

Please contact Laura Dabbish (dabbish@cmu.edu) or Prof. Robert Kraut (robert.kraut@cmu.edu) with questions about this research.

| Your Email Address | |
|---|---|

Start Survey

Questions? Contact us at: cmuEmailSurvey@gmail.com

# Survey: Communication on the Job

**CARNEGIE MELLON UNIVERSITY**
**CONSENT FORM**

**Project:** Analyzing Communication on the Job
**Conducted By:** Laura Dabbish (email: dabbish@cmu.edu )

I understand that I will be participating in a research project on how people handle communication and integrate it into their work routines. This is a research effort to inform the development of improved electronic mail systems. Professors Dan Siewiorek and Robert Kraut at Carnegie Mellon University are conducting the research.

This survey has been approved by the Carnegie Mellon University Institutional Review Board on October 28th, 2005.

---

**Participation**
I will be completing a 30-minute questionnaire. The questionnaire asks about projects I'm involved in, and my communication in the process of working on these projects through meetings, electronic mail, and other media.

**Voluntary participation**
My participation in the research project is completely voluntary. I have the right to end my participation at any time with no penalty (by quitting from my Internet browser or simply closing the questionnaire window).

**Confidentiality**
The researchers will keep my information confidential by converting my email address to a code. No information identifying individual participants will be released. Papers and reports from the research will be available to interested participants after the study has ended. No individuals will be identified in these reports.

---

If you have any questions about this study, you should feel free to ask them by contacting:

*Dr. Robert Kraut*
*Human-Computer Interaction Institute*
*5000 Forbes Avenue, Pittsburgh, PA 15206*
*kraut+@cs.cmu.edu*

You may also report any objections to the study, either orally or in writing to:

*Regulatory Compliance Administration, IRB Chair*
*Carnegie Mellon University*
*5000 Forbes Ave., Pittsburgh, PA, 15213*
*(412) 268-4727*

Close this window.


**Section 1.0 - Employment**

Are you currently employed? [either part-time or full-time for pay or profit]

- Yes
- No

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


**Section 1.1 - Email at work**

Do you use email for your work?

- (•) Yes
- ( ) No

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


**Section 1.2 - Email inbox access**

Can you access your work email inbox from this computer?

- (•) Yes
- ( ) No

Next


## Section 1.3 - Dealing with Email

**The following questions relate to dealing with your *work-related* email. Indicate your agreement with each statement.**

| | Strongly Disagree 1 | Disagree 2 | Neither Agree nor Disagree 3 | Agree 4 | Strongly Agree 5 |
|---|---|---|---|---|---|
| 1. I am able to handle my email efficiently. | ○ | ○ | ○ | ○ | ○ |
| 2. I often have trouble finding important information in my email. | ○ | ○ | ○ | ○ | ○ |
| 3. Email is critical for getting my work done. | ○ | ○ | ○ | ○ | ○ |
| 4. I often have to wait for replies to my email from others before I can complete my own work. | ○ | ○ | ○ | ○ | ○ |
| | **Strongly Disagree 1** | **Disagree 2** | **Neither Agree nor Disagree 3** | **Agree 4** | **Strongly Agree 5** |
| 5. I can easily deal with the amount of email I receive. | ○ | ○ | ○ | ○ | ○ |
| 6. Face to face communication is critical for getting my work done. | ○ | ○ | ○ | ○ | ○ |
| 7. I often miss seeing important email messages. | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| 8. I can easily reply to all the email I need to in a timely manner. | ○ | ○ | ○ | ○ | ○ |
| | **Strongly Disagree 1** | **Disagree 2** | **Neither Agree nor Disagree 3** | **Agree 4** | **Strongly Agree 5** |
| 9. I use email a lot for my work. | ○ | ○ | ○ | ○ | ○ |
| 10. Dealing with my email often pushes trivial work ahead of important work. | ○ | ○ | ○ | ○ | ○ |
| 11. Sometimes I find the amount of email I deal with overwhelming. | ○ | ○ | ○ | ○ | ○ |
| 12. It would be much harder to do my work without the use of email. | ○ | ○ | ○ | ○ | ○ |

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


## Section 2 - Email Habits

**The statements below relate to managing your primary *work* email inbox. Please rate your frequency with respect to each statement.**

| | Never 1 | Seldom 2 | Sometimes 3 | Often 4 | Always 5 |
|---|---|---|---|---|---|
| 1. I manually file my messages as soon as they come in. | ○ | ○ | ○ | ○ | ○ |
| 2. I try to keep my inbox size small. | ○ | ○ | ○ | ○ | ○ |
| 3. I use a template to compose email messages that are similar. | ○ | ○ | ○ | ○ | ○ |
| 4. I keep messages in my inbox as a reminder of things I need to do. | ○ | ○ | ○ | ○ | ○ |
| | **Never 1** | **Seldom 2** | **Sometimes 3** | **Often 4** | **Always 5** |
| 5. I file my messages into separate folders. | ○ | ○ | ○ | ○ | ○ |
| 6. I leave messages in the inbox after I have read them. | ○ | ○ | ○ | ○ | ○ |
| 7. I check my email as soon as I see or hear that a new message has arrived. | ○ | ○ | ○ | ○ | ○ |
| 8. I keep a list of tasks I need to do, or to-do's, outside of my my email program. | ○ | ○ | ○ | ○ | ○ |

| | Never<br>1 | Seldom<br>2 | Sometimes<br>3 | Often<br>4 | Always<br>5 |
|---|---|---|---|---|---|
| 9. I delete work-related email messages after I read them. | ○ | ○ | ○ | ○ | ○ |
| 10. I restrict myself to checking my email at specific times of the day. | ○ | ○ | ○ | ○ | ○ |
| 11. I check my email even when I'm at home. | ○ | ○ | ○ | ○ | ○ |

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


## Section 3 - Forms of Communication

**Over the last seven days, how much time per day did you spend doing each of the following *for work purposes*?**

| | I don't use this for work | 15 mins or less per day | 30 mins per day | 1 hour per day | 2 hours per day | 3 to 4 hours per day | 5 + hours per day |
|---|---|---|---|---|---|---|---|
| 1. Talking on the landline phone in your office | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 2. Talking on a cell phone | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 3. Reading and composing Email messages | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 4. Sending and receiving messages on Instant Messenger | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 5. Attending scheduled meetings | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 6. Having unscheduled face-to-face conversations | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


**Section 4 - Demographic Information**

1. Are you (male or female) ?

- Male
- Female

2. What is your education level? (indicate by last completed) High School

3. What is your marital status?

- married
- widowed
- divorced
- never married

4. How old were you on your last birthday (in years)?

Next


## Section 5 - General Job Information

**The questions on the next few pages relate to general characteristics of your job. If you have more than one job, answer these questions with respect to the job at which you spend the most time. Be as accurate as possible in your answers.**

1. What is your official job title as given by your employer?

2. What is the nature of your position?

- Professional
- Managerial
- Sales
- Clerical
- Other

3. How many years have you worked in your current occupation with your current employer? (round up or down to the nearest number of years)

4. How many employees does your current employer have (both full-time and part-time)? 1 to 499 employees

Next


## Section 5 - General Job Information

**Over the last seven days, for how many days did you ...**

| Number of days / last seven days | None | 1 day | 2 days | 3 days | 4 days | 5 days | 6 days | 7 days |
|---|---|---|---|---|---|---|---|---|
| 5. ... do any work for either pay or profit. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 6. ... work at home in the evening, **in addition** to working in a company location during the day. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 7. ... work from home for part of the day, or all of the day, **instead of** working in the office. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 8. ...travel out of the office for work purposes (to another location or town). | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| Number of hours / day | 1 or less | 2 to 3 | 4 to 5 | 6 to 7 | 8 to 9 | 10 to 11 | 12 to 13 | 14 or more |
|---|---|---|---|---|---|---|---|---|
| 9. During days when you work, on average, how many hours do you usually work each day? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 10. How many hours per weekday, on average, do you use the computer **for work purposes?** | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Next


