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The Burdens and Benefits of Information Flow:
Social Structure, Interdependence, Information Flow and Performance

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ABSTRACT

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Social Structure, Information Flow and Performance

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Information has become increasingly important in modern organizations. It is frequently the form and function of work. Queries, novel information, facts and reports are used to complete tasks, coordinate interdependencies, and share knowledge. While information is critical to organizational and individual effectiveness, little is known about the mechanisms whereby information affects individual performance. This dissertation encompasses three empirical studies investigating how access to and the flow of information affect individual performance. The first study examines how the search routines individuals invoke to utilize different sources of information impacts their performance. I explore competing theoretical models in which information sourced from personal and impersonal channels are complements or substitutes of each other. The results demonstrate that ambidextrous information access utilizing both personal and impersonal sources increases an individual's performance. The second study examines the effects of social structure on the flow of information within organizations. Social network theory suggests that an individual's position in an informal social network will impact their access to information. This study explicitly tests this assumption. I find that centrality and brokerage do increase an individual's information flow. Moreover, I examine the performance effects of increased information flow and find that social-structural positions of centrality and brokerage may create an information liability in that increased information flow burdens individuals and decreases their performance. The third study introduces and tests the concept of over-

coordination. While coordination is necessary to resolve interdependencies in the firm, too much coordination becomes too much of a good thing. I find that over-coordination reduces individual performance. In this study, I also examine how variation in the flow of information to individuals impacts their performance. I find that variations in information flow, the number and type of information sources, and the relevance of the information all impact individual performance. Hypotheses in all three studies are tested using a unique dataset based on survey, email traffic, company records, and managerial performance evaluations data of 152 individuals in a large financial institution.

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GENERAL INTRODUCTION

Organizational theories including social-network theory and knowledge management theory have viewed information access and control as a primary resource whereby individuals are able to increase their individual performance. Those who gain access to more information and who are control the flow of information are able to have greater influence and higher performance within their firms (Brass 1984; Burt, 1992; 1997; Hansen, Noria and Tierney 1999). An underlying assumption of these theories is that, in general, more information provides more advantage. For instance, the theory of structural holes states that the more non-redundant holes an individual brokers the higher their salaries and the more likely they are to get promoted (Burt 1997). Similarly, the resourced based view of the firm takes this assumption to the organizational level. Dierickx and Cool (1989) compare resources within organizations to a bathtub – they note that the cumulative stock of a resource is a factor of how much of the resource is flowing into the tub and how much of the resource is flowing out of the tub. The objective is to increase the inflow of a resource, such as knowledge, while limiting the "leaks" or outflows.

The linear assumption between individual information stocks and flows and individual performance fails to take into consideration the complexities of information in modern organizations. Unlike a bathtub that can hold any liquid that flows into it, individuals do not gain equal advantage from all information flows. To successfully build and information advantage we must, therefore, understand how the properties of the information, the characteristics of the flow of information and abilities and limitation of individuals themselves affect individual's ability to obtain information and use it to increase their performance.

Drawing on information processing theory (O'Reilly 1980) this dissertation reintroduces a curvilinear relationship between information flow and individual performance. In general, this research highlights that an individual's information advantage is driven by their information acquisition and processing routines and the properties of the information itself and not simply by possessing more information.

Specifically, the present research examines three aspects of information flow to individuals in organizations and explores how these affect individual performance. This effort builds a more robust understanding of information flows within organizations by identifying which properties of information and what characteristics of individuals increase individual performance and when individuals are likely to hit their information thresholds where more information becomes a liability.

This dissertation proceeds in three parts. The first study tests competing theories of individual information access routines. Specifically, this study seeks to increase our understanding of the performance implications of accessing information from personal and impersonal sources. Using competing hypotheses, I test, at the individual level, whether personal and impersonal sources of information are substitutes or complements to each other. Unlike prior studies of information access routines in uncertain environments, I show that in stable environments, individuals can benefit from accessing codified information from impersonal sources as well as information from personal sources. However, these impersonal sources must be proximate and context specific. In addition, individuals must also have 'know where' knowledge that allows them to quickly find what they are looking for in the stock of codified information.

The second study of the dissertation tests whether increased information flow – a key mechanism of social structural theories – drives task performance. This study first seeks to understand the relationship between social-structural position and information flow and then assess whether more information increases individual performance. More specifically, I explore how centrality and brokerage in informal social networks of the organization along with the level of task and outcome interdependence affect the volume of e-mail messages that an individual receives and sends. I hypothesize that social structural mechanisms are very strong predictors of information flow. However, I also predict that while social structure drives information flow to individuals, we will find a curvilinear relationship between information flow and performance. I predict that while information flow is the result of social structural position it is not the mechanism that drives individual performance.

In the third study, I test whether fluctuations in the flow of information can affect how much value individuals extract from the information they receive. Attention constraints and information processing constraints limit the amount of information individuals can utilize. While knowledge management theory and social network theory assume a linear effect between the flow of information and performance, this study reintroduces the concept of information constraint found in the information processing literature. Specifically, this study explores how variations in information flow shifts the amount of information individuals are able to process. Variation in the number and size of email messages, receiving information from many novel sources, the uniqueness of information and the quality of information are likely to affect performance. I develop hypotheses that high volumes of information flow are likely to lead to over-coordination and that information overload is much more likely for individuals with high

variance in their flow of information, in the number of sources from which the access information, in the uniqueness of the information they access and in the source of the content.

STUDY 1:

AMBIDEXTROUS INFORMATION SEARCH:

PERSONAL AND IMPERSONAL SEARCH ROUTINES AND INDIVIDUAL

PERFORMANCE

INTRODUCTION

Individuals and organizations face an increasingly competitive environment in which information capabilities are a key factor in determining their success or failure (Bharadwaj 2000; Decarolis and Deeds 1999; Demsetz 1991; Grant 1996; Haas and Hansen 2005; Hitt, Ireland, and Lee 2000; Nonaka 1994; Spender 1996). Given its importance, many scholars have asked: What determines an organization's ability to successfully manage information? In general, they have discovered that the successful use of information is dependent on properties of the information (Hansen and Haas 2001; Nonaka and Takeuchi 1995; Polanyi 1962, 1966), properties of the organization including the structural resources and capabilities of the organization (Dyer and Hatch 2006, Szulanski 1996, Tsai 2000), and the properties of the environmental context (Cohen and Levinthal 1990, Daft and Lengel 1984, Daft and Weick 1984, March, 1991). In general, these lines of inquiry invokes a contingency perspective based on a proper design of the formal and informal organization that matches the structural characteristics of the organization with the properties of the information (tacit or explicit), depending on the organization's and individual's needs (Donaldson 2001).

In this study, I take a different approach that emphasizes the performance implications of *how* individuals access information – their routines that utilize personal or impersonal sources –

not on the properties of the information, or the organizational and environmental factors. An individual may use either personal sources, impersonal sources or both to locate and use information. This study seeks to understand whether personal and impersonal search routines are substitutes or complements, and how search routines impact individual performance. In doing so, I extend theories of knowledge management by exploring the individual performance effects of knowledge utilization. I also add to the literature by exploring information use in a stable, standardized and routine task environment where the vast majority of information use focuses on the use of explicit knowledge. This distinction is important because the majority of prior studies have focused on the utilization of tacit information in novel settings (Hansen and Haas 2001). While important, these settings represent a small fraction of the knowledge utilization that occurs in organizations. Notwithstanding of the frequency of the use of codified information in more stable, routine contexts; surprisingly little research has been conducted despite the call to action of Simon nearly 60 years ago who stated, "Thus, at a time when we are acquiring devices that will transmit, store, and process symbols at unprecedented rates and volumes, *the most important change is not the growth of these devices but the growth of a science that helps us to understand how information can be transmitted, how it can be organized for storage and retrieval, how it can be used (and how it is used) in thinking, in problem-solving, in decision-making*" (Simon 1945 1997, p. 227, emphasis added).

Understanding information sourcing from personal and impersonal sources is important for practice as well as for theoretical reasons. Individuals have limited resources to invest in building their information capabilities. By understanding how strategic sourcing of information affects individual performance, these individuals can make better investment decisions to

encourage robust personal ties, to develop advanced information technologies or to strike an informed and appropriate balance between them (Hansen, Nohria and Tierney 1999). According to a recent report from the World Information Technology and Service Alliance (WITSA) organizations have been investing $10.8 million per year on average in information technology to help them codify and make better use of information; an amount nearly double their 1990 spending levels (http://www.fiercecio.com/topics/it_spending.asp, 2003). One of the goals of this study is to help identify if a firm's investments in technological capabilities are money well spent or a misguided investment strategy.

THEORY OF PERSONAL INFORMATION ACCESS

Personal information is information obtained through direct communication with others. These personal sources are ideal for conveying tacit information and reducing ambiguity through dialogue and thick communication that provides verbal as well as nonverbal cues (Daft and Lengel 1984, Daft et al. 1988, Nonaka and Takeuchi 1995). Personal interaction provides additional social cues and facilitates interpretation of the environment (Hutchings 1995), information processing (Daft and Lengel 1986) and sense-making (Weick 1995). Unlike impersonal sources, personal sources of information are also able to react to a failed search and suggest alternative search avenues or additional sources of information. Most individuals prefer to use personal sources of information and particularly face-to-face interaction particularly when tasks are complex and ambiguous (Daft and Lengel 1986, Katz and Tushman 1979, McDonald and Westphal 2003).

In addition to personal sources of information, individuals may also obtain information from impersonal sources such as documents, manuals and electronic information repositories (Daft et al. 1988; Hansen et al. 1999). Studies of information systems and codified knowledge have explored the conditions under which individuals and groups are able to effectively search for and transfer information (Gold, Malhotra and Segars 2001; Hansen et al. 1999). In general, these studies find that the higher the quality, the greater the volume, and the better the search and transfer capabilities the more likely information is to be transferred and utilized (Bystrom 2002, Huber 1991, March and Simon 1958).

Much of the discussion concerning impersonal information centers on the difficulty in codifying and transferring tacit information (Hansen 1999, Hansen and Haas 2001). Impersonal information may be limited in the degree to which it contains tacit information, but with the inclusion of assumptions, metadata and analysis, it can approximate tacit information or at least provide a more rich communication flow (Stenmark 2000). However, due to the high costs of inputting and transferring tacit information, the majority of impersonal information is likely to be explicit, know-what information (Kogut and Zander 1992).

Even though impersonal information is limited in codifying tacit information, a primary strength of impersonal information is the relative ease of information transfer. Because impersonal information is by definition codified, transfer is virtually costless (Birkinshaw and Sheehan 2001; Hansen et al. 1999). This is particularly true with advances in electronic information technologies, which make impersonal information more searchable and transferable than its paper counterparts.

Information Access and Performance

Confronted with the option of utilizing personal and impersonal information, individuals must decide how to allocate their limited time and resources to determine what search routines to invoke. This begs the question: How do search routines – accessing impersonal and personal sources of information – affect an individual's performance? To answer this question, I explore a model where personal and impersonal information are complements and a competing model in which they are substitutes.

Complementary Model

Individuals with superior performance may use both personal and impersonal sources of information in an additive ambidextrous fashion. For instance, within a task environment, personal and impersonal sources of information may provide different kinds of information. Standard questions could be answered efficiently with impersonal information (Bystrom 2002), while personal interaction may help individuals make sense of more ambiguous situations (Weick and Roberts 1993; Hutchings 1995; Van de Ven, Delbecq and Koenig 1976).

Second, individuals may build ambidextrous search routines due to the path dependent nature of information acquisition and learning (Gavetti and Levinthal 2000). One source of information could be obviously superior to the other source because more resources have been dedicated to enriching that mode of information (Hansen et al. 1999). For instance, firms could spend millions of dollars on information technology and on training employees to effectively search and transfer impersonal information, while largely ignoring and even curtailing the

development of personal relationships. On the other hand, firms could expend resources linking people and not engage in knowledge codification efforts.

Task demands may also require the use of both personal and impersonal information. As task needs change over the course of the project, individuals may need to alter the source of their information. For example, more complex tasks may require individuals to use both personal and impersonal information (Bystrom 2002). The nature of tasks may drive individuals to use both personal and impersonal sources in different sequence. Vakkari and colleagues found that personal sources of information were used early in a project and then abandoned, while impersonal sources were used throughout the process (Vakkari and Hakala 2000, Vakkari and Pennanen 2001). Similarly, Hansen, Mors and Løvås (2005) found that different phases of projects invoked different search and transfer patterns. Moreover, Hansen and Haas (2001) identify how personal information may improve the use of impersonal information. They note future research may answer the question: " … do users who rely on other people in their network to point them to useful electronic documents perform better than individuals who do not benefit from such personal recommendations?" (Hansen and Haas 2001, p. 25). These studies, focused on complex work environments, all indicate that ambidextrous search routines are an effective strategy.

Ambidextrous search may also be used by individuals in decisions environments that require accuracy. In such situations, an individual may use both impersonal and personal sources of information to cross check and verify findings found in one source of information from the other source.

Why would complementary use of personal and impersonal sources of information increase an individual's performance? Assuming that information from different sources is non-redundant, several mechanisms are likely to increase performance under a complementary model of information acquisition. If the information is redundant, then there is likely to be a decrease as opposed to an increase in performance due to wasted effort in tapping both sources of information for the same outcome.

Complementary use of personal and impersonal information may provide more information (social networks, particularly cliquish networks, are likely to provide redundant, tacit information, while impersonal information is likely to provide a broader, more diverse perspective). Individuals who systematically access both personal and impersonal sources may obtain a richer conceptual understanding by obtaining access to more information (McDonald and Westphal 2003). More robust information is likely to increase task performance by improving decision making, increasing rapid task completion, enabling sense-making, facilitating coordination, granting power to the holders of information, and providing more correct perceptions. The benefits of complementary information sources are expounded in Table I below:

Table 1: Complementary Information Access

Improvement	Rationale	Citations
Information from different sources improves decision making.	Reduces heuristics and biases	Mooney, Gurbaxani and Kraemer 1996 McDonald and Westphal 2003
Improves the speed of task completion	Allows for information reuse	Szulanski 1996, Garud and Kumaraswamy 1995, Nobeoka and Cusumano 1997
Improves sense-making	Thicker communication provides more cues.	Weick and Roberts 1993
Improves coordination	More alternatives	Cohen and Levinthal 1990, Fichman and Kemerer 1997, Van de Ven et al. 1976
More unique information grants control and brokerage.	If non-redundant, this can increase the social capital of	Burt 1997; Rowley, Behrens and Krackhardt 2000

	individuals, which will lead to better outcomes.	
Provides power	Using both impersonal and personal sources of information may provide individuals with a more accurate perception of the world around them.	Burkhardt and Brass 1990, Krackhardt 1990, Pettigrew 1973

Substitution Model

In contrast to an ambidextrous information approach, individuals with superior performance may specialize in using personal or impersonal information. This specialization may occur for several reasons. First, the search for and transfer of information has direct costs (Hansen et al. 2005, Szulanski 1996). Individual who make specific investments in search routines are likely to maximize this investment by relying predominantly on that routine to gather information (Hansen et. al. 1999, Nelson and Winter 1982). For instance, to successfully use personal information, individual needs to build connections with others who can provide appropriate information. Building this network requires an investment in building and maintaining ties and an understanding of who knows what (Wegner 1986). Upon establishing a robust informal information network, an individual is likely to rely predominantly on this network.

Time pressures may also force individuals to "satisfice" when seeking information (March and Simon 1958; Simon 1945 1997). Due to attention constraints, individuals are unlikely to deviate from their established routines or even take time to make a calculated decision to explore new options (March 1991). Moreover, Kmetz (1984), following Galbraith (1977), argued that when individuals face too much information, they can increase the time they

spend searching for and understanding information or they can reduce the amount of information that they access. Limiting the source of information to either personal or impersonal sources significantly reduces the amount of information that must be processed and increases the likelihood that the individual with have the capability to absorb and understand the information they access (Cohen and Levinthal 1990).

Moreover, Hansen et al. (1999) hypothesized that if the task requirements are known ex ante, then a single source of information that matches the task requirements will provide better results. This contingency argument of information search indicates that when individuals face a stable task environment they may clearly favor either personal or impersonal information search. Under this rubric, with precise identification of the task requirements, firms and individuals can optimize their investments in one dominant information source, resulting in cost savings and performance advantages.

Finally, individuals may specialize in one search routine because they do not perceive a significant difference between outcomes. If individuals perceive that personal and impersonal information are roughly approximate and of equal quality, individuals would not gain any information advantage in using one channel over the other. In this case, their decision of which source to use is likely to be based on personal preference and relative ease.

Why would search routines based on a single source of information increase performance? Some of the mechanisms by which this advantage may occur include specialization, focused attention, an ex ante understanding of the task characteristics, and optimization of the benefits of different information sources. The benefits of substitutable information sources are expounded in Table II below:

Table 2: Substitutable Information Access

Improvement	Rationale	Citations
Specialization	Focus on one source allows asset-specific investments to be made.	Adam Smith 1776
Focus of attention	Presumably individuals – like organizations – are likely to either specialize in search or use but incur costs in doing both.	March 1991, Simon 1945 1997
Higher quality	Quality of information may increase by limiting the number of information suppliers.	Brynjolfsson 1993
Optimization	Ex ante task knowledge allows for optimization of one source. Specifically, personal sources provide tacit and more customized information.	Hansen et al. 1999, Kogut and Zander 1992, Sanchez 1995

METHODS

Site and Sample

Alta corporation is a large financial company with over 150,000 employees. The company was founded over 100 years ago and has stores across the U.S. and in 35 other countries. The company has revenues of over $50 billion a year coming from several different lines of business. Alta has grown organically and through acquisition. The company has won numerous awards for its employment practices and has been voted one of the best places to work several times.

Data was gathered on employees in two business units that had access to the company's intranet portal (approximately 50% of the employees). With the help of senior management, I identified a sample of 154 employees embedded in two organizational units that met these criteria.

Data

I collected data on an individual's use of personal information, impersonal information and performance from five separate sources. First, I collected data on personal search routines by

means of a questionnaire (Burt 1992, Obstfeld 2005). This questionnaire measured information access, personal networks, task characteristics, demographic information and the overall satisfaction of employees, along with several control measures. The survey was pretested with five individuals to ensure the clarity of each survey item and reduce response bias. Of the 154 potential participants, 86 completed the survey – a 55% response rate.

Second, I obtained nearly 2 million e-mails that were sent or received by each employee over a nine-month period, November 2005 to July 2006. I used this data to build a behavioral measure of personal information access.

Third, I measured impersonal information search routines by collecting data regarding the use of the company's intranet portal. For all 152 employees, I counted each time and the duration of the visit he or she accessed the intranet over the course of four months (January to April 2006).

Fourth, for a more precise measure of impersonal information access, I counted each time an individual accessed his or her business unit sub-portal. These portals are the primary source of specific tools and information for employees. They contain a host of documents, procedures and templates tailored for each business unit. I collected this data for three months, from July to September 2006.

Finally, I collected individual performance data from a separate questionnaire completed by each of the employees' managers.

Measures

Personal Information

Personal information is obtained via interpersonal interaction. Several modes of interaction are utilized at Alta Corporation: face-to-face, telephone, email and instant message communications are all utilized. Although within the organization individuals use a combination of all the modes of communication. I utilize email as a proxy for personal information access. Individuals indicate that email is the primary communication mode within the organization. Email is also beneficial in that it allows personal information flow irrespective of distance. Though individuals can reach out and access personal information in a number of channels all the individuals in the organization indicate that they use email more that face-to-face interaction even with collocated individuals. Most employees at Alta are either located in a separate office or in their own cubical. Several people indicated that even if face-to-face interaction is necessary, individuals will send an email first to ask if it is a good time to stop by. Moreover, 85% of all email in the company originates from another person within the company. As a behavioral proxy for personal information access, I measured the number of e-mails an individual received. On average, individuals received over 7,000 e-mails over the 10 month period of the study, or about 25 e-mails per day.

In addition, to the behavior-based e-mail data, I utilized a series of perceptual questions regarding how frequently individuals interacted with others in their group and outside their group to verify that e-mail communication is an effective proxy of personal information, in the survey. These results indicate that email is the most frequent form of personal communication within groups and the most frequent form of communication across groups (just behind instant messaging). In creating this measure, I interviewed six managers in the communications department of the company. I asked these experts to identify how personal information is

typically accessed in the company. From these conversations, I created six measures that covered the range of personal information access. These include a measure assessing the level of face-to-face, telephone and e-mail communication they exchanged within their groups and the level of face-to-face, telephone and e-mail communication they had with others outside their group. From this data, I created six measures of perceived personal information access. A Chi-Squared test indicated there were no significant differences in the perceived amount of personal communication via different modes ($F = 1.31$, $p = .21$).

Impersonal Information

Impersonal information at Alta Corporation is primarily located in either the firm's intranet portal or in each business unit's intranet portal. The intranet portal is controlled by corporate headquarters. This portal includes general business information, contact information, documents about current initiatives and work processes, and forms for various activities. The business unit's portal has similar content to the firm's portal but includes more specific documents, tools and information about the business unit's particular needs. The business unit portals are managed by the business units with minimal oversight and support from corporate headquarters. Taken together these two sources provide a comprehensive view of impersonal information in the firm.

Following the approach taken by prior scholars (Hansen and Haas 2001), I measured the use of impersonal information by counting the number of times each individual accessed the firm and business unit portal. In addition, I measured the duration of each visit to the firm and business unit portal and the number of unique pages that were viewed at the business unit portal.

It is important to note that individuals in the organization have discretion in how they choose to access information. Those who prefer impersonal information will access the portals more frequently than those who choose other sources of information. There are no organizational initiatives to drive individuals to one source over another.

Performance

I hypothesized that efficient access to information will improve an individual's performance. I measure performance by asking managers to evaluate employees that directly report to them. Supervisory evaluations of performance are a common method for evaluating performance (Bretz, Milkovich and Read 1992). Prior research demonstrated that supervisor ratings are good indicators of performance (Arvey and Murphy 1998).

Managers were informed that the performance ratings would be confidential and were for research purposes only. They were asked to indicate to what extent they agreed or disagreed with statements regarding each employee. Four items were used to determine overall job performance: (1) adequately completes assigned duties; (2) meets formal performance requirements of the job; (3) performs tasks that are expected of him/her; and (4) neglects aspects of the job he/she is obligated to perform (reverse scored). Reponses were based on a 5 point scale, with 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. These items were modified from Williams and Anderson (1991). I also assessed the supervisor's evaluations of the individual's willingness to help others or extra-role behavior. These items include: (1) helps others who have been absent; (2) helps others who have heavy work loads; (3) takes time to listen to co-workers' problems and worries; and (4) takes a personal interest in other employees. Reponses were based on a 5 point scale with 1 = strongly disagree, 2

= disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. These items were also taken and modified from Williams and Anderson (1991). I included four questions to assess manager's perceptions of their employee's ability to find, share and use information. These questions included: (1) effectively searches for information from a variety of sources; (2) passes along information to co-workers; (3) communicates effectively within the group; and (4) communicates effectively with those outside this business unit. Reponses were based on a 5 point scale, with 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. I collapsed all 12 items into a single measure (ά.96) called *performance*.

Control Variables

Task Uncertainty

Differences in task uncertainty and complexity are likely to drive different information processing levels (Daft and Lengel 1986; Daft and Weick 1984; Pennings 1974; Van de Ven et al. 1976). Uncertainty (task complexity) can cause individuals to search more broadly (Tiamiyu 1992, Culnan 1983) or more focused (Daft and Macintosh 1981). I measured the degree of uncertainty by asking individuals three questions taken from Van de Ven, Delbecq and Koenig (1976). These include: (1) During the course of work, I often come across difficult problems that I don't know how to solve; (2) Most of the time, in my job, things are fairly predictable (reverse coded); and (3) There is not much variety in the work I generally encounter in a normal working day (reverse coded). Unless otherwise noted, all responses were based on a 5 point scale, with 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Autonomy

The degree to which workers have autonomy over their daily activities may affect the degree to which they leverage information (Griffin 1983, Thomas and Griffin 1983). I used three options modified from Griffin, Moorhead, Johnson, and Chonko (1980) to gauge employees' perceived autonomy: (1) In my job, I have the freedom to do pretty much what I want; (2) I have control over the pace of my work; and (3) I have the opportunity for independent thought and action.

Interdependence

Employees who are more independent are more likely to need novel information. Novel information stems from different sources than redundant information. The need for novel information is likely to motivate different patterns of information acquisition. I use two items to measure the degree of skill interdependence: (1) Nearly everyone in my team has the skills to do my job; and (2) In our group, we work together as a team. These items have a Cronbach's alpha of .8392.

Coordination Routines (Standardization and Meetings)

Coordination routines can drive information access and flow (Pennings 1973, Van de Ven et al. 1976). Individuals embedded in units that utilize routines, rules and standard operating procedures are more likely to rely on impersonal information while those who use planned and ad hoc meetings are more likely to rely on personal information. I measure the extent to which the business unit coordinates interdependencies through policies, plans and procedures (I called this item *standardization*) or through scheduled and ad hoc meetings (I called this item *meetings*) (Van de Ven et al. 1976).

Tenure

The longer an employee remains with the company, they more likely they are to build extensive personal networks and gain familiarity with the corporate and business unit intranet sites. I asked each employee to indicate what year and month they began working for the company. I coded tenure as the number of months each employee had been working at the firm.

Age

Prior studies of technology use have indicated that younger workers are, in general, more comfortable utilizing technology. I control for differences in age by including a variable of age.

Analysis

I employed a Kolmogorov-Smirnov (K-S) test to assess whether the sample of respondents was biased. The K-S test determines if the distribution of a single continuous variable is different for respondents verses non-respondents by calculating the maximum vertical distance between the empirical and posited distribution functions. The results showed that the respondents were not significantly different from non-respondents on any of the archival measures which included the number of intranet visits ($p=.17$), rank ($p=.93$), performance ($p=.46$) and the number of email sent ($p=.17$) and received ($p=.73$).

I also tested for heteroscedasticity of the dependent variable using the Shapiro-Francia normality test. The test statistic of the Shapiro-Francia test is the squared correlation between the ordered sample values and the expected ordered quantiles from the standard normal distribution. The results indicate that heteroscedasticity is not a problem for my dependent variable ($W' = .97$, $p= 11$). Chart 1 below provides further evidence of a normal distribution of performance. The plot expresses the quantiles of performance against the quantiles of normal distribution.

Chart 1: Shapiro-Francia Fit
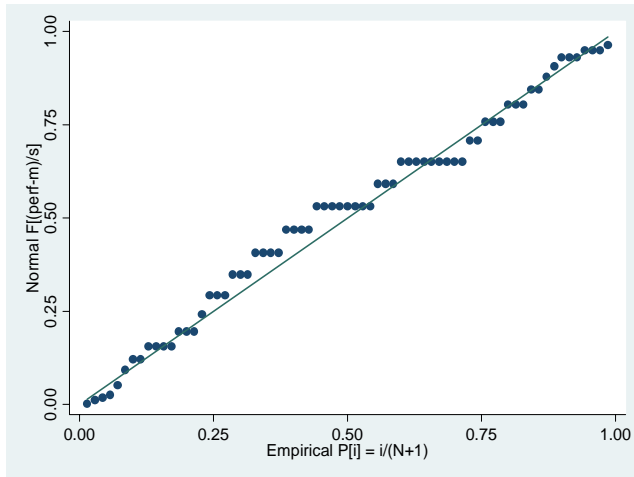
My approach in testing the complementary and substitution models employs OLS regression analysis with an interaction effect given by the equation:

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \cdots + \beta_7 x_1 x_2 + e$$

Where x_1 is the number of business unit intranet visits, x_2 is the amount of intra-group face-to-face interaction, $x_3 \cdots$ represents the rest of the independent variables, $x_1 x_2$ is the interaction term, and e is the error term. This multiplicative interaction approach … Friedrich (1982). As interaction terms often increase multicollinearity, post analysis, I examined the variance inflation factors of the model to ensure that introducing the interaction term of personal and impersonal search routines did not create excessive multicollinearity. The results of this test indicate that collinearity was not problematic in the model (VIF scores ranged between 4.18 and 1.16).

I received 86 usable survey responses. Using missing-value regressions, I imputed the value of the survey based on constructs for 42 individuals (Allison 2002). Missing-value regression techniques invoke a procedure by which missing data are imputed several times using regression imputation to produce several different complete-data estimates of the parameters. The parameter estimates are then combined to give an overall estimate of the complete-data

parameters as well as reasonable estimates of the standard errors (Newman 2002). I also received performance evaluations from managers for 74 individuals. Using missing-value regression, I imputed the value of the performance measure for 54 individuals. The un-imputed regression results were consistent with the imputed values but with slightly less significance.

Results

Descriptive statistics for all variables are reported in Table III. I tested the completing theoretical models of individual information access routines using three OLS regression models. The results are presented in Table IV. Model 1 tests the controls of tenure, age, uncertainty, autonomy, task interdependence, and personal and impersonal coordination modes on performance. The results indicate that none of the control variables are significant predictors of performance. Model 2 tests the main effects or constituent effects of impersonal search and personal search. As theorized both personal and impersonal search are related to performance. More specifically, impersonal search via business-unit intranet visits and business unit intranet duration are both significant positive predictors of performance. The regression coefficient for page views, a proxy for the number of different Web pages visited by users, indicates that unfocused use of the business unit intranet was statistically significant but negatively affected performance. This implies that individuals who engage in imprecise search are likely to waste time and effort searching for information which leads to poorer performance. The results also indicate that individuals who access the corporate intranet more frequently have poorer performance – the general nature of this information does not warrant its use.

Model 2 also indicates that some of the perceptual measures of personal search increase performance. Individuals who self-report more face-to-face interaction with those on their team

and those who report e-mailing others on different teams are likely to have better performance. However, the behavioral measure of personal search indicated personal search decreases performance; those who receive more e-mails are likely to have poorer performance.

Finally, I tested the complementarity and substitutability of personal and impersonal search in Model 3 by introducing and interaction term (Allison 1977). The results indicate that the interaction term of face-to-face communication and the use of the business unit intranet is a positive and significant. This means that are individual information search routines are complementary – ambidextrous individuals adept at using both personal and impersonal knowledge have better performance.

Discussion

Contrary to existing theory of information search, the use of codified information improves performance. Thus, ambidextrous individuals who are able to build complementary skills enabling them to leverage personal and impersonal sources of knowledge are likely to have superior performance. This capability supports the complementary model of information search. The findings also extend three of the theoretical justifications for why complementary search would be beneficial including: improved decision making, additional human capital, and more robust sensemaking.

While individuals clearly prefer personal search – an internal study conducted in 2006 within Alta reported that a vast majority of the 305 individuals surveyed preferred personal search. This finding replicates the findings of McDonald and Westphal (2003) and Hansen (1999). In addition, this study provides some of the first evidence of the performance benefits of

utilizing impersonal knowledge within organizations. A finding which contradicts the findings of Hansen and Haas (2002) who found that utilizing impersonal information hindered performance.

Why would my results differ from prior scholars? The answer lies in the context of the information search. Prior studies have focused on information search in uncertain and changing environments. In contrast, employees at Alta operate in a very stable market – the industry is highly regulated, growth is stable, and the firm is very profitable. Additional evidence of the stability of the work environment comes from the survey. In it, individuals indicated a relatively low mean level of uncertainty score of 2.49 out of 5.

Despite the similarity in personal preference for personal search routines across research settings, in more stable environments impersonal search is also important - individuals benefit from both personal and impersonal search routines. These routines are likely to improve decision making by incorporating more information and shift decision making from pure "satisficing" towards a more "optimized" decision process (Simon 1945 1997).

Successful ambidextrous search is dependent on a novel form of human capital in the form of impersonal information search capabilities. The positive effects of impersonal information use are dependent on individual capabilities. Just as knowing who to contact (social capital) can increase the effectiveness of personal search, knowing where information is located in the intranet can increase the effectiveness of technology-mediated search. In other words, akin to an individual's "transactive memory" that enables individuals to contact appropriate people, individuals must possess an *intranet navigation capability*. Those that possess this capability are able to pinpoint where to find for information among the abundant codified information stores. Thus, adding a fourth kind of knowledge may be important for individuals; in addition to know-

how (tacit knowledge), know-what (explicit knowledge), and know-who (transactive memory) (Kogut and Zander 1992, Wegner 1986); individuals can benefit from know-where (knowing where to search for impersonal knowledge). Indeed, Simon (1945 1997) noted the importance of precise search; he wrote, "Our scientific and technological knowledge, our decision-making and information-processing systems should permit us to absorb information very selectively, extracting from it just the parts we want" (Simon 1945 1997, p. 226). My results suggest that individuals cannot shift this burden entirely onto organizational systems, but they must develop an individual navigation capability that allows them to glean performance benefits from impersonal search routines.