## Section 5 - General Job Information

| Number of people | None | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
|---|---|---|---|---|---|---|---|---|
| 10. How many people report directly to you (include employees, contractors, and others) ? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 11. How many managers or supervisors do you report to? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 12. How many people, not counting yourself, report to the same supervisor/manager that you do? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| Number of meetings / week | None | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
|---|---|---|---|---|---|---|---|---|
| 13. Over the last week, how many **scheduled** meetings did you attend (including group or committee meetings, one-on-one meetings, etc.)? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| Number of projects | None | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
|---|---|---|---|---|---|---|---|---|
| 14. Over the last week, how many separate projects have you worked on (where projects are long-term activities requiring a series of tasks and actions)? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Next


## Section 6 - About your job

**The statements in this section describe your work. Please select how much you disagree or agree with each as they relate to your job (check one box for each item).**

| | Strongly Disagree 1 | Disagree 2 | Neither Agree nor Disagree 3 | Agree 4 | Strongly Agree 5 |
|---|---|---|---|---|---|
| 1. I have the freedom to decide how to complete my work on the job. | ○ | ○ | ○ | ○ | ○ |
| 2. The amount of work I am asked to do is fair. | ○ | ○ | ○ | ○ | ○ |
| 3. My job requires that I do the same exact thing over and over. | ○ | ○ | ○ | ○ | ○ |
| 4. Doing my job depends on the work of many different people. | ○ | ○ | ○ | ○ | ○ |
| | **Strongly Disagree 1** | **Disagree 2** | **Neither Agree nor Disagree 3** | **Agree 4** | **Strongly Agree 5** |
| 5. It is basically my own responsibility to decide how my job gets done. | ○ | ○ | ○ | ○ | ○ |
| 6. In my job, other people's work depends directly on mine. | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| 7. I get to do a number of different things in my job. | | | | | |
| 8. I have too much work to do everything well. | | | | | |

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


## Section 7 - About your job and the people you work with

**How much do you disagree or agree with the following statements as they relate to your job?**

| | Strongly Disagree 1 | Disagree 2 | Neither Agree nor Disagree 3 | Agree 4 | Strongly Agree 5 |
|---|---|---|---|---|---|
| 1. All in all, I am satisfied with my job. | ○ | ○ | ○ | ○ | ○ |
| 2. I would decide to take the same job again without hesitation. | ○ | ○ | ○ | ○ | ○ |
| 3. In general I like working here. | ○ | ○ | ○ | ○ | ○ |

**How much do you agree or disagree with the following statements about you and the people you work with most closely?**

| | Strongly Disagree 1 | Disagree 2 | Neither Agree nor Disagree 3 | Agree 4 | Strongly Agree 5 |
|---|---|---|---|---|---|
| 4. We work together in a well-coordinated fashion. | ○ | ○ | ○ | ○ | ○ |
| 5. We have very few misunderstandings about what to do. | ○ | ○ | ○ | ○ | ○ |
| 6. We accomplish tasks smoothly and efficiently. | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| 7. There is much confusion in the way we accomplish tasks. | | | | | |

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


## Section 8 - About you

**The questions below ask about your feelings and thoughts in general (*in both work and non-work situations*) during the last month. In each case, please indicate how often you felt or thought a certain way.**

| | Never<br>1 | Almost Never<br>2 | Sometimes<br>3 | Fairly often<br>4 | Very Often<br>5 |
|---|---|---|---|---|---|
| 1. In the last month, how often have you felt that you were unable to control the important things in your life? | ○ | ○ | ○ | ○ | ○ |
| 2. In the last month, how often have you felt confident in your ability to handle personal problems? | ○ | ○ | ○ | ○ | ○ |
| 3. In the last month, how often have you felt that things were going your way? | ○ | ○ | ○ | ○ | ○ |
| 4. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? | ○ | ○ | ○ | ○ | ○ |

Next


## Section 9 - Email management

**The questions in this section relate to specific properties of your primary work email inbox. Please refer to your email program when responding.**

1. What email client / program do you use most often for dealing with your email at work?

- ○ Microsoft Outlook, Outlook Express, or Exchange
- ○ Lotus Notes / Domino, or Lotus Worksphere
- ○ Novell GroupWise
- ○ Mozilla Thunderbird
- ○ Oracle Email or Collaboration Suite
- ○ Sun ONE, JavaMail, or Java System
- ○ Qualcomm Eudora
- ○ Mac OS X Mail App
- ○ Other [ ]

2. How many **total** email messages (both read and unread) are currently in your inbox? [ ]

3. How many email folders do you currently have set up? (places within your email program where you can store email messages; your inbox counts as one) [ ]

| Filters | Yes | No |
|---|---|---|
| 4. Do you have software filters or rules set up to automatically FILE email messages into folders? | ○ | ○ |
| 5. Do you have software filters or rules set up to automatically DELETE email messages? | ○ | ○ |

Next


## Section 10 - Email management

**The questions below relate to your actions with your work-related email.**

**Try to think of your actions over the last week with the email program you use most often when responding.**

6. In what situations do you check your work email? (select "yes" for all situations that apply)

| | Yes | No |
|---|---|---|
| a. In my office | ○ | ○ |
| b. At home | ○ | ○ |
| c. In meetings at work | ○ | ○ |
| d. In transit to and from work | ○ | ○ |
| e. In transit while traveling on business (i.e., in airport, car, train) | ○ | ○ |
| f. In hotels while traveling on business | ○ | ○ |

| Number of times checking your email each day | None | 1 to 2 | 6 to 10 | 11 to 20 | 9 to 16 | 31 to 40 | More than 41 |
|---|---|---|---|---|---|---|---|
| 7. On a typical work day, how many times do you look at your email inbox to read new messages? | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| Number of messages | 1 to 10 | 11 to 30 | 31 to 50 | 51 to 70 | 71 to 90 | 91 to 110 | More than 120 |
|---|---|---|---|---|---|---|---|
| 8. How many new email messages have you ***received*** in the past 24 hours? | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 9. How many new email messages have you ***read*** in the past 24 hours? | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| 10. How many email messages have you ***sent*** in the past 24 hours? | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


**Section 11 - Your Email Inbox**

1. How long has it been since you last checked your email for new messages?

**hours and minutes.**

2. How many new email messages have arrived since you last checked?

3. Out of the last 20 messages you received ***in your inbox***, about how many were unsolicited commercial email messages, or spam?

Next


## Section 12 - Messages in your inbox

**The next questions ask about each of the 5 most recent work or personal messages in your inbox.**

**They will be easiest to answer if you keep your email inbox window open and easy to switch to from your Internet browser window.**

**PLEASE DEAL WITH ANY NEW MESSAGES AS YOU NORMALLY WOULD and record your actions as indicated on the following screens.**

**Click the "Next" button below when you are ready to begin this section of the survey.**

Next


**Please go to the most recent work-related or personal email message in your inbox (skip spam messages).**

**Hit the "next" button below when you are ready to answer questions about that message.**

Next


**Email Message # 1 out of 5 messages**

1. Is this a new message? (a message you have not yet read)

- ○ Yes
- ○ No

2. What kind of message is this?

- ○ Work-related
- ○ Personal
- ○ Other (please describe) [ ]

3. Subject line of the message (copy from the email message)

[ ]

| **Importance to YOUR work** | **Not related to my work** | **Not Important 1** | **Slightly Important 2** | **Somewhat Important 3** | **Moderately Important 4** | **Extremely Important 5** |
|---|---|---|---|---|---|---|
| 4. How important is the content of this message **for doing YOUR work?** (on a scale of 1 to 5) | ○ | ○ | ○ | ○ | ○ | ○ |
| **Importance to SENDER's work** | **Not related to the sender's work** | **Not Important 1** | **Slightly Important 2** | **Somewhat Important 3** | **Moderately Important 4** | **Extremely Important 5** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5. How important is the content of this message **for the SENDER's work**? (on a scale of 1 to 5) | | | | | | |
| **Replying to this message** | **I don't need to reply to this message** | **In the next month** 1 | **In the next week** 2 | **In the next day** 3 | **In the next hour** 4 | **Immed-iately** 5 |
| 6. How quickly do you need to respond to this message? (on a scale of 1 to 5) | | | | | | |
| **Work required** | **This message requires no work** | **Less than 15 mins** 1 | **15 mins to 1 hour** 2 | **2 to 3 hours** 3 | **4 to 5 hours** 4 | **More than 6 hours** 5 |
| 7. How much work does this message require of you? (in terms of time required) | | | | | | |
| **Length of time** | **I don't need this message** | **A day or less** | **A few days** | **A few weeks** | **A few months** | **A year or more** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8. How long into the future will you keep this message? | | | | | | |
| **Deadlines** | **No deadlines associated with this message** | **Within the day** | **Within the week** | **Within the next few weeks** | **Within the next few months** | **Within the year** |
| 9. How soon are any deadlines for the project or task associated with this message? | | | | | | |
| **Project activity - time spent** | **No job-related project or task associated with this message** | **Little or no time 1** | **A fair amount of time 2** | **Half of my time 3** | **Over half of my time 4** | **Almost all of my time 5** |
| 10. How much of your time at work is spent on the project or task associated with this message? | | | | | | |

| **Sender** |
|---|
| 11. What is the sender's relation to you? |

- Direct supervisor
- Direct subordinate
- Direct co-worker (e.g. member of the same group, working on the same project, etc.)
- Other member of the same organization
- External work contact or client
- Social contact (e.g., family member, friend outside of work, etc.)
- I do not know the person who sent this message
- Other (please describe)

12. If the sender is a member of the same organization, what is their level in the organization relative to you?

- Higher than me
- The same as me
- Lower than me
- I don't know their level in the organization

13. How frequently have you communicated with the sender, via any means, over the past month (in person, over the phone, via email, or via IM)?

- Once a day
- Several times a week
- Once a week
- Once every other week
- Once a month
- Not at all

14. Is this message a follow-up from a previous interaction?

- Yes, reply to a message I sent
- Yes, reply to a message I did not send
- Yes, follow-up from a conversation in person
- Yes, follow-up from a phone conversation

| | |
|---|---|
| ○ Yes, follow-up from a conversation on Instant Messenger | |
| ○ No | |

| **Other recipients** | | | | | | |
|---|---|---|---|---|---|---|
| | **Only me** | **2-3 individuals** | **4-5 individuals** | **6-7 individuals** | **8 or more individuals** | **A distribution list** |
| 15. Who else received this message? | ○ | ○ | ○ | ○ | ○ | ○ |

| **Content** | | |
|---|---|---|
| **16. In this message, the sender is...** | **Yes** | **No** |
| a. Requesting something (e.g., an action, information, or file) | ○ | ○ |
| b. Delivering something (e.g., information or file) | ○ | ○ |

| **17. More specifically, the sender is... (select "yes" for all that apply)** | **Yes** | **No** |
|---|---|---|
| a. Proposing a joint activity (e.g., a meeting, a joint project, etc.) | ○ | ○ |
| b. Reminding about something (e.g., a deadline, commitment, event, etc.) | ○ | ○ |
| c. Suggesting changes to something (e.g., an ongoing project or event, meeting times, etc.) | ○ | ○ |
| d. Committing to do something (e.g., perform an action, attend a meeting, etc.) | ○ | ○ |
| e. Refusing to do something (e.g., perform an action, attend a meeting, etc.) | ○ | ○ |

| | | |
|---|---|---|
| f. Being social (e.g., thanking, greeting, welcoming, inviting to a social event, etc.) | ○ | ○ |
| g. Other (please describe briefly) | | |

| **18. The sender was providing or requesting... (select "yes" for all that apply)** | **Yes** | **No** |
|---|---|---|
| a. Information in the form of facts or data (e.g., file, document attachment, etc.) | ○ | ○ |
| b. Information in the form of an opinion | ○ | ○ |
| c. Meeting logistics data (time, place, location, etc.) | ○ | ○ |

| **19. The sender was talking about.. (select "yes" for all that apply)** | **Yes** | **No** |
|---|---|---|
| a. Short-term activity (one-time task, lasting less than a week : e.g., individual meeting, event, other work task) | ○ | ○ |
| b. Recurrent/repeated activity (projects greater than a week, longer-term task: e.g., committee, project, etc.) | ○ | ○ |

| **Your Action** | | |
|---|---|---|
| **20. What <u>was or will be</u> your action based on the message? (select "yes" for all actions you did or plan to do)** | **Yes** | **No** |
| a. Read the message. | ○ | ○ |
| b. Delete the message. | ○ | ○ |
| c. Mark the message (either unread, or with color or flag). | ○ | ○ |
| d. File the message into a folder. | ○ | ○ |
| e. Reply to the message immediately. | ○ | ○ |
| f. Postpone replying to the message until later. | ○ | ○ |

| | | |
|---|---|---|
| g. Forward the message to another person. | ○ | ○ |
| h. Compose a new message to another person. | ○ | ○ |

| **Other Actions Outside of Email** | | |
|---|---|---|
| **21. What other actions outside of your email program did you take or do you plan to take based on the message? (select "yes" for all actions you did or plan to do)** | **Yes** | **No** |
| a. Perform work associated with the message (e.g., create or edit a document, gather information, etc.). | ○ | ○ |
| b. Communicate directly with the sender about this message via phone, IM, or in person. | ○ | ○ |
| c. Communicate with person besides the sender about this message via phone, IM, or in person. | ○ | ○ |

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


**Your responses for the previous email message have been recorded.**

**Please hit "next" when you are ready to move on to the next most recent work-related or personal email message in your inbox (skip spam messages).**

Next

Questions? Contact us at: cmuEmailSurvey@gmail.com


This is the last page of the survey!

Please indicate below if you would like to be informed of the results of this survey.

**Section 13 - Contact Information**

1. ***Would you like to be informed via email of the results of this study when they are available?***

- ○ Yes
- ○ No

2. Your email address (this will be used only for a one time email to inform you of our findings) :

Next

# You finished the survey! Thank you!

**If you indicated that you would like to be informed of the results of this survey, we will be sending you information via the email address you provided at the beginning of the survey.**

**Thank you for your time! Your contribution is valuable to our research project and to the advancement of email technologies.**

**If you have any questions regarding the study, contact us at: cmuEmailSurvey@gmail.com**

# Appendix B: Email Survey Regression Tables

This appendix contains the full set of tables corresponding with the statistical analyses performed in Chapter 4.

## B.1 Message Importance

We measured message importance to the receiver using four different importance items. Correlations between scale items are shown in Table B.1 below.

Table B.1. Means and Correlations Between Receiver Importance Scale Items

| | Item | Mean (SE) | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| 1 | Importance to receiver | 3.13 (0.05) | * | | | |
| 2 | Perceived need in future | 2.43 (0.04) | 0.48 | * | | |
| 3 | Related project activity | 1.90 (0.03) | 0.62 | 0.47 | * | |
| 4 | Work deadlines assoc | 1.87 (0.03) | 0.45 | 0.42 | 0.61 | * |

These scale items were all positively correlated above the 0.40 level, and the scale was highly reliable with standardized alpha = 0.78.