While the goal of this study was to focus on the performance implications of an individual's search routines, a third important finding regarding the structure of organizational information emerged. My results suggest that generating general codified information is not a successful knowledge-management strategy. Building the corporate intranet, rather than codifying more specific information found in business units, is an effort spent on a resource that is likely to decrease individual performance when this knowledge is accessed. This suggests that firms should focus on the codification of *proximate* and business-unit-*specific* information to increase individual performance. This suggests that information specificity is more important than information access. In other words, while information stored at the corporate level is ubiquitous across the organization, its use is too general and actually decreases individual performance. However, the application and use of local and specific information increases performance.

Theoretically this relates back to the sensemaking argument for complementary search. However, it identifies a clear boundary condition of the theory. While more information from personal and impersonal sources is likely to increase performance this is only true when the impersonal sources are proximate to the individual. Understanding, meaning and sensemaking appear to be able to occur from impersonal sources but only when "thick" communication can be approximated via customization (Daft and Weick 1984; Daft and Lengel 1986). Locally customized information is much more likely to be understood even when comes in impersonal format.

In addition to the contributions to theory noted above, this study provides a methodological contribution by focusing on performance and search routines at the individual level. This approach provides many advantages. First, it allows me to directly test the individual mechanisms of information search and performance. The majority of prior studies linking information acquisition to performance has measured performance at the firm or group level. Second, by studying the use of information at the individual level, I can identify and test the micro-mechanisms of information search explicitly. An additional advantage of measuring performance at the individual level is that I circumvent the problem of aggregating different modes of access and the degree to which they are accessed to a group proxy. By focusing on the individual level, I am able to observe the inherent individual heterogeneity and explore the performance consequences of this diversity. More explicitly, prior scholars have contended that effective use of impersonal information provides firms with a performance advantage (Bharadwaj 2000, Brynjolfsson 1993, Hitt and Brynjofsson 1996, Lucas 1993). However, the mechanisms that link technology and firm performance are unclear. Bharadwaj (2000) noted,

"Although the analysis indicates that superior IT capability leads to improved firm performance, the underlying mechanisms through which this is achieved are in no means clear" (Bharadwaj 2000, p. 188). By focusing on the individual level, I am able to directly test the performance implications of individual search.

This research, of course, has a few limitations. First, the sample focused on standardized and routine task environments, thus the findings should only be generalized to similar contexts. Second, the personal search behavioral measure was limited to e-mail interaction. It could be that some individuals engage in personal search but do so through other communication channels. As noted above, I tested for this with data from the survey, but future research could explicitly measure different forms of personal search. It is also interesting to note the difference in the behavioral – which indicated a negative first order effect – and the perceptual measure of personal information access – which indicated a positive effect. Future research could disentangle the difference between perceptual and behavioral measures. It would be particularly interesting to explore how perceptual measures result in increased performance evaluations.

Finally, future research should explore why local impersonal information increases performance while the use of codified impersonal information at the corporate level decreases performance. It could be that individuals have capacity to absorb the local information (Cohen and Levinthal 1990), that the specificity of the information reduces the transaction costs of its utilization (Willamson 1981), or that the local information is "pre-processed" (Daft and Lengel 1986).

In conclusion, this study utilized competing theoretical models to test whether personal and impersonal sources of information are substitutes or complements. The results indicate that

individuals who utilize information from personal and impersonal sources of knowledge in a complementary fashion have superior performance. This study sheds light on the origins of knowledge capabilities and indicates that individuals must develop an ambidextrous capability to leverage both personal and impersonal sources of knowledge.

STUDY 2:

THE BURDEN OF INFORMATION:

THE ANTECENDENTS AND CONSEQUENCES OF INFORMATION FLOW WITHIN ORGANIZATIONS

Introduction

Organizations face an increasingly competitive environment in which appropriate use of information is a key factor in determining their success or failure (Argote and Ingram 2000; DeCarolis and Deeds 1999; Demsetz 1991; Grant 1996; Hitt, Ireland and Lee 2000; Nonaka and Takeuchi 1995; Spender 1996). More effective use of information can increase innovation (Amabile 1988; Hurley and Hult 1998), accelerate organizational learning (Argote 1999, Argyris and Schon 1978, Huber 1991, Senge 1990), shorten product development cycles (Clark and Fujimoto 1991, Hansen and Haas 2001, Szulanski 1996), increase successful business development (Haas and Hansen 2005), and lead to firm-environment fit (Daft and Lengel 1986). Because of these benefits, managing internal knowledge has become an important effort for many companies. In fact, a recent study of large companies in the U.S. documented that on average they invest $10.8 million per year in technologies that help them codify and make better use of information (World Information Technology and Service Alliance 2003).

Many organizational theories invoke information flow as a fundamental mechanism affecting individual performance. Information's importance stems from the oft-contested nature of information within organizations (Ocasio 1997, Thornton and Ocasio 1999, Weick 1995), the failure of information transfers within organizations (Szulanski 1996, 2000; Dyer and Hatch

2006), and the fact that the information is an important resource that may be used independently or traded for other resources (Ancona and Caldwell 1992; French and Raven 1959; Siebert, Kraimer and Liden 2001). Increased information flow bestows power and influence on the recipient (Brass 1984, Kilduff and Krackhardt 1994, Tsui 1984).

More specifically, social-network theorists have highlighted the important effect of structural position on information flow and performance. As Brass and Burkhardt (1993) note, "From a resource dependency perspective, the interdependencies among employees are based on the exchange of information. … The inherent ambiguity of organizational settings … coupled with the subjective nature of power … points out the importance of information … ." (pp. 446-447) Individuals who are centrally positioned in a network gain control over more information and have greater independence and power. This, in turn, increases the likelihood that they will obtain better individual outcomes. As Brass (1984) stated, "Actors or units occupying central positions in a network are viewed as potentially powerful because of their greater access to and possible control over relevant resources. … being in a position to control communications within the department is particularly important to being promoted." (pp. 520-532)

In addition to the information benefits of centrality, brokers of unconstrained structural holes gain similar information advantages (Ancona and Caldwell 1992; Burt 1992, 1997). Brokers have access to more information, obtain information sooner than their peers, and have more opportunities to utilize their information by playing individuals off one another and acting as a *tertius* – a third party who benefits (Burt 1997, Obstfeld 2005). Burt (1992) identifies the benefits of brokerage as access, timing and referrals. A broker's network provides access to information, according to Burt, "well beyond what the player could process alone. … The

network that filters information coming to the player also directs, concentrates, and legitimates information received by others about the player" (Burt 1992 pp. 47-48). He further notes that the access to information and the ability to control that information set the stage for *tertius* strategies. Brokers of unconstrained structural holes are able to use the currency of information (which they have in abundance) to gain personal advantages. In other words, brokers of unconstrained structural holes are likely to have increased information flow and gain performance advantages from this resource.

Scholars studying interdependencies within organizations have posited a similar effect to the social-network theorists: higher levels of interdependence result in more information flow which, in turn, leads to higher individual performance. Increased information flow facilitates coordination – effectively resolving interdependencies (Thompson 1967; Van de ven, Delbecq and Koenig 1976; Pennings 1973). Because information flow is the backbone of coordination activities, high levels of interdependency are likely to be coupled with high levels of information flow (Thompson 1967). The frequency of communication is likely to increase in parallel to interdependence (Ancona and Caldwell 1992, Katz and Tushman 1979, Van de Ven et al. 1976). Increase information flow is likely to increase performance particularly at high levels of interdependency.

Despite the ubiquity of information flow as a primary mechanism in social network theory and theories of interdependence, knowledge management theory highlights that information transfers are not automatic. In fact, some scholars have gone so far as to claim that one of the primary reasons firms exist is to facilitate this flow (Kogut and Zander 1994). However, despite that fact, that firm boundaries appear to enable information flow, particularly

as the distance from the sender to the receiver of knowledge increases (Grant 1996, Stuart and Sorenson 2003), the internal flow of information is limited by communication and information processing costs (Birkinshaw 2002; Hansen, Mors and Lovas 2005; Hansen et al. 1999; Szulanski 2000). Because of these costs, the assumption that knowledge transfer will occur on its own within a firm is unfounded (Szulanski 2000). Indeed there is ample evidence that information flows within organizations are often impeded by properties of the information, by characteristics of the sender and receiver of the knowledge, and by the communication mode used for the transfer (Hansen et al. 1999, Szulanski 1996).

While social network theory and theories of interdependence disagree with knowledge management theory as to the relative ease of information flow to individuals within organizations, they all agree that more information is likely to lead to increased performance. The assumption that more is better likely holds for organizational performance, but the relationship between information flows and individual performance is likely to be limited by the individual's information processing abilities (O'Reilly 1980, March and Simon 1958).

The purpose of this paper is to identify the antecedents and consequences of information flow at the individual level. While social-structure and interdependence are likely to drive information flow, it is, however, which is relatively more important in determining information flow. Seibert et al. (2001) highlight the importance of understanding the antecedents to information flow. They note, "To date, the role of the proposed explanatory processes – access to information, bargaining control, and referral – have not been empirically examined." (p. 21) While there is much empirical evidence in the literature that supports the association between

social-structural position and performance, the mechanisms by which individual performance increases is not clear.

In addition, to exploring the antecedents of information flow, this paper explores the direct effect of information flow on individual performance. In contrast, to theories of social networks, interdependence and knowledge management, I reintroduce the curvilinear relationship between information flow and individual performance found in information processing theory – individual performance is likely to increase as information flow increases up to a threshold after which performance is likely to decrease.

In sum, this paper constructs a direct and behavioral examination to the information flow. In doing so, it seeks to not only increase our understanding of information flow but also inform the theories that are built upon it. Formally, my research questions are: 1) What are the antecedents to information flow at the individual level within organizations? And, 2) How does information flow affect an individual's performance?

Information in Organizations

Information Flow

Communication is the most obvious form of information flow in organizations. Information flow entails received and sent information. Norms of reciprocity predict that individuals who receive information are likely to either directly or indirectly respond to the communication (Schein 1992 1997). Because of this, receiving and sending information are likely to be highly correlated. Moreover, prior studies have also assumed that the social structure and interdependence predict both receiving and sending behaviors. For example, those individuals more central in social networks are more likely to receive and send information

because they have a greater number of contacts. However, despite strong correlations, the antecedents of information flow are likely to affect receiving and sending differently. Indeed, the while social structure may increase both receiving and sending flow, the magnitude may be different. Precisely understanding this difference for social structural theories and theories of interdependence is an additional contribution of this paper.

Antecedents of Information Flow
Social-Structural Antecedents

Network Centrality

Informal social networks have been shown to play an important role in facilitating intra-firm information flow (Brass and Burkhardt 1990, Cross and Cummings 2004, Hansen et al. 2005, Tsai 2001). Individuals more central in social networks are exposed to more information (Rowley, Behrens and Krackhardt 2000) which is likely to translate into information advantages for these individuals (Brass 1984, Cross and Cummings 2004). Said differently, a person's centrality in a social network determines their "potential *communication activity*" (Freeman 1979, p. 221; emphasis in the original). Specifically, individuals more central in a network are likely to have more communication pass through them and are more likely to control information flow than individuals on the periphery of a network (Cohn and Marriott 1958, Freeman 1979, Simmel 1955). The volume of information flow is the primary benefit of centrality and brokerage as Knoke and Burt (1983) point out, "sociological and economic concepts such as access and control over resources [most notably information], and brokerage of information … naturally yield a definition of centrality since the difference between the source and the receiver is less important than *just participating in many interactions*." (p. 174, emphasis added). The

more central an individual is the more interactions they are likely to have and the more information they are likely to receive. This information can then be leveraged for personal gain.

Because individuals more central in a network have a shorter distance to reach others in the network, they are more likely to use fewer intermediaries, take less time sharing information, and expend less effort to reach their targets, reducing the cost of receiving and sending information (Freeman 1979) and increasing the volume of information flow to the individuals. Thus:

> *Hypothesis 1a: Individuals more central in intra-firm networks are more likely to* ***receive*** *more information.*
> *Hypothesis 1b: Individuals more central in intra-firm networks are more likely to* ***send*** *more information.*

Brokerage

Brokers mediating the non-redundant ties between others within a network obtain information advantages from their position. According to Burt (1997), "the manager who creates a bridge between otherwise disconnected contacts has a say in whose interests are served by the bridge. … As the broker between otherwise disconnected contacts, a manager is an entrepreneur in the literal sense of the word — a person who adds value by brokering the connection between others." (p. 342) These entrepreneurs of structural holes gain access to unique information sooner than their more constrained counterparts (Burt 1997), possess the ability to control the flow of information (Reagans, Zuckerman and McEvily 2004) and may even obtain advantages by connecting others, rather than preserving the structural hole surrounding them (Obstfeld 2005). In any case, leveraging the information advantages provided by the brokerage position leads to many individual performance advantages, such as accelerated career advancement,

higher salaries, larger bonuses, and an increased likelihood of involvement in innovation (Burt 1992, 1997, 2004; Obstfeld 2005).

The information advantages provided to brokers are limited to the extent that information flow can bypass the brokers (Burt 1992) and to the extent that brokers do not utilize their position. While brokers may benefit by receiving information sooner than others and by controlling the flow of information, the value of their structural position is dependent on leveraging the flow of information around them. Two disconnect parties may be connected through a broker who can manipulate their association with each by maintaining the separation between the parties or by joining them together; but in either case the value a broker obtains stems from an increased flow of information to and from the broker (Burt 1992, Obstfeld 2005, Simmel 1955). Hence:

> *Hypothesis 2a: Brokers of unconstrained structural holes are more likely to receive information.*
> *Hypothesis 2b: Brokers of unconstrained structural holes are more likely to send information.*

Interdependence

Like social network theory, the theory of interdependence relies on an axiom of increased information flow. Simply stated, as interdependence increases, information sharing (to resolve the interdependence) within the organization must also increase (Thompson 1967, Gittell 2001). Scholars have identified two primary forms of interdependence between individuals both of which are likely to drive information flow to individual within organizations: task and outcome (Pennings 1973; Van de Ven et al. 1976; Wageman 1995).

Task Interdependence

Much of the work that is accomplished in today's organizations involves high levels of task interdependence. According to a recent report from the Bureau of Economic Analysis services now comprises nearly seventy percent of the United States' gross domestic product (Source: BEA "Growth Domestic Product by Industry: 2003-2005", December 11, 2006). Providing services, in general, introduces more task interdependence. As the level of task interdependence increases within a group, the importance of coordinating this interdependence via reciprocal interaction (Bartlett and Ghoshal 1993, Van de Ven et al. 1976) also increases (Thompson 1967).

Reciprocal interactions dramatically increase the flow of information. Wageman (1995) highlights this fact. She notes, "Studies of task interdependence have demonstrated that higher levels of task interdependence result in more communication, helping and information sharing than do individualistic tasks." (p. 149) Though much of the pioneering work on reciprocal interdependence demonstrated that information flowed primarily through face-to-face interaction such as formal and ad hoc group meetings (Pennings 1973, Van de ven et al. 1976), technologies such as email have become a substitute for much of this interaction. Increased task interdependence increases the need for more coordination activities. Hence:

Hypothesis 3a: Individuals engaged in more interdependent tasks will receive more information.
Hypothesis 3b: Individuals engaged in more interdependent tasks will send more information.

Outcome Interdependence

Studies linking individual autonomy with group interdependence posit that when individuals' rewards are based on their own outcomes, they are more likely to take actions to maximize personal gains. However, when incentives are tied to group performance and goals,

individuals are more willing to coordinate their efforts with others in the group, improving the group processes and outcomes (Miller and Hamblin 1963; Rosenbaum, Moore, Cotton, Cook, Hieser, Shovar and Gray 1980; Shea and Guzzo 1989; Wageman 1995). Group rewards lead to more cooperative behavior (Locke and Latham 1990) and encourage effective group processes (Wageman 1995). As Wageman and Baker (1997) state, "The chief benefit of interdependent rewards is that they provide incentives for cooperation." (p. 142) Coordination and cooperative behaviors likely include an increased flow of information between members of the group. Hence:

> *Hypothesis 4a: Individuals offered group incentives will receive more*
> *information.*
> *Hypothesis 4b: Individuals offered group incentives will send more information.*

Consequences of Information Flow

Prior studies of structural position have demonstrated that individuals who are brokers and more central are likely to obtain many information benefits that will likely translate into increased performance (See Brass 2002 - Unpublished manuscript, for a review). Brokers of unconstrained structural holes are likely to have higher individual performance as they glean the benefits of occupying a *tertius* role (Burt 1992, 1997; Rodan and Galunic 2005). Burt (1992) claims, "The *tertius* monitors information about activities in the firm more effectively than bureaucratic control can. … The *tertius* knows the parameters of organization problems early. The *tertius,* easily shifting network time and energy from one solution to another, is highly mobile relative to the bureaucracy. … The *tertius* is low cost relative to the bureaucracy that would otherwise monitor personnel." (p. 116) Burt also examines the performance outcomes of early promotion and higher salary and shows that brokers do gain these performance benefits more abundantly than their less well-positioned peers (Burt 1997).