As reported in Chapter 4 above, using single item measures we also assessed the receiver's perception of message importance to the sender, urgency of message response, and the amount of work a particular message required of them. We looked at the correlation between the receiver importance scale and these three single item measures of message perceptions. These correlations along with the means for each measure are reported in Table B.2 (a reproduction of Table 4.4).

Table B.2. Correlations and Means for Message Perception Measures

| | Item | Mean (SE) | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| 1 | Importance to receiver | 2.56 (0.03) | * | | | |
| 2 | Importance to sender | 3.67 (0.05) | 0.58 | * | | |
| 3 | Urgency of response | 2.65 (0.05 | 0.71 | 0.29 | * | |
| 4 | Work required | 1.95 (0.03) | 0.66 | 0.39 | 0.42 | * |

Because our measures of message perceptions are all positively correlated with each other, and are highly positively correlated with our measure of importance to the receiver, we cannot be sure they are accurately measuring the four distinct concepts we intended to measure. It may be that receivers are unable to distinguish between importance of a message to the sender versus to themselves, and between the importance, urgency, and work required by a message. Or our measures may have been insufficient to capture the difference between these two concepts. Another possibility is that these measures were subject to common method bias, because all the

items were in close proximity in the same section of the questionnaire they may have been answered in a similar way.

Because these items were all so highly correlated with importance to receiver, we could not use them as distinct outcome variables. Thus, for the remainder of our analyses we considered only the receiver's perception of importance of a message to their own work because this measure utilized a highly reliable four-item scale and because receivers were likely to be most accurate in assessing their own perceptions of importance.

We were interested in looking at the influence of message characteristics on perceived message importance. Table B.3 shows the correlations between our work importance scale, message characteristics, and actions on a message (reply speed and likelihood of saving a message) as well as mean values. The mean values shown for items 3 and 4 indicate the probability of the message sender being a work contact or friend or family, because these items are binary. In addition, the means shown for items 7-16 indicate the probability of a message containing the type of content represented by the item.

Table B.3. Means and Correlations for Importance, Relationship, Content Types, and Action on a Message

| | Item | M | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Importance | 2.58 | * | | | | | | | | | | | | | | | |
| **2** | Relative Status | 1.22 | 0.25 | * | | | | | | | | | | | | | | |
| **3** | Work Contact | 0.73 | 0.45 | 0.63 | * | | | | | | | | | | | | | |
| **4** | Friend of Family | 0.11 | -0.25 | -0.36 | -0.56 | * | | | | | | | | | | | | |
| **5** | Num Recipients | 2.89 | -0.22 | 0.02 | 0.04 | -0.18 | * | | | | | | | | | | | |
| **6** | Comm Frequency | 3.09 | -0.28 | -0.26 | -0.34 | -0.01 | 0.16 | * | | | | | | | | | | |
| **7** | Request | 0.64 | 0.52 | 0.16 | 0.28 | -0.20 | -0.07 | -0.16 | * | | | | | | | | | |
| **8** | Follow-up | 0.42 | 0.37 | 0.11 | 0.20 | -0.02 | -0.36 | -0.25 | 0.22 | * | | | | | | | | |
| **9** | Commitment | 0.25 | 0.30 | 0.06 | 0.13 | -0.08 | -0.06 | -0.08 | 0.29 | 0.25 | * | | | | | | | |
| **10** | Amendment | 0.20 | 0.30 | 0.05 | 0.15 | -0.10 | 0.05 | -0.11 | 0.23 | 0.18 | 0.18 | * | | | | | | |
| **11** | Refusal | 0.03 | 0.16 | 0.04 | 0.06 | 0.00 | -0.03 | -0.06 | 0.13 | 0.16 | 0.22 | 0.18 | * | | | | | |
| **12** | Delivering Info or | 0.61 | 0.12 | 0.11 | 0.19 | -0.15 | 0.13 | -0.04 | 0.01 | 0.08 | 0.12 | 0.11 | 0.03 | * | | | | |
| **13** | Reminder | 0.34 | 0.13 | 0.07 | 0.12 | -0.11 | 0.18 | -0.09 | 0.18 | 0.08 | 0.16 | 0.18 | 0.09 | 0.19 | * | | | |
| **14** | Social | 0.14 | -0.11 | -0.09 | -0.13 | 0.26 | -0.03 | -0.07 | -0.08 | 0.08 | 0.05 | 0.07 | 0.25 | 0.00 | 0.01 | * | | |
| **15** | Speed of Response | 0.27 | 0.28 | 0.09 | 0.15 | -0.04 | -0.13 | -0.12 | 0.23 | 0.15 | 0.13 | 0.11 | 0.16 | 0.02 | 0.00 | 0.02 | * | |
| **16** | Likelihood of Saving | 0.51 | 0.45 | 0.03 | 0.13 | -0.05 | -0.12 | -0.10 | 0.19 | 0.17 | 0.12 | 0.12 | 0.03 | 0.03 | 0.04 | -0.13 | 0.16 | * |

### B.1.1 Importance to the Receiver

For this outcome (work importance to the receiver) we tested a set of linear regression models- the first with only sender characteristics as predictors (Model 1), and then progressively added each type of message content in a blocks: requesting, follow-up, delivering, and social (Models 2-5). Table B.4 presents a summary of the standardized beta weights for the fully specified models for the outcome variable of importance to the receiver.

Individual differences accounted for 35% of the variance in the perceived importance of a message for the receiver's own work, indicating that some people rate their email messages as more important on average than others do. In the first model, sender characteristics significantly affected how much importance people assigned their messages, accounting for an additional 28% of the variance in perceived message importance for the receiver. Respondents perceived messages with fewer recipients to be more important. In contrast, having a work relationship with the sender and having less communication with the sender in the past increased the importance of a message. Table B.4 presents all models in the regression analysis of importance to the receiver.

The second model in Table B.4 shows that request content explains an additional 13% of the variance in message importance scores. Messages requesting information, requiring action outside of email, and requiring communication were all perceived as significantly more important to the receiver. The strong influence of requests for action on a message's perceived importance indicates the impact of others' demands on how people direct their attention on the job. New action requests were a significant proportion of all message content (43% of messages, Figure 4.2) and significantly increased importance ratings. These messages may cause people to shift gears and to add new tasks to their current stack.

Model 3 adds follow-ups and coordination content to the model in predicting message importance (following a previous interaction, committing, amending, proposing or refusing to do something). The increase in the variance accounted for by the third model over the second model shows that follow-up content plays a relatively minor role in determining message importance (Model 3 R-squared = . 45 versus .41 for Model 2).

The fourth model added delivery content (delivering information, opinion or reminder) to the model, with a 1% increase in variance accounted for. Messages delivering

information or opinions were perceived to be more important to the receiver. Finally social content was added for Model 5, with no increase in variance explained and social content significantly decreasing the importance of a message for receiver's work. This finding indicates that participants rated messages based on their importance to work; social messages were typically non-work-related and rated unimportant.