Centrality is also likely to increase individual performance. For instance, Brass (1984, 1985) found that individuals more central in their departments are more likely to be promoted in the next three years. Centrality is likely to increase information flow both of information related to their specific job and "beyond what is expected as per job descriptions." (Sparrowe, Liden, Wayne and Kraimer 2001, p. 322). The increase in information flow reduces an individual's dependency on others and provides more resources to exchange with others, both of which are likely to increase individual performance (Sparrowe et al. 2001).

Similarly, interdependent individuals able to coordinate their interdependence effectively also are likely to achieve higher performance outcomes (Gittell 2001). While in most prior studies the effects have been studied at the group level not the individual level, the results are clear: At high levels of interdependence groups perform better than low levels of interdependence (Johnson and Johnson 1989, Wageman 1995).

However, while the interdependence, centrality and brokerage are likely to increase the flow of information to individuals, they are likely to be limited in their ability to utilize this information due to direct costs associated with processing information (March and Simon 1958). As the level of information flow increases to individuals, their costs of processing information are likely to increase. At some point the costs of processing information are likely to overcome the benefits of information flow at which point, additional information flow will become a liability to individual performance (Galbraith 1973, March and Simon 1958, O'Reilly 1980, Tushman and Nadler 1978, Wageman and Baker 1997). Thus, while brokerage, centrality and interdependence are likely to increase information flow, at high levels of flow, the processing costs of additional information are likely to exceed the incremental benefits. Hence:

H5: As information flow increases, individual performance will first increase and then decrease.

Methods

Data and Sample

With the input of senior management, I invoked a systematic sampling design in a large financial institution based on three criteria. The individuals in each group must: 1) perform roughly the same task; 2) rely on information from others to accomplish their job; and 3) have access to multiple communication modes including e-mail. The final study population included 152 employees in two business units.

I collected a record of each e-mail sent or received by all 152 employees over a 9-month period (November 2005 to July 2006). About 1.8 million e-mails were sent and received over this period. For each e-mail, I collected data regarding the date, time, and file size of each e-mail.

I collected data on an individual's antecedents of information sharing by means of a survey. I used standard egocentric network survey design to measure the respondent's task, advice, information, and friendship ties (Burt 1992, Obstfeld 2005). In the name generator portion of the survey, I asked the respondent to indicate those individuals whom they interact with to get work done, whom they rely on as a key source of information, whom they interact with most for informal social activities, and whom they turn to for advice and mentoring. For each question, I provided up to seven blank lines to list contacts. The mean number of individuals recalled was 11.48 individuals (standard deviation = 5.4; minimum = 2; maximum = 20). I combined responses from these questions into a single network. I record a tie between ego and alter if either of these relationships were present (Obstfeld 2005). I measure the strength of

the ties between ego and alter following prior network research by asking respondents how strong a relationship they have to the individuals they previously identified: strong, somewhat strong, somewhat weak, or I prefer to avoid this person (Burt 1992, Granovetter 1973, Obstfeld 2005). This question was followed with a question that assessed the degree to which alters are connected to each other: strong, somewhat strong, somewhat weak, weak, or not acquainted (Burt 1992). See Figure I for a rendering of the network.

Figure 1: Rendering of the Network Structure
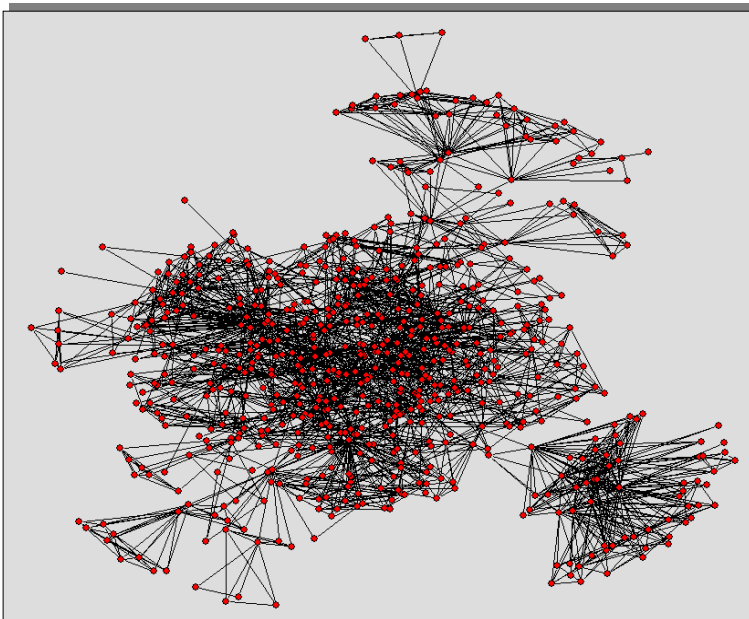
The survey also measured the respondents' perceived level of task and outcome interdependence, task characteristics, and their demographic information, along with several control measures. Of the 152 potential participants, 86 completed the survey – a 56% response rate.

Second, to get an independent source of performance, I surveyed each individual's manager and asked him or her to evaluate the employees that report directly to them. Supervisory

evaluations of performance are a common method for evaluating performance (Bretz, Milkovich and Read 1992) and a satisfactory indicator of performance (Arvey and Murphy 1998).

Measures
Dependent Variables

Receiving and Sending Information

I assessed receiving and sending information by taking an aggregate count of the total number of e-mails each individual received and sent each day for 9 months. On average, each individual received 7,065 e-mails, or 785 per month, and sent 5,564 e-mails, or 618 per month.[1] (See table 1 for descriptive statistics.)

Performance

Because the annual employee evaluations conducted within the firm have little variance, they were unlikely to be a reliable predictor of individual performance. Thus, in order to construct a better measure of performance, I surveyed each individual's direct manager and asked him or her to evaluate the employee's inrole, extrarole and information performance. I used three survey items to determine task performance: adequately completes assigned duties on time, meets formal performance requirements of the job, and performs tasks that are expected of him/her ($\acute{\alpha} = .796$) (Williams and Anderson 1991). Extra-role performance was created from four items: takes time to listen to co-workers' problems and worries, takes a personal interest in other employees, helps others who have been absent, and helps others who have heavy work loads ($\acute{\alpha} = .978$). (Williams and Anderson 1991). Four items were used to measure information performance: effectively searches for information from a variety of sources, passes along

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[1] I analyzed the number of e-mails received based on unit-level differences. I found that the unit that provides internal support to other organizational functions was significantly different (F =.007 and F = .017) than the unit that serves external clients (F = .182). I therefore include a unit-level control variable to account for any differences due to an individual's location within a specific unit.

information to co-workers, communicates effectively within the group, and communicates effectively with those outside of this business unit (ά = .985). After multiple reminders to complete the manager's survey, I received 64 usable surveys – a 42% response rate.

Independent Variables

Degree Centrality

Using UCINET (Borgatti, Everett and Freeman 1999), I determined the degree centrality for each individual in the study. Degree centrality determines centrality by counting the number of edges incident on a given node. Borgatti and Everett (2006) identify this measure as effective in measuring radial volume. In other words, degree centrality is effective in examining the volume rather than the reach of nodes and "summarizes a node's connectedness with the rest of the network." (p. 13). This measure of centrality examines only proximate or "immediate" effects and immediate risk . In this case, degree centrality examines the likelihood that information will flow to and from an individual by estimating the effect of direct contact on the information flow to and from the individual.

Brokerage Effect Size

I constructed the brokerage score for each individual in the network using UCINET (Borgatti et al. 1999). This measure identifies brokers who bridge non-redundant structural holes. Specifically, it is constructed by taking the number of non-redundant ties over the total number of ties (Burt 1992). I standardized the score by dividing the number by the average brokerage number (Burt 1992, 1997). Brokerage effect size measures the extent to which individuals are uniquely connected to diverse groups.

Task Interdependence

I used three statements to measure the perceived level of task interdependence. All items were reverse-coded: In my job, I have the freedom to pretty much do what I want; I have control over the pace of my work; I have the opportunity for independent thought and action (Griffin et al. 1980, Becerra and Gupta 2003). The scale ranged from 1, strongly disagree, to 5, strongly agree. These items have a $\alpha = .55$.

Outcome Interdependence

I asked employees to indicate what percent of their annual bonus was based on their group performance (Wageman 1995). The results ranged from 0 to 100% with an average of 49 and standard deviation of 27.4.

Control Variables

Team Solidarity: Perceptions of team solidarity may invoke a willingness to share information (Gouldner 1960). This item measures the perceived level of solidarity within the work team using three survey items. These items have an $\alpha = .74$.

Uncertainty: The perceived level of uncertainty may increase an individual's need to obtain and process more information. This item measures an individual's level of perceived uncertainty by asking four questions (Van de Ven et al. 1976). These items have an $\alpha = .60$.

Support for Innovation: This item measures the extent to which individuals perceived the firm as supportive of innovation and creativity by asking three questions (Scott and Bruce 1994, Morrison and Phelps 1999). These items have an $\alpha = .81$.

Coordination Modes: I controlled for differences in coordination modes using measures that assess impersonal coordination activities, such as plans, policies, and procedures; and

personal coordination activities, such as meetings, informal communication, and coordination through leaders (Pennings 1973; Van de Ven et al. 1976).

Rank: Based on company records, I coded the rank of each employee. They fell into one of five categories: Executive / SVP (6 individuals), SVP or VP (39 individuals), VP or AVP (70 individuals), AVP or officer (14 individuals), or other (23 individuals).

Education: I asked individuals to indicate the highest level of education they had finished: high school or equivalent, some college, bachelor's degree, master's degree or equivalent, or more than a master's degree. Individuals with a bachelor's degree represented the largest category.

Age: In the survey, I asked employees what year they were born in and then calculated their age. Age ranged from 24 to 65 years old, with a mean of 43.5 years old.

Tenure: In the survey, I asked employees to indicate how long they had been employed at the firm. Tenure ranged from 0 to 39 years with an average of 11.7 years and a standard deviation of 8.58 years.

Analysis

In my analytic approach, I faced a number challenges. First, because network data are relational in nature, they violate assumptions of independent observation (Cross and Sproull 2004). I overcome this by utilizing different networks to measure my dependent and independent variables. Specifically, I utilize the e-mail communications to ascertain information flow and each individual's ego-centric network gleaned from the survey to build their centrality and brokerage measures as well as their perceived measures of task and outcome interdependence.

Second, I received 86 usable survey responses. Using missing-value regressions, I imputed the values of the survey based on constructs for 5 individuals (Allison 2002). The un-imputed regression results were consistent with the imputed values but with slightly less significance.

Third, as the hypotheses and theories predict, there was a high correlation between receiving and sending information at the individual level. I tested for endogenity using the Hausman (1978) test. This test indicated that the results would indeed be biased (F = 22.97; p. = .000). Because of this, using standard Ordinary Least Squares (OLS) regression approach would yield biased results. As a solution, I utilized a Seemingly Unrelated Regression (SUR) (Zellner 1962) model to test Hypotheses 1-4. The SUR model runs both equations for receiving and sending information simultaneously while building an error covariance matrix from both equations rather than a random error term.

Finally, I tested the performance effects of information flow (Hypotheses 5) using OLS regression with robust standard errors. I ran three separate models. In the first, I collapsed information flow into a single measure to explore the overall effect of flow on performance. In the second I ran a separate regression model to test the performance effects of receiving information. In the third model, I tested the independent effects of sending behaviors.

Results

The SUR regression results in Table V summarize the tests of the hypotheses regarding the antecedents to information flow. I found full support for Hypothesis 1a and 1b. An

individual's centrality increases his or her likelihood of both receiving and sending information (p < .01). Each 10% increase in centrality will increase the number of e-mails received each month by nearly 62 messages and the number of e-mails sent nearly 60 messages. More central individuals in the thick of things do send more messages than their more peripheral counterparts.

Hypothesis 2a was also fully supported; brokerage increased receiving behaviors (p < .01). However, Hypothesis 2b was not supported; brokerage did not significantly affect information sending behaviors. Brokers do receive more information but do not necessarily send more information than non-brokers. This implies that brokers are acting as information filters and not as simple connectors. Their structural position allows them to receive more information but it does not necessarily require them to pass this information along.

Hypothesis 3a and 3b predicted that as task interdependence increased information flow would also increase. Both were also not supported; perceived task interdependence does not appear to drive information flow. The fact that increased interdependence does not significantly increase information flow has been found in recent research on interdependence. For instance, Hoegl and Weinkauf (2005) found that high levels of information flow were only important in the initial stage of interdependent projects, in the later stages of projects information flows decreased without detrimental effects to project performance. Even more surprising, Srikanth (2007) found that highly interdependent software development teams were able to coordinate activities with minimal communication from the very beginning of complex projects. The findings in this study further suggest our need to rethink the assumption that the flow of information must increase as the level of interdependency increases.

Hypothesis 4a and 4b predicted that outcomes interdependence would increase information flow. Both were supported in model 2, but when centrality was added to the regression in model 3 neither was significant. In model 4 outcome interdependence predicted receiving information but not sending information.

Hypothesis 5 predicted a curvilinear effect between information flow and performance – performance would first increase and then decrease as information processing costs overwhelmed the information benefits. These regression results testing this hypothesis are summarized in Table VII. This hypothesis was not statistically supported. However, and more interestingly, rather than supporting a curvilinear effect, increased information flow had an immediate negative impact on performance albeit in a linear fashion.

In order to more fully understand this negative effect of information flow on performance, I ran a separate set of regression models (reported in Table VIII) which parsed the performance effects for receiving and sending information. The findings which support a notion of information processing costs, indicate that receiving information significantly decreases performance while sending information is less detrimental. While the regression results were not significant for the effect of sending information on performance, sending flows suggests that sending also decreases performance (See Figure 3).

In the performance models, I controlled for the perceived level of information flow. Like Seibert et al. (2001), I found that, in contrast to the level of actual information flow, an individual's perceived level of information flow is positively associated with their performance. I ran another set of regressions to more fully understand how perceived information flow positively impacts performance. To do so, I separated performance into in-role, extra-role and

information sharing performance. I find that behavioral based measure of information flow to individuals decreases their in-role and information performance; however, those who perceive that they have more flow have increased extra-role performance. Thus, it appears that it is not the actual level of information flow but the perception of information flow that drives extra-role performance, while the actual information flow not the perception of flow drives in-role and information performance.

Discussion

The primary goal of this study was to identify the antecedents and performance consequences of information flow at the individual level in organizations. Using two theoretical approaches, I tested a number of mechanisms predicted to drive information flow. The results reveal a number of interesting findings. First, I find the burden of information flow almost immediately dwarfs any performance benefits of receiving and sending information (See Figure 2). This implies that structural position does indeed provide information advantages such as increase information flow, but individuals should be chiefly concerned with preserving their attention and information processing capabilities (March and Simon 1958; Ocasio 1997). Social-structural positions must be carefully managed to garner more divergent information and explicitly limit the volume of information (Burt 1997); doing so may create a network position that bestows the control, access, and timing benefits to the individual while not overwhelming them with volumes of information.

This result also suggests that individuals have an information processing constraint that should be considered in tandem with network constraint and information transfer constraints.

This constraint modifies the preexisting theoretical relationship between social-structural position and performance from linear relationship where more is better to a curvilinear relationship where performance increases for a time and then decreases. More information is only beneficial if individuals have the time to sift through the information their ties provide them. Brokering abundant and unconstrained structural holes and residing at the hub of a large network only provide information advantages insofar as the individual can process the information gleaned from their location. Additional information, beyond an individual's information threshold does not provide an advantage and may be a liability. In fact, prior studies of information overload suggest that once past the processing threshold, any additional information can cause systemic breakdowns and not merely create additional costs and inconveniences (O'Reilly 1980, Rudolph and Repenning 2002). Said differently, the costs of information flow appear to quickly overwhelm the benefits of additional information.

Knowledge management scholars have identified and focused on constraints to the flow of information or transfer constraints (Szulanski 1996). The fundamental challenge of knowledge management is transferring what is effective in one part of the organization to other parts of the organization so that they may also benefit from the knowledge. In general, scholars have found that the properties of the knowledge (tacit and explicit) and properties of the senders (absorptive capacity), in a large part, determine the degree to which information will flow (e.g. Cohen and Levinthal 1990; Nonaka and Takeuchi 1995; Szulanski 1996, 2000). This paper suggests that information processing constraints may provide an additional and substantive obstacle in building an effective knowledge capability within the organization. Removing the constraints to information flow may have the unintended negative consequence of overwhelming the

information processing capabilities of individuals and ultimately shifting the problem from constraints in the flow of information to constraints in the processing of information. Recipients of information must have the capacity to process and utilize the information they receive.

Second, an individual's position in the informal social structure of the organization is the most significant factor in determining the flow of information he or she receives. This finding reinforces the importance of understanding how the informal structure within organizations creates competitive advantage. If information flow is a form of inimitable competitive advantage (Barney 1996, Dyer and Hatch 2006), then unpacking the antecedents to the flows of information is a critical task for managers; otherwise they are no better off than those peripheral to the firm, and intraorganizational information benefits may created more by accident than by design (Argote and Ingram 2000). Moreover, because this study identifies the primacy of social structure in shaping information flow, it reinforces the importance of informal networks as organizing principles. Informal networks may be fundamental in shaping intra-firm as well as inter-firm governance (Allatta 2005, Barley and Kunda 2006). Leaders wishing to create an information capability need to understand the informal social structure of their organization and how these structures impact the flow of information.

Third, this paper highlights the importance of differentiating between perceived information flow and actual information flow. Individuals who perceive that they receive large volumes of information were rated by their managers as having higher extra-role performance. These results are similar to prior work of Siebert, Kraimer and Liden (2001) who – using a perceptual measure of performance and information flow – found that an individual's information flow increased their performance. Similarly, the work of Kilduff & Krackhardt

(1994) found that being perceived as having a powerful friend related to reputation for good performance, while actually having a powerful friend was not related. Individuals perceive that "more information is better" and managers appear to agree. However, this attitude may actually increase the problem of information constraint. If those in the organization that perceive to receive a lot of information attribute their performance to increased information, then others may seek out more information, overloading their information processing capabilities and decreasing their performance. This highlights the importance of the behavioral based measures of information flow and the independent evaluations of performance included in this study.

This paper explores two theoretical questions in the existing theories of interdependence. First, it examines if it is necessary to have high communication flow to resolve interdependencies. Second, it explores performance at the individual level allow us to understand the individual effects of coordination activities. It could be that while each project would benefit from high levels of information flow, the performance of individuals engaged in multiple projects will deteriorate as they are overwhelmed.

Finally, the results of this study highlight that information flow can be broken down into receiving and sending flows and that these flows of information should be considered as orthogonal dimensions and studied as distinct constructs. Doing so introduces the following four possible conditions for individuals in organizations: low receiving and low sending; low receiving and high sending; high receiving and low sending; and high receiving and high sending (See Figure 2). Individuals who have little overall information flow (receive and send a low amount of information) can be considered "Spartans" who were known for their laconic tendencies. On the other hand, individuals who receive and send a lot of information are

"brokers" connecting others through a high volume of information flow. In the off diagonals, "spammers" receive little but send a lot, and "filters" receive a lot but send little. Mapping the data from the current study onto these dimensions with median splits of receiving and sending, yields the following chart (See Figure 5). Future research could unpack each dimension to help us understand why individuals fall into each category and, more importantly, generate an understanding of the performance consequences of different patterns in information flow.

Of course this study has a few limitations that should be made explicit. First, it is clear that the current study emphasizes the "Spartan" and "Broker" positions – where flows of receiving and sending are nearly equally matched for each individual. Future work could unpack the "off diagonals" and determine the antecedents of spamming and filtering behaviors.

Second, like most studies of networks (and all single event studies) it is difficult to infer causality. Although a significant contribution of this study has been utilizing two distinct networks in the analysis, this approach has not solved the causality conundrum. It is difficult to determine if those who send and receive more information become brokers or if brokers tend to send and receive more information. Future work could seek to disentangle the causality of receiving and sending information and social-structural position by measuring the networks and communication patterns over time.

Furthermore, the generalizability of the results is limited because the study covers only one organization. This study also focused on an organization where standardized work and routine tasks predominant. Future work may examine the antecedents and consequences of information flow in more ambiguous contexts.

One of the strengths of this research also creates an additional limitation. Because I focus on individual outcomes, this study ignores any effects that information flow may have on group performance. Future work might examine group-level effects of information flow and compare these to the individual effects reported here.

While formal hypotheses regarding the direct effects of centrality and brokerage on performance were not developed in this paper, I find that centrality does increase performance, but the same effect for brokerage is not statistically significant. This finding further highlights the need for careful investigation of the causal mechanisms between social-structural position and performance. A recent meta-analysis of social capital and individual performance, found that social capital as defined by the number of contacts and the extent to which individuals engage in networking activities was not related to career satisfaction or promotion but did predict an individual's salary (Ng, Eby, Sorensen and Feldman 2005). Additional mechanisms that may influence the control, access and timing advantages of social structural position should be investigated in future research.

In summary, increased information flow is driven by social-structural position and by outcome interdependence; however, each affects receiving and sending information differently. More important, I find an almost immediate negative relationship between information flow and performance. The cost of receiving information quickly overcomes the benefits of increased inflow, and the cost of sending information immediately overcomes the benefits of outflow. Individuals seeking to build information resources through network ties must consider the costs of information load in addition to network constraint. Similarly, organizational leaders must understand that in an information intensive age, one of their primary objectives should be to

understand and encourage information filtering as well as information flow. In the words of Herbert Simon written 60 years ago, "The most important change is not the growth of these [IT] devices but the growth of a science that helps us to understand how information can be transmitted, how it can be organized for storage and retrieval, how it can be used (and how it is used) in thinking, in problem-solving, in decision-making." (Simon 1947, p. 227) Understanding information resources, was then, and continues to be an important challenge for managers and scholars.

Study 3

Pushing the Limits of Information:

Understanding the Performance Consequences of Over-coordination and Variation in the Flow and Source of Information

Introduction

In 1850, four percent of the jobs in the United States were centered on the task of processing information (Shenk 1997). Today, according to a Bureau of Economic Analysis report in 2005 nearly 70% of jobs are focused on handling information. In fact, not only are more individuals engaged in information processing tasks, but the volume of information has increased dramatically. Summarizing the findings of a recent survey of over 1,200 employees in the U. K., Lewis (1996) noted, "Professional and personal survival in modern society clearly depends on our ability to take on board vast amounts of new information. Yet, that information is growing at an exponential rate" (Lewis 1996).

This deluge of information has created "a climate of infoglut" (Edmunds and Morris 2000 and "data smog" (Shenk 1997). This torrent of information threatens to overwhelm individuals and lead to "analysis paralysis" (Stanley and Clipsham 1997), "information fatigue syndrome" (Oppenheim 1997) and "information overload" (O' Reilly 1980). Edmonds and Morris in a recent review of information overload research note, "It is apparent that an abundance of information, instead of better enabling a person to do their job, threatens to engulf and diminish his or her control over the situation" (Edmunds and Morris 2000 p. 18).

The origins of information overload were first investigated by Georg Simmel. He noted that in large cities individuals are overloaded with information and in response tune out their environment leading to jaded and calcified behaviors (Simmel 1950). A few years later, March and Simon (1957) developed the concept of bounded rationality. This theory claims that individuals are cognitively overloaded and make decisions based on satisficing rather than the maximizing outcomes in the decision process (March and Simon 1957). Information processing theory further introduced the concept of information underload and overload (O'Reilly 1980). This theory (O'Reilly 1980) demonstrated a curvilinear effect between the flow of information and performance; information flow increases individual performance up to a point after which all additional information is likely to be disregarded as individuals become overwhelmed and disengage (Meier 1963). The effects of this are that individuals are likely to ignore and mishandle information (Sparrow 1999), experience increased stress (Jones and Thomas 1997; Malhotra, 1982; Schick et. al., 1990), make suboptimal decisions (Bawden, 2001; Schroder et. al., 1967), and to be overconfident in their decisions (Meyer 1998; Jacoby 1984; O'Reilly 1980).

Information overload is increasingly problematic because advances in information technology allow information to be created and distributed at very low costs while the costs of processing the information remain relatively high. This sets up a situation where significant burdens are likely to be placed on individual information processing capacity (Losee 1998).

While it is clear that information overload is widely felt, the implications of information overload for theory and practice are underdeveloped. Understanding the flow and the pace of information is just as critical to modern information intensive organizations as understanding the flow of goods through a factory floor were to organizations focused on the production of

physical goods. Examining information flow to individuals within organizations has the potential to refine our theories of coordination and knowledge management. Concomitantly, there are very few empirical studies of information overload particularly in the organizational sciences (See Eppler and Mengis 2004 for a recent review). Of the few studies that have been completed many are based on perceptual rather than behavioral measures of information flow (e.g. O'Reilly 1980).

This paper specifically seeks to enrich the existing theories of information flow, interdependence and individual performance by answering the following questions. 1) How do coordination efforts affect individual performance in information intensive organizations? 2) How does variance in the flow of information affect individual performance? And 3) How does an information source affect individual performance?

Information Flow and Individual Performance

In knowledge intensive, service focused, companies, communication is an integral part of the core work that occurs (Blackler 1995, Starbuck 1992, 1993, Alvesson 1993). Email communication makes up a substantial portion of an individual's communication routine. Generating, receiving and responding to these communications can consume a significant portion of typically person's work day. As shown in Figure 2 below, in this study, individuals reported that email was the most common form of communication within the group and the second most common form of communication with others outside their group. On average individuals in the sample sent 28 emails a day and received 36 emails a day–a total of 64 emails every day.

Figure 2: Source of Information
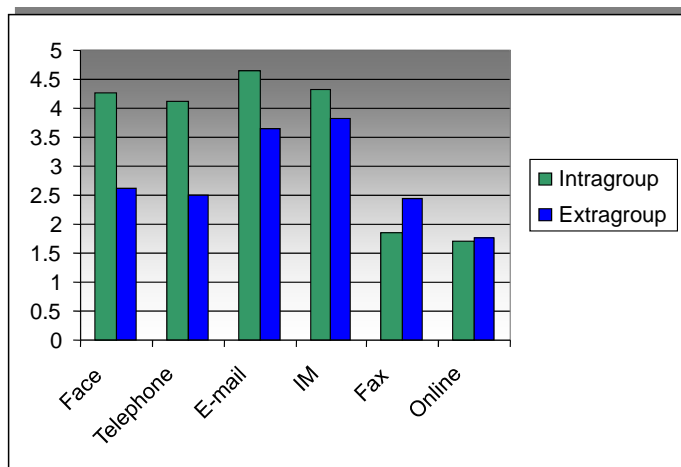
Over-coordination and Performance (The Use of Carbon Copy)

Most of the literature on interdependence and coordination has focused on coordination failures due to insufficient coordination routines and mechanisms (Thompson 1967). In general, it is assumed that, at high levels of interdependence, intensive coordination efforts are needed and that the more coordination that occurs the better the performance of individuals and units. However, it may be equally plausible, if not studied, that individuals invest too many resources and too much effort coordinating interdependencies. Rather than a linear effect between coordination and performance, coordination may improve performance up to a point after which more coordination actually decreases performance.

The work of Van De Ven, Delbecq and Koenig (1976) and Pennings (1974) identified three primary processes individuals resolve interdependences. These include: impersonal coordination through rules and routines, personal coordination via vertical and horizontal communication channels and group coordination via planned and ad hoc meetings (Van de ven,

et. al. 1976). Their findings indicate that as the level of interdependence (and uncertainty) increases individuals shift from reliance on impersonal modes to group modes of coordination. They note that "organizational sociologists … and social psychologists … suggest there are potential benefits (e.g., efficiency, corrective feedback, speedy conflict resolution and quality in task performance) and costs (e.g., information omission, distortion, overload and low motivation) in the use of any specific coordination mechanism." (Van de ven, et. al. 1976, p. 324). Despite the mention of information overload associated with coordination efforts, no follow up work examined this effect.

An over-coordination effect may be increasingly more common given the ease of communication. It is virtually costless to carbon copy an email message to others "to keep people in the loop." However, this behavior may have the unintended consequence of expending unnecessary resources over-coordinating interdependences even when the level of interdependence is very high. There may be instances where the benefits of coordination are not worth the associated information processing costs.

With the use of email communication, an unlimited number of individuals can be involved in personal or group coordination efforts. However, the low cost of including others is likely to reduce the effectiveness of individuals who receive these messages. Over use of carbon copied email messages over-coordinates interdependence and is likely to increase the information processing load of individuals without resolving interdependencies and subsequently decrease the recipient's performance.

Moreover, information contained on carbon copied email communication is costly as each individual copied on emails sent to multiple people must scan the email to determine what

elements of the message are relevant and what is irrelevant. In contrast to carbon copy email messages, email sent directly to a single recipient is customized for the recipient and is likely to contain more useful and have less irrelevant information. This customization likely increases the ration between useful and worthless information. Hence:

> H1: Individuals who receive more carbon copy email messages are likely to have poorer performance.

Variation in Source: Isolation and Structural Approaches

Information flow is central to theories of organizational structure and interdependence. They more precisely identify organizational structure as a mechanism whereby firms insulate their core and critical operations while building external facing units to process environmental cues (Thompson 1967). However with the specialization of tasks, organizations face the challenge of coordinating the interdependence between units and individuals. These structural arguments assume homogeneity of information processing needs within units and heterogeneity across units. Specialized units coordinated through formal (Galbraith 1974) or informal (Thompson 1967) efforts isolating information processing requirements within units while integrating across them. Theories of formal and informal structures assume that units will be successful if they have sufficient slack resources to handle peak information processing loads.

A key objective of organizational structure is to reduce the information processing requirements of individuals by controlling the amount and type of information they receive and process. Early studies of information processing focused primarily on the relationship between the organization (or the individual) and the environment. Daft and Lengel (1986) and Daft and Weick (1984) posited that effective organizations which faced increased environmental

uncertainty would correspondingly increase their efforts to glean information from the environment. Under this contingent view of organizational information processing, the peaks and valleys of information flow required information processing efforts that matched the demand (Daft and Lengel 1986). Successful performance was a function of identifying the level of uncertainty in the environment and then marshalling the required resources to process enough information to make sense of the uncertainty.

Foundational arguments in organizational theory are built around the concept of creating a structural design leveraging the organizational structure to insulate the "technical core" of the organization from external shocks (Thompson 1967). This approach isolated information from most individuals by building structural separation from the external environment. Only a limited few were subjected to the environmental pressures and were subsequently required to bare the processing burden. As Thompson (1967) noted:

> It would therefore be advantageous for an organization subject to criteria of rationality to remove as much uncertainty as possible from its *technical* core by reducing the number of variables operating on it. Hence if both resource-acquisition and output-disposal problems—which are in part controlled by environmental elements and hence to a degree uncertain or problematic—can be removed the technical core, the logic can be brought closer to closure, and the rationality, increased. … we suggest that organizations cope with uncertainty by creating certain parts specifically to deal with it, specializing other parts in operating under conditions of certainty or near certainty (Thompson 1967 p. 12-13).

Insulating the core activities of the organization reduced the need to process information and allows units to focus on their core tasks. Galbraith (1974) and Tushman and Nadler (1978) articulated this argument as they sought to solve the problem of information processing constraint by modifying the organizational structure of the firm such that the information requirements were carefully matched to the information capabilities in specific and segmented

units thereby reducing task interdependences and the associated information burden through formal organizational design.

The central idea cutting across structural approaches to solving interdependence is that exposure to the environment increases information processing requirements to make sense of changes in the environment. Thus, for individuals like units, external information is likely to be more difficult to process and require a greater investment of resources.

H2: Individuals that obtain more information from external sources are likely to have poorer performance.

Variation in Load: Amount and Size

Following Schick, Gordon and Haka (1990) I define information load as the amount of information that an individual is required to process (seek, screen, comprehend, combine, evaluate, interpret, and use) in a given time period (Schick, Gordon and Haka 1990, Schroder et. al. 1967); and define information overload as the condition where information processing demands on an individual's time to perform interactions and internal calculations exceed the supply or capacity of time available for such processing (Schick, Gordon and Haka 1990).