Table B.4. Linear Regression of Perception of Message Importance to Receiver

| **Factor** | **Sender Relationship** | **Request** | **Follow-up** | **Deliver** | **Social** |
|---|---|---|---|---|---|
| | beta | beta | beta | beta | beta |
| Intercept | -0.43*** | -0.83*** | -0.92*** | -1.00*** | -0.96*** |
| **Relationship to Sender** | | | | | |
| Number of recipients | -0.24*** | -0.20*** | -0.16** | -0.17*** | -0.17*** |
| Communication Frequency | -0.10*** | -0.07** | -0.04* | -0.05* | -0.06** |
| Is Work contact? | 0.77*** | 0.63*** | 0.56*** | 0.54*** | 0.52*** |
| Is Friend of Family? | -0.38*** | -0.23*** | -0.23*** | -0.23*** | -0.15* |
| **Request** | | | | | |
| Requesting info, opinion | | 0.73*** | 0.64*** | 0.65*** | 0.64*** |
| **Follow-up** | | | | | |
| Following prev. interaction | | | 0.26*** | 0.24*** | 0.25*** |
| Committing | | | 0.17*** | 0.15*** | 0.15*** |
| Amending | | | 0.22*** | 0.20*** | 0.22*** |
| Refusing | | | 0.10 | 0.10 | 0.20 |
| **Deliver** | | | | | |
| Delivering Info or Opinion | | | | 0.17*** | 0.17*** |
| Reminding | | | | -0.00 | -0.01 |
| **Social** | | | | | |
| Social Content | | | | | -0.26*** |
| **Model R-squared** | 0.28 | 0.41 | 0.45 | 0.46 | 0.46 |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

## B.2 Actions on a Message

There were several possible actions people could take on a message. Primarily we were interested in two types of actions: *reply actions*-- whether the user had already replied to, planned to reply to, or did not plan to reply to a message, and *location actions*-- whether a user ends up storing a message after processing (whether they file, delete, or leave the message in the inbox).

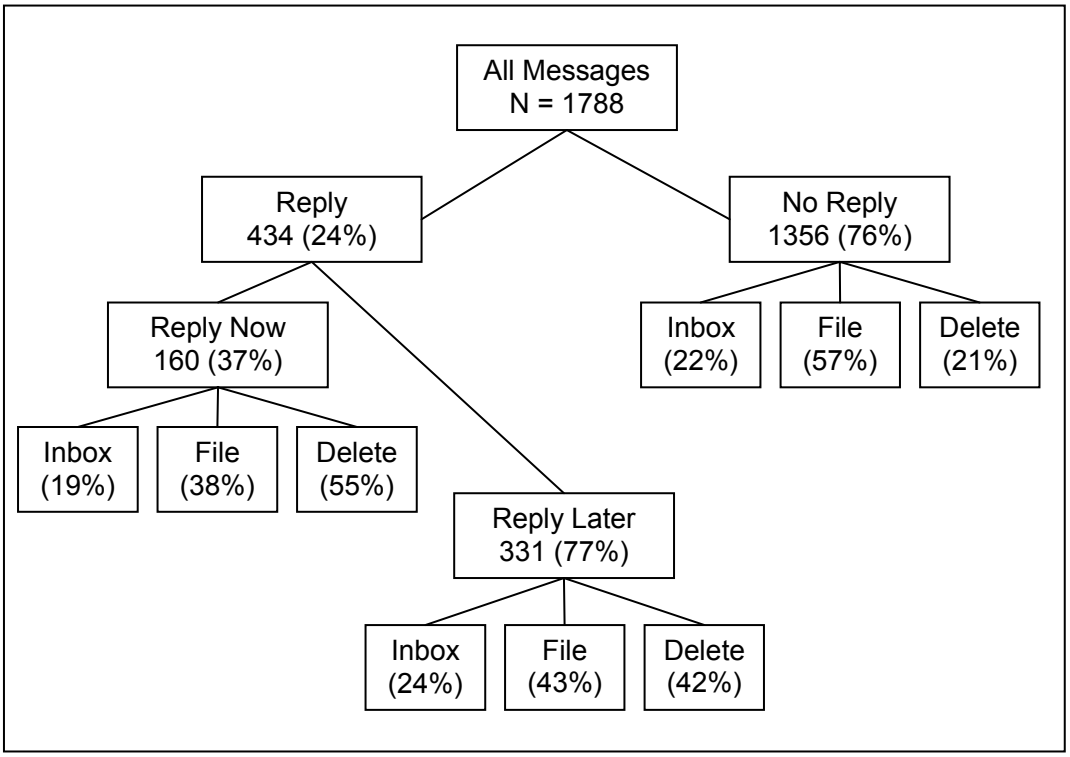


Figure B.1. Distribution of messages across reply and location action.

Out of the 1788 messages, respondents felt that 76% did not require any reply, 9% required an immediate reply, and 19% required a reply that they postponed (Figure B.1). There may be message characteristics that differentiate messages that respondents felt required a reply from those that did not require a reply. We consider the characteristics that predict message response in detail below.

There were three possible resting places for a message: users could file a message into a folder, delete it, or leave it in the inbox. Figure B.1 shows the breakdown of locations by reply action. Overall respondents deleted 54% of their email, filed 27% into folders, and kept 23% in their inbox. It is notable that for messages where a response was postponed,

only 24% were left in the inbox. This is counter to previous work that has found that people tend to leave the majority messages in the inbox (Dabbish et al., 2005) and previous literature that suggests that individuals use the presence of email messages as a reminder to respond (Bellotti et al., 2003; Ducheneaut & Bellotti, 2001; Whittaker & Sidner, 1996). At the same time, people were less likely to delete messages that did not need a reply (21%) than those that did (47%). Regardless of reply action, in this sample people were more likely to file or delete messages than leave them in the inbox; a high percentage of messages were deleted in this sample (54%). We examine the factors associated with leaving a message in the inbox in a following section.

### B.2.1 Effects on Likelihood of Message Reply

We were interested in examining influences on the decisions people make regarding the fate of an email message, particularly whether they will reply to it or not. Recall that respondents indicated that only 24% of the messages they received required a reply. We created a binary variable for message reply that was equal to '1' if the respondent reported replying to the message immediately or planned to reply to the message, and was equal to '0' if the respondent did not say the message required a reply.

We hypothesized that several categories of message characteristics influence the reply decision: perceived importance of the message to the sender and the receiver, perceived urgency of response, sender characteristics, and message content. Using logistic regression, we tested a model including these message characteristics to predict the likelihood of message response controlling for individual differences using the cluster command in Stata (see Table B.5 for regression results- coefficients, standard error, and odds ratio are reported).

Individual differences accounted for 15% of the variance in the probability of response to a message. The factors included in our model accounted for an additional 14% of the variance in the probability of response to a message. The results indicate that people were significantly more likely to respond to messages they rated as important to their own work. Holding all other variables at their average levels, a one-point-deviation increase in the importance of a message to the receiver increased the probability of reply by 1.3 times.

Sender characteristics did not have an influence on the likelihood of replying to a message in our model. This analysis suggests sender characteristics only influence action on a message as mediated by perceptions of message importance.

Table B.5. Logistic Regression of Replying vs. No Response

| | **Reply Immediately (vs. Later)** | | |
|---|---|---|---|
| **Factor** | ***b*** | **(SE)** | **Risk Ratio** |
| **Relationship to Sender** | | | |
| Number of recipients | -0.042 | (0.041) | 0.916 |
| Communication Frequency | 0.019 | (0.044) | 1.036 |
| Is Work contact? | 0.225 | (0.234) | 1.115 |
| Is Friend of Family? | 0.502 | (0.281) | 1.194 |
| **Request** | | | |
| Requesting action, info, or opinion | 0.756*** | (0.161) | 1.455*** |
| **Follow-Up** | | | |
| Following from prev. comm | 0.427** | (0.160) | 1.235** |
| Committing | 0.031 | (0.166) | 1.014 |
| Amending | -0.209 | (0.190) | 0.923 |
| Refusing | 0.891** | (0.328) | 1.185** |
| **Deliver** | | | |
| Delivering Info or Opinion | 0.055 | (0.147) | 1.027 |
| Reminding | -0.421** | (0.160) | 0.821** |
| **Social** | | | |
| Social Content | 0.537* | (0.209) | 1.222* |
| **Perceptions of Message** | | | |
| Importance to Receiver | 0.246** | (0.088) | 1.342** |
| **R-squared (variance explained)** | 0.14 | | |
| **p-value (predictive power)** | <0.0001 | | |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

Message content types were associated with changes in likelihood of message response. Request content increased the likelihood of response to a message by 1.5 times. In addition follow-ups from previous interactions were 1.2 times more likely to receive a response. Interestingly messages containing a refusal to do something were also 1.2 times more likely to receive a response. Messages delivering a reminder were 0.8 times less likely to receive a response, while social content surprisingly increased the likelihood of

response by 1.3 times even though respondents considered social messages relatively unimportant, compared to the work-related messages.

Table B.6. Multinomial Logistic Regression of Replying Immediately and Postponing Reply (vs. Not Replying to a Message)

| | **Reply Immediately** | | | | **Postpone Reply** | | | |
|---|---|---|---|---|---|---|---|---|
| **Factor** | ***b*** | **(SE)** | **Risk Ratio** | **95% CI** | ***b*** | **(SE)** | **Risk Ratio** | **95% CI** |
| **Relationship to Sender** | | | | | | | | |
| Number of recipients | **-0.14** | **(0.09)** | **0.87** | **0.73-1.03** | **-0.03** | **(0.05)** | **0.97** | **0.88-1.06** |
| Communication Frequency | **-0.03** | **(0.07)** | **0.97** | **0.84-1.12** | **0.01** | **(0.05)** | **1.01** | **0.92-1.12** |
| Is Work contact? | **0.44** | **(0.41)** | **1.56** | **0.71-3.45** | **0.23** | **(0.25)** | **1.26** | **0.77-2.06** |
| Is Friend of Family? | **-0.31** | **(0.54)** | **0.74** | **0.26-2.12** | **0.78**** | **(0.31)** | **2.19*** | **1.19-4.03** |
| **Request** | | | | | | | | |
| Requesting action | **0.48** | **(0.31)** | **1.61** | **0.88-2.96** | **0.85***** | **(0.19)** | **2.34***** | **1.62-3.38** |
| **Follow-Up** | | | | | | | | |
| Following from prev. comm | **0.029** | **(0.28)** | **1.03** | **0.60-1.78** | **0.57**** | **(0.18)** | **1.77**** | **1.24-2.54** |
| Committing | **0.47** | **(0.27)** | **1.60** | **0.95-2.70** | **-0.25** | **(0.20)** | **0.78** | **0.52-1.16** |
| Amending | **0.19** | **(0.28)** | **1.21** | **0.70-2.08** | **-0.38** | **(0.23)** | **0.69** | **0.43-1.08** |
| Refusing | **0.71** | **(0.53)** | **2.04** | **0.72-5.75** | **0.10** | **(0.46)** | **1.11** | **0.45-2.71** |
| **Deliver** | | | | | | | | |
| Delivering Info or Opinion | **-0.16** | **(0.26)** | **0.85** | **0.51-1.43** | **0.07** | **(0.16)** | **1.07** | **0.78-1.47** |
| Reminding | **0.19** | **(0.27)** | **1.21** | **0.71-2.05** | **-0.60**** | **(0.20)** | **0.55**** | **0.37-0.81** |
| **Social** | | | | | | | | |
| Social Content | **0.03** | **(0.44)** | **1.03** | **0.43-2.42** | **0.58**** | **(0.23)** | **1.79*** | **1.15-2.79** |
| **Perceptions of Message** | | | | | | | | |
| Importance to Receiver | **0.42**** | **(0.15)** | **1.52**** | **1.15-2.02** | **0.05** | **(0.10)** | **1.22*** | **1.01-1.48** |
| Constant | **-3.962***** | **(0.64)** | | | **-3.225***** | **(0.41)** | | |
| **R-squared (variance explained)** | **0.13** | | | | **0.13** | | | |
| **p-value (predictive power)** | **<0.0001** | | | | **<0.0001** | | | |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

### B.2.2 Effects on Likelihood of Postponing Message Response

Our initial analyses compared messages replied to versus not. For messages requiring a response, what makes someone reply immediately versus delay their response? To examine this question we next looked at only the sub-set of messages receiving a response (both immediate and postponed), and analyzed how message characteristics and perceived importance affected likelihood of replying immediately. We coded a binary variable equal to '2' if messages were replied to immediately, '1' if message response was postponed, and '0' if no reply was needed. Using multinomial logistic regression we compared Immediate reply (value of 2) to our comparison case of postponed response (value of 1), using the cluster command in Stata to group by participant id, controlling for individual differences in our analysis. Individual differences accounted for 43% of the variance in likelihood of replying to an email message. Results are presented in Table B.6 of Appendix B.

Messages were more likely to be replied to immediately if they were perceived as important to the receiver's work. Messages were more likely to be replied to later if they were from a friend or family member, requesting action, following up a previous interaction, containing social content, and of higher importance to the receiver. Message replies were less likely to be postponed if they contained reminders.

We next performed a regular logistic regression on a binary variable set to '1' if a message was replied to immediately and '0' if it was replied to later, again controlling for individual differences using the cluster command in Stata. The results are shown in Table B.7. This analysis showed that of messages perceived to require a response, messages containing a commitment were about twice as likely to receive an immediate response (rather than a delayed one). In addition messages containing a reminder were twice as likely to receive an immediate response.

Table B.7. Logistic Regression of Replying Immediately vs. Postponing Response

| | Reply Immediately (vs. Later) | | |
|---|---|---|---|
| **Factor** | ***b*** | **(SE)** | **Risk Ratio** |
| **Relationship to Sender** | | | |
| Number of recipients | **-0.13** | **(0.11)** | **0.87** |
| Communication Frequency | **-0.04** | **(0.10)** | **0.96** |
| Is Work contact? | **-0.16** | **(0.48)** | **0.85** |
| Is Friend of Family? | **-1.08** | **(0.60)** | **0.34** |
| **Request** | | | |
| Requesting action | **-0.40** | **(0.36)** | **0.67** |
| **Follow-Up** | | | |
| Following from prev. comm | **-0.64** | **(0.37)** | **0.53** |
| Committing | **0.75*** | **(0.30)** | **2.12*** |
| Amending | **0.58** | **(0.34)** | **1.79** |
| Refusing | **0.73** | **(0.74)** | **2.07** |
| **Deliver** | | | |
| Delivering Info or Opinion | **-0.10** | **(0.36)** | **0.91** |
| Reminding | **0.74*** | **(0.46)** | **2.09*** |
| **Social** | | | |
| Social Content | **-0.31** | **(0.18)** | **0.73** |
| **Perceptions of Message** | | | |
| Importance to Receiver | **0.25** | **(0.11)** | **1.28** |
| Constant | **-1.16** | **(0.81)** | |
| **R-squared (variance explained)** | **0.20** | | |
| **p-value (predictive power)** | **<0.0001** | | |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

### B.2.3 Path Analysis for Response Speed

In addition to performing the above logistic regressions, we also examined the influence of message characteristics on response speed. We created a continuous variable for message reply speed that was equal to '0' if the respondent reported not replying to the message, '1' if the respondent reported planning to reply to the message later, and '2' if the respondent reported planning to reply to the message immediately.

Using standard least squares regression, we performed mediation analysis including these message characteristics to predict the likelihood of message response[10], first regressing message characteristics on response speed, and then regressing message characteristics on our mediating variables: message importance to the sender, receiver, and perceived message urgency (results reported below in Table B.8 and B.9).