If time is needed to process information, then individuals with sufficient resources to process information at their peak rate of information flow will perform better than those who are quickly overwhelmed. However, it is unlikely that individuals will have the necessary slack to handle times of peak information flow. Therefore, individuals that receive a relatively constant flow of information are more likely to have the necessary resources to handle the load and experience fewer periods of overload.

Fluctuations in the load of information are likely to have detrimental performance effects because as individuals become overloaded they become completely ineffective; rather than

having a slightly negative effect on performance, overload causes systematic failure. For instance, Meier's (1964) study of library operators found that once they were overloaded "the resultant performance of the institution begins to deviate more and more from the ideal as load increases." (Meier 1964, p. 541) Studies of incremental and trivial task disruptions report a similar finding: once individuals become overloaded their performance deteriorates dramatically facing a consistent flow of information are likely to be able to process information effectively (Rudolph and Repenning 2002).

Because overload and underload are both costly, individuals who experience more fluctuation in the amount of email they receive will process information less efficiently. Thus, ceterus parabis:

H3: Individuals that experience greater variation in the size of email they receive are more likely to have poorer performance.

Variation in Source: Cognitive Scheme and Language

Routine and stable information flow is likely to require relatively less cognitive energy to process than information that is unusual or different. Cohen and Levinthal (1990) demonstrated that a firm's information processing capability termed "absorptive capacity" can increase a firm's ability to understand and utilize information from external sources. They note, "At the most elementary level, this prior knowledge includes basic skills or even a shared language. … [It] confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends." (Cohen and Levinthal 1990 p. 128). Individuals, like firms, can develop information processing capabilities. Familiarity with others increases an individual's ability to quickly assimilate information from them. Individuals who obtain information from stable and

routine sources are likely to develop "shared skills and language" allowing them to process information more quickly.

Moreover, linguists have extensively examined the information processing requirements of unique or novel information. Universally, they have found that information which does not fit into existing schema (Rumelhart 1975), scripts (Schank and Abelson 1977), frames (Minsky 1975), or categories (Lackoff 1987) requires additional effort and even may require the adaptation of existing or the creation of new linguistic frameworks. Hence:

> H4: Individuals that obtain information from more varied sources are more likely to have poorer performance.

Variation in Quality: Spam

Individuals frequently receive junk email. Despite many organizations best efforts to block "junk mail" and "spam" with network firewalls and advanced email filters often these messages get through. Spamming is the "abuse of electronic messaging systems to send unsolicited bulk messages, which are universally undesired." (Wikipedia.com). These messages are unlikely to provide value to the organization and are likely to distract individuals from their tasks – if only for a brief moment. Those who receive large amounts of junk mail have significantly higher information processing costs with no added coordination advantages or unique information advantages. In addition, spam takes up the information processing capacity of individuals. Thus:

> H5: Individuals who receive more spam are likely to have poorer performance.

Methods

Sample and Data Collection

I invoked a systematic sampling design in a large financial institution that leveraged data on 152 people from three data sources. First, I collected a record of each e-mail sent or received by all 152 employees over a 9-month period (November 2005 to July 2006). About 1.8 million e-mails were sent and received over this period. For each e-mail, I collected data regarding the date, time, and file size of each e-mail. I coded each email source based on the following characteristics: internal mail generated by an individual (83%), internal mail generated by an office or organization (e.g. customer support office) (1%), external mail (e.g. mail from customers) (12%) and spam (4%). I also coded each message as a message sent to a single individual or sent to multiple recipients. 17.9% percent of the email messages were sent to multiple recipients.

In addition to the email data, I collected performance data by surveying each individual's manager. I asked him or her to evaluate the employees that report directly to them. Supervisory evaluations of performance are a common method for evaluating performance (Bretz, Milkovich and Read 1992) and a satisfactory indicator of performance (Arvey and Murphy 1998).

Third, I collected data on an individual's perceived level of task and outcome interdependence, task characteristics, and demographic information. Of the 152 potential participants, 86 completed the survey – a 56% response rate.

Finally, I also measured each individual's egocentric networks by asking for their task, advice, information, and friendship ties (Burt 1992, Obstfeld 2005). For each question, I provided seven blank lines to list contacts. The mean number of individuals recalled was 11.48 individuals (standard deviation = 5.4; minimum = 2; maximum = 20). I combined responses from these questions into a single network. I record a tie between ego and alter if either of these

relationships were present (Obstfeld 2005). The name generator questions was followed with a question that assessed the degree to which alters are connected to each other: strong, somewhat strong, somewhat weak, weak, or not acquainted (Burt 1992).

Measures

Dependent Variables

Performance

To measure performance, I surveyed each individual's direct manager and asked him or her to evaluate the employee's inrole, extrarole and information performance. I used three survey items to determine task performance: adequately completes assigned duties on time, meets formal performance requirements of the job, and performs tasks that are expected of him/her (ά = .796) (Williams and Anderson 1991). Extra-role performance was created from four items: takes time to listen to co-workers' problems and worries, takes a personal interest in other employees, helps others who have been absent, and helps others who have heavy work loads (ά = .978) (Williams and Anderson 1991). Four items were used to measure information performance: effectively searches for information from a variety of sources, passes along information to co-workers, communicates effectively within the group, and communicates effectively with those outside of this business unit (ά = .985). After multiple reminders to complete the manager's survey (Dillman 1991), I received 64 surveys – a 42% response rate.

Independent Variables

Over Coordination: Carbon Copied Mail

For each email message I am able to determine if the message was sent to multiple or single recipients. I constructed a measure of the amount of carbon copied mail received. I

counted how many individuals were included on each message. For example, a message that included 2 people would receive a score of 2 while a message that was sent to 10 people would receive a score of 10. I then constructed a measure of the magnitude of carbon copied messages by adding the total score for each individual.

External vs. Internal Mail

As noted above I coded each source of email along four dimensions: internal mail generated by an individual, internal mail generated by an office or organization (e.g. customer support office), external mail (e.g. mail from customers) and spam. To construct this measure, I collapsed the internal mail into one category and the external mail into another category. On average 83.9% of email is internal and 16.05% is external. I then constructed the ratio of external to internal mail.

Variation in the Number of Email

I measured the number of email by taking a count of each email received each day, week, and month. I then constructed the average number of email received along with a standard deviation for the entire group for each time period. I then took the ratio between the each individual's standard deviation and the group standard deviation. Daily, weekly and monthly measures were constructed to determine if the results are sensitive to differences in the time period evaluated.

Variation in the Size of Email

Similar to the measure above, I constructed an average size and standard deviation received for the entire group for each day, week and month. I then determined the average and

standard deviation for each individual. Finally, I calculated the ratio between the individual's value and the group average standard deviation.

Variation in the Number of Sources

I examine how many unique sources emailed each respondent. Individuals may receive email from a few people or from many people. This measure ranged from 5986 to 20 with an average of 2197 unique sources.

Superfluous Information: Spam

Spam was coded as a 1 or 0 depending on the source of the email. Because of the tight email controls in the organization, many junk email were filtered at the organizational level. However, about 12.3% of the email received were junk mail. The vast majority of the junk email received were permission based junk mail such as email from hotels, restaurants, credit card offers and online retailers. While most of the email was permission based, meaning the recipient allowed or requested the mail, the nature of the mail is unrelated to the goals of the organization and likely distract employees from their tasks.

Control Variables

Task Interdependence

Task interdependence can affect how much information is received. Individuals who are more interdependent are likely to share more information to resolve the interdependence. To control for variation in the level of interdependence, I measured each individual's perceived level of interdependence by asking three questions. All items were reverse-coded: In my job, I have the freedom to pretty much do what I want; I have control over the pace of my work; I have the

opportunity for independent thought and action (Griffin et al. 1980, Becerra and Gupta 2003).

The scale ranged from 1, strongly disagree, to 5, strongly agree. These items have a ά = .55.

Outcome Interdependence

Outcome interdependence can also affect the level of email communication. To account

for this, I asked employees to indicate what percent of their annual bonus was based on their

group performance (Wageman 1995). The results ranged from 0 to 100% with an average of 49

and standard deviation of 27.4.

Coordination Modes

I controlled for differences in coordination modes using measures that assess impersonal

coordination activities, such as plans, policies, and procedures; and personal coordination

activities, such as meetings, informal communication, and coordination through leaders

(Pennings 1973; Van de Ven et al. 1976).

Uncertainty

The perceived level of uncertainty may increase an individual's need to obtain and

process more information. This item measures an individual's level of perceived uncertainty by

asking four questions (Van de Ven et al. 1976). These items have an ά = .60.

Team Solidarity

Perceptions of team solidarity may invoke a willingness to share information (Gouldner

1960). This item measures the perceived level of solidarity within the work team using three

survey items. These items have an ά = .74.

Social Network Position

An individual's position in the informal network of the organization affects how much information they receive. To control for this, I constructed the brokerage score for each individual in the network using UCINET (Borgatti et al. 1999). This measure identifies brokers who bridge non-redundant structural holes. Specifically, it is constructed by taking the number of non-redundant ties over the total number of ties (Burt 1992). I standardized the score by dividing the number by the average brokerage number (Burt 1992, 1997). Brokerage effect size measures the extent to which individuals are uniquely connected to diverse groups.

Rank, Age and Tenure

Based on company records, I coded the rank of each employee. They fell into one of five categories: Executive / SVP (6 individuals), SVP or VP (39 individuals), VP or AVP (70 individuals), AVP or officer (14 individuals), or other (23 individuals). In the survey, I asked employees what year they were born in and then calculated their age. Age ranged from 24 to 65 years old, with a mean of 43.5 years old. Finally, in the survey, I asked employees to indicate how long they had been employed at the firm. Tenure ranged from 0 to 39 years with an average of 11.7 years and a standard deviation of 8.58 years.

Volume of Information

In order to isolate the effect of variation in the flow of information it is important to control for the relative volume of information each individual receives. I include a count of the number of emails each individual sent over the nine months of the study.

Analysis

Table 10 presents the descriptive statistics and correlations of the variables. Because significant correlations were found in the data, I investigated for the potential of multicollinearity

using variance inflation factors (VIF). VIF scores were computed using the following formula where Rj is the multiple correlation coefficient.

$$VIF_j = \frac{1}{1 - R_j^2}$$

The maximum VIF obtained in any of the models was 6.88 – well below the suggested cutoff score of 10 proposed by Ryan (1997) and Neter, Wasserman, and Kunter, (1990) where collinearity might become problematic. To further ensure the results were not significantly impacted by multicollinearity, I ran several regression models excluding variables with marginally high VIF scores. The results were consistent with the results presented here. It is clear that multicollinearity was not a significant issue for the results.

As noted in study 1, I employed a Kolmogorov-Smirnov (K-S)   test to assess whether the sample of respondents was biased. The results showed that the respondents were not significantly different from non-respondents on any of the archival measures. I also tested for heteroscedasticity of the dependent variable using the Shapiro-Francia normality test. Again no significant problem was indentified with the data, however to control for the potential of possible outliers in the data I employed Ordinary Least Squares (OLS) regression with robust standard errors. Robust standard errors employs Huber-White standard error estimates standard errors that are adjusted for correlations of error terms across observations.

Results

Table XI presents the regression results showing the effects of information flow on individual performance. Model I tests the effects of the control variables on performance. The results indicate that individuals with higher outcome interdependence have higher performance;

however, task interdependence was not a significant predictor of performance. Interestingly, impersonal and personal coordination processes and the perceived level of uncertainty were not significant predictors of individual performance.

The regression result presented in Model II tests hypotheses 1-5. Hypothesis 1 stated that individuals who receive more carbon copied email are likely to have poorer performance. This hypothesis was fully supported at the .001 level. This provides evidence of the negative effects of over-coordination for individuals. Individuals who receive more carbon copied messages have poorer performance. Standardized coefficients indicate that over-coordination had the largest negative effect on performance of any of the constructs under study. The effect is just larger than the effect of variation in the size and number of email and over twice as large as receiving spam and external information.

Hypothesis 2 predicted that individuals who receive more external information relative to internal information would have higher information processing costs and subsequently poorer performance. The regression results indicate that the reverse is true; receiving more external information increases individual performance. Rather than being negative, the coefficient was positive and marginally significant at the .1 level. External information provides value above and beyond the increased processing costs.

Hypothesis 3 predicted that the variation in an individual's information flow negatively impacts their performance. An individual's variation the flow of email they receive decreased their performance (p < .01). Hypothesis 4 predicted that variation in the number of unique information sources would have a negative impact on an individual's performance. This hypothesis was not supported; more varied sources of information did not have a statistically

significant impact an individual's performance. Hypothesis 5 predicted that individuals who received more spam would have poorer performance. This hypothesis received moderate support ($p < .1$). Flows of irrelevant information disrupt an individual and decrease their performance.

As a robustness check, I ran three additional models (Models III-V) which decompose performance into task, extra role and information performance. These regression results indicate that over-coordination has a universal negative effect on performance – it negatively affects task, extra-role and information sharing performance. External information, in contrast, significantly impact task performance, but the effect decreases for information performance and becomes non-significant for extra-role performance. External information predominantly increases task or in-role performance. Variation in the flow of information remained significant for task performance but the negative effect becomes marginally significant for information and extra-role performance. Like over-coordination, variation in the flow of information mostly impacted in-role performance. In a like fashion, receiving junk information only significantly negatively impacts task performance and has no effect on extra-role and information performance.

Discussion

Indentifying a threshold after which additional coordination is detrimental modifies our preexisting theory of interdependence in important ways (Thompson 1967). The level of coordination needed to resolve interdependence has been viewed as a dyadic construct: two individuals or business units needing to share information by pooling, sequencing or reciprocating information flow (Thompson 1967). The findings in this paper indicate that coordination should be examined as an individual level construct in addition to the dyadic level construct. Doing so introduces the idea of an individual coordination capacity. This capacity

allows us to view coordination not dyadic state between two units (Thompson 1967) or as a process enacted to resolve interdependence (Van de ven et. al. 1976), but, rather, as the sum of multiple dyadic interactions each requiring individual coordination efforts. Indentifying the proper amount of coordination is likely to be specific to individual's capacity and their involvement in multiple coordination arenas. Organizations with high interdependence across multiple areas will require careful and strategic integrate actions and avoid mass coordination efforts. If not carefully managed, coordination at the individual level can overwhelm individuals, decreasing their performance.

Introducing the concept of an individual coordination capacity further shifts the focus from diagnosing the type of dyadic interdependence present (Thompson 1967) or the processes by which interdependence is resolved (Van de ven, et. al., 1976) to a focus on the volume of coordination. With this focus, the problem then shifts from a focus on coordination failures (Thompson 1967), to the concept of over-coordination. In fact, this study finds some of the first evidence of over-coordination; too much coordination hinders individual performance.

The concept of an individual coordination capacity is also important in that it directly predicts individual performance, while coordination processes, the perceived level of task interdependence and the perceived level of uncertainty had no effect on individual performance in this study (Thompson 1967, Van de ven, et. al. 1976).

Over coordination is exacerbated by an imbalance in the costs of sending and receiving email messages. It is virtually costless to send information via an email to multiple recipients (Van Zandt 2001); however, the cost of receiving and utilizing the message remains constant despite the number of recipients. This imbalance in the costs of sending and receiving

information can quickly lead to over-coordination. Others desiring to "keep others in the loop" will engage in coordinate efforts that are not necessary and even detrimental.

These findings in this study also refine our theories of information processing and knowledge management in important ways. First, information processing theory is a relatively static theory that predicts a certain point beyond which individual's are overloaded with information (O'Reilly 1980). However, the results in this study indicate that the important comparison is not the individual's processing capacity over the absolute volume of information flow but their ability to respond to fluctuations and variation in the flow of information. Rather than making investments to handle heavy volumes of information, individuals need the capacity to quickly adapt to variation in the flow of information. In other words, fluctuation in the flow of information appears to be as disruptive as high volumes of information. Information processing theory needs to account for dynamic variation as well as information overload or underload.

A more dynamic view of information processing theory has direct implications for theories of organizational structure and knowledge management. The dynamic nature of information flow makes it very difficult to match organizational structure with information processing requirements (Galbraith 1974). Individuals can use different strategies to manage large volumes of information or too little information but these strategies are ineffective when there is frequent fluctuation in the volume of information. This implies that structural approaches aimed at matching the level of information processing capacity to the level of processing need may be ineffective.