We were interested how response speed was influenced by importance to the sender versus the receiver, and as shown in our analyses above, these two distinct concepts are influenced by different features of the message. In addition we wanted to examine whether certain senders were taken into account more than others, and thus look at the interaction between sender relationship and importance to the sender. However our perception variables were highly correlated and collinear[11]. The high correlation between perceived importance to sender and importance to receiver may indicate a receiver bias in interpreting sender message importance; they may equate it directly with their own assessments of how important a message is. This result corresponds with previous work showing that recipients of an email message have difficulty empathizing with the sender.

Because of this collinearity we excluded both importance to the sender and perceptions of urgency from our subsequent analyses and included only importance to the receiver

To test the extent to which perceived message importance to the receiver mediated the influence of message characteristics on response speed, we next performed a regression of importance to receiver, our mediating variable, on response speed. Finally we performed a regression with both our independent variables (message characteristics) and our mediator (perceived message importance) in the model, to look at the influence of the mediator on the independent variable's regression coefficients. Standardized beta weights from the results of these regressions are reported in Table B.8 and B.9 below.

We tested mediation of importance to the receiver on response speed for each of the independent variables, using the Sobel test. Results are reported in Table B.10 below.

[10] Controlling for individual differences using the cluster command in stata

[11] Meaning that both importance to the sender and importance to the recipient were conveying essentially the same information and it would not make sense to include both in a regression analysis. We tested for collinearity using collin command in stata. Results will be included here.

Table B.8. Regression Analysis on Speed of Response to a Message

| Factor | Sender Relationship | Request | Follow-up | Deliver | Social | Importance to Receiver |
|---|---|---|---|---|---|---|
| | beta | beta | beta | beta | beta | beta |
| Intercept | -0.14* | -0.35*** | -0.39*** | -0.38*** | -0.39*** | -0.21** |
| **Relationship to Sender** | | | | | | |
| Number of recipients | -0.12*** | -0.11*** | -0.08** | -0.08** | -0.07** | -0.05 |
| Communication Frequency | -0.04 | -0.02 | -0.01 | -0.02 | -0.01 | -0.00 |
| Is Work contact? | 0.22** | 0.16* | 0.11 | 0.11 | 0.11 | 0.03 |
| Is Friend of Family? | 0.04 | 0.12 | 0.11 | 0.11 | 0.07 | 0.10 |
| **Request** | | | | | | |
| Requesting info, opinion, action | | 0.38*** | 0.32*** | 0.32*** | 0.33*** | 0.21*** |
| **Follow-up** | | | | | | |
| Following prev. interaction | | | 0.16** | 0.16** | 0.16** | 0.10 |
| Committing | | | 0.07 | 0.07 | 0.08 | 0.05 |
| Amending | | | 0.07 | 0.07 | 0.07 | 0.02 |
| Refusing | | | 0.40** | 0.41** | 0.39* | 0.36* |
| **Deliver** | | | | | | |
| Delivering Info or Opinion | | | | -0.00 | -0.01 | -0.04 |
| Reminding | | | | -0.04 | -0.04 | -0.04 |
| **Social** | | | | | | |
| Social Content | | | | | 0.09 | 0.13 |
| **Perceptions of Message** | | | | | | |
| Importance to Receiver | | | | | | 0.18*** |
| **Model R-squared** | 0.03 | 0.07 | 0.08 | 0.08 | 0.08 | 0.10 |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

Table B.9. Path Analysis for Speed of Response to a Message

| **Outcome Variable** | **Importance to Receiver** | **Response Speed** | **Response Speed** | **Response Speed** | **Percent of Effect Mediated?** |
|---|---|---|---|---|---|
| | β | β | β | β | β |
| Intercept | -0.96*** | -0.39*** | -0.01 | 0.04 | |
| **Sender Relationship** | | | | | |
| Number of recipients | -0.17*** | -0.07** | | -0.05 | 39%*** |
| Communication Frequency | -0.06** | -0.01 | | -0.00 | 59%** |
| Is Work contact? | 0.52*** | 0.11 | | 0.03 | 66%*** |
| Is Friend of Family? | -0.15** | 0.07 | | 0.10 | 37%* |
| **Request** | | | | | |
| Requesting action | 0.64*** | 0.33*** | | 0.21*** | 35%*** |
| **Follow-up** | | | | | |
| Following prev. interaction | 0.25*** | 0.16** | | 0.10 | 31%*** |
| Committing | 0.15*** | 0.08 | | 0.05 | 34%** |
| Amending | 0.22*** | 0.07 | | -0.02 | 58%*** |
| Refusing | 0.20 | 0.39* | | 0.36* | |
| **Deliver** | | | | | |
| Delivering Info or Opinion | 0.17*** | -0.01 | | -0.04 | 100%** |
| Reminding | -0.00 | -0.04 | | -0.04 | |
| **Social** | | | | | |
| Social Content | -0.26*** | 0.09 | | 0.13 | 66%*** |
| **Perceptions of Message** | | | | | |
| Importance to Receiver | | | 0.26*** | 0.18*** | |
| **Model R-squared** | 0.46 | 0.08 | 0.07 | 0.10 | |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

Table B.10. Sobel Mediation Test Results

| Outcome Variable | Test Statistic | *P<Z* | Percent of total effect that is mediated | Ratio of direct to indirect effect |
|---|---|---|---|---|
| **Sender Relationship** | | | | |
| Number of recipients | 4.50 | <0.001 | 39% | 0.64 |
| Communication Frequency | 3.14 | 0.002 | 59% | 1.42 |
| Is Work contact? | 4.62 | <0.001 | 66% | 1.93 |
| Is Friend of Family? | 2.53 | 0.01 | 37% | 0.27 |
| **Request** | | | | |
| Requesting action, info, opinion | 5.13 | <0.001 | 35% | 0.54 |
| **Follow-up** | | | | |
| Following prev. interaction | 4.27 | <0.001 | 31% | 0.45 |
| Committing | 2.79 | 0.005 | 34% | 0.52 |
| Amending | 3.63 | <0.001 | 58% | 1.40 |
| Refusing | 1.21 | 0.23 | 6% | 0.06 |
| **Deliver** | | | | |
| Delivering | 3.28 | 0.001 | 100% | 0.88 |
| Reminding | 0.07 | 0.94 | <1% | 0.00 |
| **Social** | | | | |
| Social Content | 3.64 | <0.001 | 66% | 0.40 |

### B.2.4 Effects on Likelihood of Message Retention

We next looked at whether particular message characteristics were associated with retaining a message versus deleting it. A binary variable 'Saved' was set to '0' if a user deleted the message and '1' otherwise. We analyzed the likelihood of retaining a message using logistic regression with 'Saved' as our binary outcome variable, controlling for individual differences by using the cluster command in Stata. The analysis looked at the relationship between sender characteristics, message content, perceived message importance, and likelihood of message retention versus deletion.

Sender characteristics did not significantly affect the probability of retaining a message. Messages with social content were less likely to be retained (about half as likely, or 0.47 times). This was to be expected since these messages may be less likely to contain information or need action. Finally perceptions of message importance significantly affected whether messages were saved. A one point increase in the receiver's importance

score of a message related to a 5.09 times increase in the likelihood of retention. Thus receivers saved messages they felt were important for their work either because they needed action or contained information.