Rather than focusing on matching organizational structure to the level of information processing (Daft and Lengel 1986), these finding suggest, individuals should invest in strategies

which are focused on handling variation to the flow of information. Leaders can either increase individual's ability to adapt quickly to fluctuations in information volume or insulate them from fluctuations in information. Thompson (1967) discussed insulating the core of organization from the external environment in order to reduce coordination requirements. This effort of insulating the core may have the unintended benefit of standardizing the flow of information for individuals in these units. Thus, insulating structures may acts as an information control mechanism rather than an efficiency mechanism. This introduces a new logic for organizational structure – one that focuses on moderating fluctuations in the flow of information not on matching capacity coordination to the level of interdependence.

A dynamic view of information processing has implications for knowledge management as well. Knowledge management has historically focused on controlling content and ensuring knowledge transfer (Szulanski 1996; Nonaka and Takeuchi 1995). The findings presented here imply that leaders should also focus on managing variation in the flows of information. Rather than focusing on transfer problems, leaders should consider the preservation of attention and information processing capacity along with the desire to share knowledge (March and Simon 1958, Szulanski 2000). Information relevance and usefulness are critically important.

Also, while prior research has demonstrated that weak ties and brokerage opportunities increase individual performance (Granovetter 1973; Burt 1997), this study disaggregates the effect of external information from the position in the information social structure. The results demonstrate that access to external information does increase performance despite likely increased information processing costs. However, external information is not uniformly important; the quality of the information received plays a critical role in determining if the

information will increase or decrease performance. SPAM is detrimental to individual performance. This form of information distracts individuals indicating that efforts to preserve attention are critical (Simon 1947). Formal structure can insulate core functions (Thompson 1967) but organizations need to create new ways to insulate individuals and preserve their attention from aggressive rather than passive information invasion.

Of course, this study has a few limitations. Foremost, this work does not directly examine the psychological mechanism whereby variation in information flow negatively impacts individual performance. The negative effect could be due to two things: First, information flow is a disruption that requires a psychological refractory period as individuals switch between tasks (Welford 1952). This would imply that more information is worse regardless of the flow or pace of the information. In other words the detrimental effect of variation in information is due to the constant shifting of cognitive processes. Second, the negative effect could be due to the fact that variation causes stress and increases uncertainty because individuals are not able to plan their work load (Edmonds and Morris 2000). This is effect is more directly related to the flow of information. A recent study conducted in the U.K. found that, in general, too much information increases tension, stress, erodes personal relationships, decreases decision making ability, and increases the costs of collating information (Waddington 1996). However, it is unclear if these psychological effects directly impact individual performance. Future research could investigate what psychological mechanism decreases individual performance.

Future research could also explore the causal nature of variation in information flow. It may be that individuals receive more constant information flows, are involved in fewer instances

of over-coordination, and receive less superfluous information because they are better performers. A longitudinal approach to this problem would allow causality to be established.

In conclusion, the purpose of this study was to examine how different properties of information flow affect individual performance. I examine how coordination activities, variance in the amount of information, and the type of information source affect individual performance. The results highlight the importance of information pacing activities to control both the content and the flow of information. Firms need to reduce fluctuation in the flow of information, insulate individuals from superfluous information flows and prevent over-coordination.

General Conclusion

The findings in the dissertation demonstrate that analyzing information access and flow at the individual level is an important exercise. Study 1 demonstrated that an individual's performance is affected by the manner in which they source information. Individuals with an ambidextrous capability who are able to source information from both personal and impersonal repositories have higher performance.

Study 2 demonstrated that more information is not necessarily better - despite the predictions of knowledge management theories and social network theories. The findings suggest that while social structure does indeed drive information flow this flow may be detrimental to performance. It is also not the mechanism whereby the social structural positions of brokerage and centrality increase performance. This study adds to our theoretical understanding of the relationship between social structure and individual performance, suggesting that alternative mechanisms beyond information flow are likely driving the performance effects of central players and brokers of structural holes and that information constraint, as well as, structural constraint may limit the benefits of structural position. Moreover, the findings suggest that knowledge management theories, while focusing on search and transfer problems, have ignored the critical and fundamental problem of information overload.

Finally, Study 3 examined variation in the flow of information. Variation in the flow and sources of information impacts individual performance. More stable and more diverse flows improve individual performance while irrelevant information and over-coordination efforts decrease it. This study suggests that assessing coordination at the individual level, in addition to

the type of interdependence and coordination modes or processes provides an important view of an individual's coordination capability.

The findings in these three studies suggest that information is an important resource which has substantial effects on individual performance. Individuals who possess the capabilities to effectively access and utilize information have higher performance than their peers. Most importantly, this research demonstrates that the mechanism of information flow has dramatic explanatory power for theories of social networks, interdependence, knowledge management, and information processing. Understanding information flow builds a greater understanding and refinement of these important theories.

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Tables

Table 3: Study 1 Descriptive Statistics and Correlations

	Variable	N	Mean	Std De	Min	Max	1	2	3	4	5	6	7
1	Performance	152	3.53	0.39	1.84	4.46	1						
2	Number Email†	152	0.00	1	-1.38	4.06	-0.22*	1					
3	BU- Web Visits†	137	0.00	1	-1.51	4.62	-0.035	0.115	1				
4	BU Duration†	137	0.00	1	-0.99	4.35	-0.024	-0.05	0.521*	1			
5	BU Page Views†	137	0.00	1	-0.90	7.34	-0.25*	0.023	0.548*	0.774*	1		
6	Internet Visits†	141	0.00	1	-1.60	2.33	-0.25*	0.23*	0.617*	0.513*	0.541*	1	
7	Group Face	152	0.00	1	-3.27	0.93	0.33*	-0.09	-0.32*	-0.250*	-0.350*	-0.505*	1
8	Group Telephone	152	4.20	0.96	1	5	-0.18*	0.18*	0.150	0.055	-0.027	0.204*	-0.067
9	Group Email	152	4.67	0.65	1	5.13	-0.005	0.24*	0.075	-0.093	-0.133	0.213*	-0.117
10	Face-to-Face	152	2.69	1.25	1	5	-0.18*	0.26*	0.167	0.073	0.134	0.275*	0.045
11	Telephone	152	2.50	0.56	1	3	0.075	0.039	0.011	-0.047	-0.012	0.003	0.051
12	Email	152	3.65	0.52	1	4	0.223*	0.138	0.036	0.091	0.110	0.115	-0.056
13	Tenure	131	11.73	8.58	0	39	-0.02	-0.01	-0.022	-0.017	-0.018	-0.099	0.009
14	Impersonal	152	3.43	0.61	1	5	0.168*	-0.04	-0.029	0.025	-0.017	-0.047	0.175*
15	Personal	152	2.58	0.57	1	4	0.028	-0.08	-0.009	0.092	0.099	0.041	0.041
16	Interdependence	152	3.47	0.56	1.667	5	0.017	0.072	0.049	-0.073	-0.027	0.087	0.081
17	Age	152	43.10	8.33	24	65	0.094	-0.11	-0.098	-0.116	-0.187*	-0.345*	0.114
18	Uncertainty	152	2.49	0.73	1	5	0.069	-0.12	0.037	0.213*	0.192*	0.171*	0.059
19	Face * BU Visits	137	-0.32	0.89	-4.84	2.81	0.250*	0.022	0.075	0.020	-0.062	-0.132	0.45*

		8	9	10	11	12	13	14	15	16	17	18	19
8	Group Telephone	1											
9	Group Email	0.57*	1										
10	Face	0.30*	0.126	1									
11	Telephone	0.17*	0.071	0.15	1								
12	Email	0.04	0.141	0.03	0.70*	1							
13	Tenure	0.07	-0.046	-0.13	0.18*	0.08	1						
14	Impersonal	-0.15	-0.26*	-0.13	0.035	0.09	-0.013	1					
15	Personal	-0.06	-0.122	-0.2*	-0.12	0.06	0.001	0.22*	1				
16	Interdependence	0.04	0.054	0.22*	-0.03	-0.09	-0.23*	0.047	-0.13	1			
17	Age	0.03	-0.111	-0.1*	0.024	-0.13	0.60*	0.022	-0.026	-0.215*	1		
18	Uncertainty	0.03	-0.091	-0.06	-0.11	-0.00	0.1086	0.122	0.295*	0.0424	-0.278*	1	
19	Face * BU Visits	-0.04	-0.052	0.18*	-0.10	-0.11	-0.134	0.052	-0.140	0.0027	0.0025	-0.1107	1

(* Denotes significance at .05 level. † Variables have been standardized.)

Table 3: OLS Regression Estimates Search Routines on Performance

	(1) Controls	(2) Full Model	(3) Interaction
Controls			
Tenure	-0.006	-0.002	-0.001
	(0.92)	(0.34)	(0.25)
Age	0.009	0.002	0.002
	(1.29)	(0.32)	(0.36)
Standardization	0.091	0.041	0.035
	(1.35)	(0.54)	(0.47)
Meetings	-0.002	0.001	0.023
	(0.03)	(0.01)	(0.32)
Autonomy	0.049	0.059	0.068
	(0.65)	(0.88)	(1.03)
Uncertainty	0.046	0.046	0.051
	(0.79)	(0.73)	(0.78)
Impersonal Information			
BU-Web Visits		0.106***	0.085**
		(3.19)	(2.20)
BU Duration		0.146***	0.139***
		(3.63)	(3.53)
BU Page Views		-0.221***	-0.217***
		(6.09)	(6.00)
Internet Visits		-0.080*	-0.071*
		(1.97)	(1.76)
Personal Information			
Number of E-mail Sent		-0.066*	-0.069*
		(1.64)	(1.80)
Group Face-to-Face		0.082**	0.045*
		(2.45)	(1.16)
Group Telephone		-0.085	-0.089
		(1.53)	(1.54)
Group E-mail		0.092	0.100
		(1.19)	(1.27)
Other Face-to-Face		-0.016	-0.023
		(0.50)	(0.75)
Other Telephone		-0.107	-0.074
		(0.85)	(0.57)
Other E-mail		0.273**	0.265**
		(2.24)	(2.16)
Face * BU-Web Visits			0.075**
			(1.99)
Constant	2.647***	2.255***	2.130***
	(5.33)	(3.26)	(2.87)
Observations	131	128	128
R-squared	0.05	0.42	0.44

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

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Table 4: Study 2 Descriptive Statistics and Correlations

Number	Variable	Obs	Avg	Stddev	Min	Max	1	2	3	4	5	6	7	8
1	Age	86	43.10	8.34	24.00	65.00	1.00							
2	Tenure	131	11.73	8.59	0.00	39.00	.60*	1.00						
3	Education	86	2.67	0.79	1.00	5.00	-0.26*	-0.41*	1.00					
4	Uncertainty	86	2.49	0.74	1.00	5.00	-0.28*	0.11	-0.20*	1.00				
5	Team	86	4.07	0.52	2.00	5.00	0.38*	.33*	0.01	-0.02	1.00			
6	Group Norms	86	3.59	0.41	2.00	4.50	0.02	0.02	.29*	-0.16*	.38*	1.00		
7	Impersonal	86	3.43	0.61	1.00	5.00	0.02	-0.01	-0.16	0.12	0.15	0.10	1.00	
8	Personal	86	2.58	0.58	1.00	4.00	-0.03	0.00	-0.08	.30*	0.16	0.07	.23*	1.00
9	BU	137	206.42	136.46	0.00	838.00	-0.10	-0.02	.21*	0.04	-0.10	0.16	-0.03	-0.01
10	Unit	152	0.25	0.43	0.00	1.00	-0.18*	-0.04	.24*	-0.10	0.01	.24*	-0.12	-0.05
11	Task Inter.	86	3.57	0.56	2.00	5.00	-0.22*	-0.24*	.18*	0.04	0.05	-0.11	0.05	-0.13
12	Outcome Inter.	86	49.41	27.71	0.00	100.00	-0.10	0.07	-0.20*	0.13	-0.05	0.05	0.16	0.01
13	Centrality	102	22.25	16.63	1.00	79.00	0.19	.23*	-0.06	-0.12	.20*	0.18	0.10	-0.04
14	Brokerage	102	10.97	13.72	1.00	63.34	.20*	.24*	-0.07	-0.11	0.18	0.13	0.15	-0.07
15	All Flow	152	12630.15	7238.87	35.00	38201.00	-0.09	-0.01	0.14	-0.15	0.14	.23*	-0.06	-0.09
16	All Flow 2	152	212000000	253000000	1225	1460000000	-0.07	-0.02	0.14	-0.17*	0.12	.18*	-0.04	-0.08
17	Perceived Flow	86	4.66	0.85	1.00	5.00	-0.08	-0.04	0.03	-0.09	0.06	0.04	.-26*	-0.11
18	Received	152	7065.93	3622.61	28.00	18930.00	-0.04	0.00	0.06	-0.17*	0.09	.17*	-0.07	-0.09
19	Received 2	152	63000000	66600000	784	358000000	0.02	-0.06	0.00	-0.16	0.01	-0.02	0.01	-0.05
20	Sent	152	5564.22	4023.93	7.00	21906.00	-0.12	-0.02	.20*	-0.12	.17*	.27*	-0.04	-0.08
21	Sent 2	152	47000000	74900000	49	480000000	-0.03	-0.01	0.14	-0.10	0.06	0.06	0.00	-0.02
22	Performance	69	3.54	0.53	1.83	4.50	0.14	-0.01	-0.28	0.04	0.07	-0.17	0.17	-0.04
23	Inrole	69	4.19	0.54	2.00	5.00	0.16	-0.01	-0.13*	0.06	0.14	-0.01	.29*	0.03
24	Extrarole	69	3.95	0.66	2.25	5.00	0.04	-0.01	-0.39*	0.00	-0.09	-0.36*	-0.04	-0.07
25	Information	69	4.05	0.74	1.50	5.00	0.16	-0.01	-0.18	0.03	0.08	-0.11	0.14	-0.03

	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
9	1.00																
10	0.14	1.00															
11	0.05	0.12	1.00														
12	-0.10	-0.07	-0.07	1.00													
13	0.11	0.15	-0.15	0.02	1.00												
14	0.10	0.15	-0.16	0.07	.97*	1.00											
15	0.12	.30*	0.07	0.13	.49*	.50*	1.00										
16	0.11	.28*	0.05	0.11	.52*	.54*	.96*	1.00									
17	0.04	.23*	0.02	-0.03	-0.01	0.02	.27*	.22*	1.00								
18	0.10	.25*	0.06	0.15	.49*	0.50	.94*	.87*	.27*	1.00							
19	0.07	0.09	0.01	0.11	.39*	0.43	.50*	.66*	0.06	.55*	1.00						
20	0.12	0.32	0.07	0.09	.45*	.45*	.95*	.94*	.24*	.79*	.41*	1.00					
21	0.07	.19*	-0.02	0.01	.43*	.47*	.62*	.79*	0.09	.43*	.50*	.72*	1.00				
22	-0.09	-0.42*	-0.03	0.00	0.04	0.06	-0.13	-0.15	0.08	-0.12	-0.18	-0.13	-0.14	1.00			
23	0.16	-0.33*	-0.12	-0.06	0.09	0.10	-0.15	-0.16	-0.07	-0.18	-0.19	-0.12	-0.09	.79*	1.00		
24	-0.24	-0.32*	0.02	-0.03	-0.05	-0.01	-0.09	-0.11	.25*	-0.04	-0.06	-0.13	-0.16	.74*	.35*	1.00	
25	-0.10	-0.38*	-0.06	0.03	0.07	0.09	-0.12	-0.11	0.05	-0.13	-0.09	-0.10	-0.05	.90*	.69*	.50*	1.00

Table 5: Regression Results of Seeming Unrelated Regression of Information Received and Sent