Table B.11. Logistic Regression of Saving vs. Deleting (Base)

| **Outcome Variable** | **Save vs Delete** | | |
|---|---|---|---|
| | β | SE | Odds Ratio |
| Constant | 0.34 | 0.26 | |
| **Sender Relationship** | | | |
| Number of recipients | -0.06 | 0.09 | 0.94 |
| Communication Frequency | 0.14 | 0.09 | 1.15 |
| Is Work contact? | -0.30 | 0.23 | 0.74 |
| Is Friend of Family? | 0.40 | 0.27 | 1.49 |
| **Request** | | | |
| Requesting action | -0.26 | 0.18 | 0.77 |
| **Follow-up** | | | |
| Following prev. interaction | 0.26 | 0.17 | 1.29 |
| Committing | -0.09 | 0.19 | 0.91 |
| Amending | -0.20 | 0.21 | 0.82 |
| Refusing | -0.03 | 0.44 | 0.97 |
| **Deliver** | | | |
| Delivering Info or Opinion | 0.26 | 0.16 | 1.30 |
| Reminding | -0.04 | 0.17 | 0.96 |
| **Social** | | | |
| Social Content | -0.75** | 0.22 | 0.47** |
| **Perceptions of Message** | | | |
| Importance to Receiver | 1.63*** | 0.13 | 5.09*** |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

Table B.12. Multinomial Logistic Regression of Leaving an Email Message in the Inbox and Filing an Email Message into a Folder (vs. Deleting)

| | **Leave in Inbox (vs. Delete)** | | | | **File (vs. Delete)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Factor** | ***b*** | **(SE)** | **Risk Ratio** | **95% CI** | ***b*** | **(SE)** | **Risk Ratio** | **95% CI** |
| **Relationship to Sender** | | | | | | | | |
| Number of recipients | **-0.033** | **(0.042)** | **0.967** | **0.89-1.05** | **0.003** | **(0.047)** | **1.003** | **0.91-1.10** |
| Communication Frequency | **-0.028** | **(0.048)** | **0.972** | **0.89-1.07** | **0.040** | **(0.050)** | **1.041** | **0.94-1.15** |
| Is Work contact? | **-0.380** | **(0.232)** | **0.683** | **0.43-1.08** | **0.003** | **(0.256)** | **1.003** | **0.61-1.65** |
| Is Friend of Family? | **0.087** | **(0.290)** | **1.09** | **0.62-1.93** | **0.300** | **(0.332)** | **1.349** | **0.70-2.58** |
| **Request** | | | | | | | | |
| Requesting action | **-0.174** | **(0.182)** | **0.840** | **0.59-1.20** | **-0.446*** | **(0.194)** | **0.640** | **0.44-0.94** |
| **Follow-Up** | | | | | | | | |
| Following from prev. comm | **0.077** | **(0.180)** | **1.080** | **0.76-1.54** | **0.159** | **(0.186)** | **1.173** | **0.81-1.69** |
| Committing | **-0.102** | **(0.191)** | **0.903** | **0.62-1.31** | **0.127** | **(0.181)** | **1.136** | **0.80-1.62** |
| Amending | **-0.222** | **(0.213)** | **0.801** | **0.53-1.22** | **-0.061** | **(0.205)** | **0.941** | **0.63-1.40** |
| Refusing | **-0.795** | **(0.531)** | **0.451** | **0.16-1.28** | **0.131** | **(0.526)** | **1.140** | **0.41-3.19** |
| **`Deliver** | | | | | | | | |
| Delivering Info or Opinion | **-0.344** | **(0.178)** | **0.709** | **0.50-1.01** | **0.347** | **(0.180)** | **1.415** | **0.99-2.01** |
| Reminding | **0.094** | **(0.163)** | **1.099** | **0.80-1.51** | **-0.141** | **(0.179)** | **0.868** | **0.61-1.23** |
| **Social** | | | | | | | | |
| Social Content | **-0.711**** | **(0.260)** | **0.491** | **0.30-0.82** | **-0.071** | **(0.246)** | **0.932** | **0.57-1.51** |
| **Perceptions of Message** | | | | | | | | |
| Importance to Receiver | **1.001***** | **(0.120)** | **2.742** | **2.17-3.47** | **1.401***** | **(0.125)** | **4.058** | **3.18-5.18** |
| Constant | **-1.524***** | **(0.413)** | | | **-4.039***** | **(0.426)** | | |
| **R-squared (variance explained)** | **0.177** | | | | **0.177** | | | |
| **p-value (predictive power)** | **<0.0001** | | | | **<0.0001** | | | |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

### B.2.5 Effects on the Likelihood of Filing a Message

As Figure B.1 shows, a proportion of messages in our study were left in the inbox (23%). We were interested in whether respondents were deliberately leaving certain email messages in the inbox, as this behavior has been commonly cited in previous qualitative research and potentially contributes to overload in email use (Bellotti et al., 2003; Ducheneaut & Bellotti, 2001; Whittaker & Sidner, 1996).

We coded a variable 'File_vs_Inbox' equal to '1' if the message was left in the inbox, equal to '2' if it was filed, and equal to '0' if it was deleted. We tested a model to see whether message characteristics—the perceived importance of the message, sender characteristics, message content, and reply action—predicted keeping the message in the inbox or filing it, versus deleting it. Using multinomial logistic regression we predicted whether a message was left in the inbox versus deleted as a function of sender, content and importance, controlling for individual differences using the Stata cluster command, and whether a message was filed versus deleting it. These results are reported in Table B.12 above.

To further examine influences on message location action, we took the subset of messages that were saved rather than deleted, and coded a binary variable equal to '1' if a message was filed into a folder other than the inbox, and '0' if the message was left in the inbox. Using regular logistic regression we looked at the likelihood of filing a message versus leaving it in the inbox, as a function of message characteristics, again controlling for individual differences using the Stata cluster command. It is interesting to note that individual differences accounted for a large portion of the variance in the probability of a message being left in the inbox (43%), suggesting stable differences among respondents. For example, some people keep messages in their inbox regardless of message content, as an overarching strategy (Whittaker & Sidner, 1996).

People in our sample were more likely to keep messages they considered important in the inbox, increasing the likelihood of leaving in the inbox by one and a half times (or decreasing the likelihood of filing by 0.639 times).

We hypothesized that messages requesting an action and reminder messages would be left in the inbox as a memory aid, but the results did not support these hypotheses. In fact,

messages requesting an action or information were significantly more likely to be filed, with a request increasing the likelihood of filing a message into a folder by 1.525 times.

Messages containing refusals were more likely to be left in the inbox versus filed (about three times more likely). Messages delivering information or opinions were also more likely to be left in the inbox versus filed into a folder (almost two times more likely to be left in the inbox or 0.567 times less likely to be filed). Other types of message content such as reminders, follow-ups, commitments, etc. may only influence message retention in a mediated fashion through their effect on message importance.

Table B.13. Logistic Regression of Filing vs. Leaving in the Inbox

| | **Filing (vs. Leave)** | | |
|---|---|---|---|
| **Factor** | ***b*** | **(SE)** | **Risk Ratio** |
| **Relationship to Sender** | | | |
| Number of recipients | -0.042 | (0.049) | 0.959 |
| Communication Frequency | -0.045 | (0.053) | 0.956 |
| Is Work contact? | -0.266 | (0.306) | 0.766 |
| Is Friend of Family? | -0.017 | (0.361) | 0.983 |
| **Request** | | | |
| Requesting info, opinion | 0.422* | (0.199) | 1.525* |
| **Follow-Up** | | | |
| Following from prev. comm | -0.135 | (0.201) | 0.873 |
| Committing | -0.186 | (0.208) | 0.830 |
| Amending | -0.204 | (0.224) | 0.816 |
| Refusing | -1.156* | (0.456) | 0.315* |
| **Deliver** | | | |
| Delivering Info or Opinion | -0.568** | (0.189) | 0.567** |
| Reminding | 0.228 | (0.203) | 1.257 |
| **Social** | | | |
| Social Content | -0.470 | (0.358) | 0.625 |
| **Perceptions of Message** | | | |
| Importance to Receiver | -0.448*** | (0.127) | 0.639*** |
| Constant | 2.261*** | (0.455) | |
| **R-squared (variance explained)** | 0.123 | | |
| **p-value (predictive power)** | <0.0001 | | |

*$p$<0.05; **$p$<0.01; ***$p$<0.001

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