Variable	Controls Model 1		Interdependence Model 2		Centrality Model 3		Brokerage Model 4	
	Received	Sent	Received	Sent	Received	Sent	Received	Sent
Age	-0.0149	-0.0285**	-0.0079	-0.0249*	-0.0070	-0.0186	-0.0064	-0.0203
	(-0.0144)	(-0.0136)	(-0.0141)	(0.001)	(-0.0137)	(-0.0147)	(-0.0146)	(-0.0158)
Tenure	0.0080	0.0132	0.0044	0.001	-0.0039	-0.0010	-0.0038	0.0011
	(-0.0137)	(-0.0129)	(-0.0134)	(0.0129)	(0.0129)	(0.0138)	(0.0136)	(0.0147)
Education	-0.1026	0.0080	0.0090	0.0803	-0.0007	0.0541	-0.1152	-0.0707
	(-0.1044)	(-0.0981)	(0.1057)	(0.1018)	(0.0975)	(0.1050)	(0.1093)	(0.1182)
Uncertainty	-0.2704	-0.1963	-0.2469*	-0.1780	-0.176*	-0.1756	-0.2040	-0.1412
	(-0.1410)	(-0.1326)	(0.1356)	(0.1306)	(0.1226)	(0.1320)	(0.1284)	(0.1388)
Team	0.0910	0.2777	0.1293	0.3312*	-0.0015	0.1896	0.2154	0.4734**
	(-0.2004)	(-0.1884)	(0.1997)	(0.1923)	(0.1789)	(0.1927)	(0.2032)	(0.2198)
Group Norm	0.2476	0.3028	0.0900	0.1805	0.0272	0.0631	0.0835	0.1188
	(-0.2429)	(-0.2283)	(0.2440)	(0.2349)	(0.2269)	(0.2443)	(0.2436)	(0.2634)
Impersonal	-0.0753	0.0220	-0.1312	-0.1037	-0.1105	-0.0243	-0.0410	0.0473**
	(-0.1381)	(-0.1298)	(0.1346)	(0.1296)	(0.1212)	(0.1305)	(0.1260)	(0.1362)
Personal	-0.0186	-0.1077	0.0100	-0.1037	0.0062	-0.0784	-0.0174	-0.1078
	(-0.1589)	(-0.1494)	(0.1556)	(0.1497)	(0.1362)	(0.1467)	(0.1449)	(0.1567)
BU	0.0002	0.0005	0.0004	0.0006	0.0018*	0.0021**	-0.0174**	0.0023**
	(-0.0007)	(-0.0007)	(0.0007)	(0.0007)	(0.0009)	(0.0010)	(0.0010)	(0.0011)
Unit	0.3861	0.4839**	0.4411**	0.5213***	0.2225	0.2633***	0.5989***	0.6207***
	(-0.2078)	(-0.1953)	(0.2000)	(0.1926)	(0.1977)	(0.2129)	(0.2085)	(0.2254)
Task Interdependence			0.0213	-0.0568	0.1691**	0.0756	0.0650	-0.0266
			(0.1545)	(0.1487)	(0.1334)	(0.1476)	(0.1500)	(0.1622)
Outcome Interdependence			0.0108***	0.0067**	0.0057	0.0034	0.0061**	0.0039
			(0.0032)	(0.0031)	(0.0027)	(0.0030)	(0.0031)	(0.0033)
Centrality					0.4672***	0.4256***		
					(0.0816)	(0.0903)		
Brokerage							0.1999**	0.0788
							(0.0927)	(0.1002)
Constant	0.4715	-0.6542			-0.7238	-1.0774	-0.8981	-1.4150
	(1.1521)	(1.0830)			(1.1000)	(1.2170)	(1.2570)	(1.3590)
Chi-Squared	15.2200	31.0800	27.83	37.08	87.3400	75.6300	46.7900	43.8200
R-Squared	0.1063	0.1954	0.1786	0.2246	0.4897	0.4539	0.3396	0.3250

Notes. *p<0.10, **p<0.05, ***p<.01. Standard Errors are in parentheses below coefficients.

Table 6: OLS Regression Results of Information Flow on Performance

	Model I	Model II	Model III
Education	-0.10	-0.09	-0.10
	(0.061)	(0.059)	(0.064)
Age	0.000	-0.004	-0.003
	(0.008)	(0.009)	(0.009)
Satisfaction	0.100	0.121*	0.122*
	(0.073)	(0.072)	(0.077)
Perceived Flow	0.093	0.125	0.120
	(0.076)	(0.064)	(0.070)
Task Interdependence	-0.064	-0.070	-0.074
	(0.116)	(0.115)	(0.111)
Outcome Interdependence	0.000	0.000	0.000
	(0.002)	(0.002)	(0.002)
Information Flow	-0.150	-0.191**	-0.167*
	(0.091)	(0.091)	(0.092)
Flow Squared	0.033	0.027	0.041
	(0.035)	(0.037)	(0.037)
Centrality		0.337*	
		(0.157)	
Brokerage			0.072
			(0.046)
Constant	3.23***	3.12***	3.22***
	(0.532)	(0.554)	(0.541)
R-squared	0.13	0.18	0.15
F	1.72	1.87	1.66
Prob of F	0.11	0.08	0.12
Number	66	66	66

Notes. *p<0.10, **p<0.05, ***p<.01. Standard Errors are in parentheses below coefficients.

Table 7: OLS Regressions Results Information Flow, Structural Position and Interdependence on Performance

Variable	Received			Sent	
	Centrality	Brokerage		Centrality	Brokerage
Education	-.0980*	-0.1051*	Education	-.1019	-0.1062
	(0.0588)	(0.0585)		(0.0515)	(0.0665)
Age	-0.0009	-0.0020	Age	-0.0013	-0.0015
	(0.0091)	(0.0088)		(0.0088)	(0.0091)
Satisfaction	0.0803	0.0951	Satisfaction	0.0864	0.0867
	(0.0648)	(0.0621)		(0.0612)	(0.0659)
Perceived Flow	0.1034**	0.1169	Perceived Flow	0.1251*	0.0987
	(0.0607)	(0.0702)		(0.0647)	(0.0660)
Task Interdependence		-0.0509	Task Interdependence		-0.0451
		(0.1109)			(0.1111)
Outcome Interdependence		0.0002	Outcome Interdependence		-0.0451
		(0.0018)			(0.1111)
Received	-0.1125*	-0.1341	Sent	-0.1778	-0.0832
	(0.0838)	(0.0901)		(0.0900)	(0.0895)
Centrality	0.2891**		Centrality	0.3516*	
	(0.1582)			(0.1687)	
Brokerage		0.0712	Brokerage		0.0586
		(0.0470)			(0.0475)
Constant	3.0793***	3.248***	Constant	2.793***	3.3177***
	(0.5140)	(0.5325)		(0.5189)	(0.5322)
F	2.0800	1.9700	F	2.3100	1.6100
R-Squared	0.1506	0.1469	R-Squared	0.1791	0.1271
N	64.0000	64.0000	N	64.0000	64.0000

Notes. *p<0.10, **p<0.05, ***p<.01. Standard Errors are in parentheses below coefficients.

Table 8: OLS Regressions Results Information Flow, Structural Position and Interdependence on Inrole, Extra-role and Information Performance

	Sent					
	Inrole	Extrarole	Info	Inrole	Extrarole	Info
Education	0.001	-0.208***	-0.070	0.035	-0.164**	-0.035
	(0.066)	(0.074)	(0.090)	(0.065)	(0.074)	(0.088)
Age	0.006	-0.002	0.010	0.006	-0.002	0.008
	(0.008)	(0.009)	(0.010)	(0.008)	(0.009)	(0.011)
Perceived Flow	0.012	0.231***	0.0960	-0.0110	0.205**	0.0720
	(0.076)	(0.085)	(0.103)	(0.076)	(0.087)	(0.102)
Sent	-0.140	-0.067	-0.166	-0.086	-0.006	-0.117
	(0.109)	(0.122)	(0.148)	(0.108)	(0.122)	(0.144)
Sent2	0.020	-0.014	0.036	-0.010	-0.051	0.000
	(0.043)	(0.048)	(0.059)	(0.004)	(0.049)	(0.058)
Centrality	0.063	0.009	0.056			
	(0.079)	(0.089)	(0.108)			
Brokerage				(0.008)	(0.008)	(0.013)
				(0.007)	(0.007)	(0.009)
Constant	3.889***	3.545***	3.343***	3.807***	3.475***	3.297***
	(0.539)	(0.605)	(0.734)	(0.546)	(0.621)	(0.733)
F	0.632	2.934	0.780	0.726	2.309	0.045
R-Squared	0.061	0.233	0.075	0.068	0.188	0.083
N	65	65	65	65	65	65

Notes. *p<0.10, **p<0.05, ***p<.01. Standard Errors are in parentheses below coefficients.

Table 10: Study 3 Descriptive Statistics and Correlations

| Variable	Obs	Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Performance	69	3.54	0.53	1.8	4.5																				
2 Task Performance	69	3.88	0.58	1.7	4.7	0.77																			
3 Information Performance	69	4.05	0.74	1.5	5	0.9	0.66																		
4 Extrarole Performance	69	3.95	0.66	2.2	5	0.74	0.27	0.5																	
5 Interdependence*	152	3.47	0.56	1.6	5	-0.03	-0.03	-0.06	0.02																
6 Group Bonus*	152	14.81	13.68	0	100	0.11	0.06	0.09	0.11	-0.01															
7 Team*	152	4.07	0.52	2.3	5.2	0.07	0.19	0.08	-0.09	0.05	0.23														
8 Uncertainty*	152	2.49	0.74	1	5	0.04	0.07	0.03	0	0.04	-0.14	-0.02													
9 Impersonal Coordination*	152	3.43	0.61	1	5	0.17	0.34	0.14	-0.04	0.05	0.02	0.15	0.12												
10 Personal Coordination*	152	3.59	0.41	2	4.5	-0.17	0.08	-0.11	-0.36	-0.11	0.2	0.38	-0.16	0.1											
11 Rank	131	4.76	0.79	3	7	0.15	0.04	0.06	0.24	-0.09	-0.23	-0.1	0.37	0.2	-0.42										
12 Age*	152	43.1	8.34	24	65	0.14	0.12	0.16	0.04	-0.22	0.19	0.38	-0.28	0.02	0.02	0.02									
13 Education*	152	2.53	0.97	0	5	-0.17	0.04	-0.13	-0.29	0.18	0.17	0.1	-0.22	-0.14	0.3	-0.39	-0.08								
14 Tenure	131	11.73	8.59	0	39	-0.01	0	-0.01	-0.01	-0.24	0.3	0.33	0.11	-0.01	0.02	0.03	0.6	-0.3							
15 Sent	152	5564.22	4023.93	7	21906	-0.13	-0.08	-0.1	-0.13	0.07	0.22	0.17	-0.12	-0.04	0.27	-0.52	-0.12	0.2	-0.02						
16 Unit	152	0.67	0.47	0	1	14	-0.02	0.05	0.29	-0.1	0.05	0.09	-0.04	0.02	-0.04	0.08	0.03	-0.27	0.11	0.09					
17 Vardailysize	152	0.81	0.43	0.008	2.09	-0.37	-0.03	-0.34	-0.26	0.12	0.18	0.09	-0.09	-0.06	0.27	-0.54	-0.21	0.22	-0.05	0.73	0.04				
18 external	152	0.15	0.18	0	0.95	18	0.24	0.17	0.05	-0.15	-0.15	0	0.02	0	-0.13	0.14	0.27	-0.13	0.24	-0.22	0.08	-0.25			
19 uniquesender	152	0.37	0.15	0.003	1	-0.16	-0.06	-0.17	-0.15	0.08	0.17	0.06	-0.06	-0.04	0.2	-0.39	-0.08	0.14	0.01	0.67	-0.04	0.7	-0.05		
20 cced	152	2585.36	2585.36	0	13929	-2	-0.12	-0.14	0.22	0.03	0.19	0.11	-0.06	-0.02	0.25	-0.44	-0.13	0.16	0.01	0.92	0.1	0.66	-0.27	0.61	
21 spam	152	0.14	0.1	0	0.56	0.07	0.07	0.05	0.06	-0.21	-0.17	0.02	0.04	0.05	-0.16	0.32	0.28	-0.23	0.29	-0.4	0.06	-0.43	67	-0.22	-0.43

Table 9: OLS Regress Results of Information Flow Properties on Performance

|	Model I Controls	Model II Performance	Model III Task Performance	Model IV Information Performance	Model V OCBO
interdependence	.0343 (.1009)	-.0002 (.0876)	-.0306 (.0897)	-.0328 (.1215)	.0625 (.1248)
groupbonus	.0058* (.0032)	.0058** (.0025)	.0034 (.0031)	.0081** (.0036)	.0060 (.0039)
team	.1223 (.1151)	.1294 (.1118)	.1805 (.1231)	.1973 (.1939)	.0104 (.1475)
uncertainty	-.0107 (.0749)	-.0343 (.0660)	.0331 (.0788)	-.0227 (.1088)	-.1133 (.0929)
impersonal coord	.0734 (.0892)	.0606 (.0807)	.2009*** (.0789)	.0711 (.1308)	-.0899 (.0948)
personal coord	-.1702 (.1573)	-.1556 (.1416)	.0667 (.1595)	-.1583 (.1694)	-.3752* (.2090)
rank	-.0010 (.1159)	-.0148 (.0926)	.0029 (.1027)	-.1038 (.1303)	.0564 (.1017)
age	.0017 (.0087)	-.0044 (.0076)	-.0101 (.0086)	.0002 (.0118)	-.0034 (.0109)
education	-.1318** (.0575)	-.1453*** (.0484)	-.0543 (.0474)	-.1569** (.0747)	-.2245*** (.0737)
tenure	-.0107 (.0089)	-.0126 (.0079)	-.0086 (.0079)	-.0197 (.0120)	-.0096 (.0115)
sent	-.0000 (.0000)	.00009*** (.0003)	.0000 (.0000)	.0001*** (.0000)	.0001** (.0000)
unit	.0575 (.1859)	.00864 (.1447)	-.0018 (.1608)	-.1195 (.2335)	.1473 (.2072)
variation daily size		-.8080*** (.3257)	-.7583*** (.2793)	-.8798* (.4654)	-.7860* (.5092)
unique sender		.7396 (.7908)	1.3192 (.8289)	-.3496 (1.361)	1.2492 (1.097)
external		.6639** (.3429)	1.1248*** (.4236)	.9629** (.4752)	-.0959 (.5092)
cc'ed		-.0001*** (.0000)	-.0001*** (.0000)	-.0001** (.0000)	-.0001*** (.0000)
spam		-1.4181* (.7585)	-1.8829** (.8736)	-1.502 (1.063)	-.8695 (1.0451)
_cons		4.3889*** (.9998)	2.9430*** (1.1654)	5.3693*** (1.441)	6.1043*** (1.1942)
N	62	62	62	62	62
R-squared	0.1912	0.4510	0.4275	0.3488	0.4689
Prob F	1.40	3.08	2.65	2.05	2.23

Notes. *p<0.10, **p<0.05, ***p<.01. Standard Errors are in parentheses below coefficients.

FIGURES

Figure 3 The Negative Effect of Information Flow on Performance
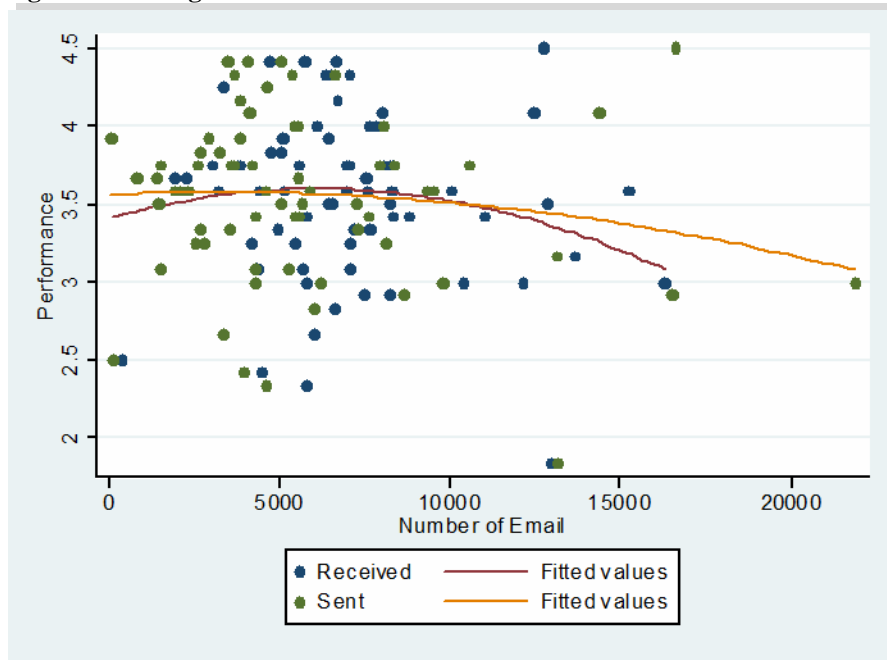
Figure 4: Descriptive Typology of Receiving and Sending
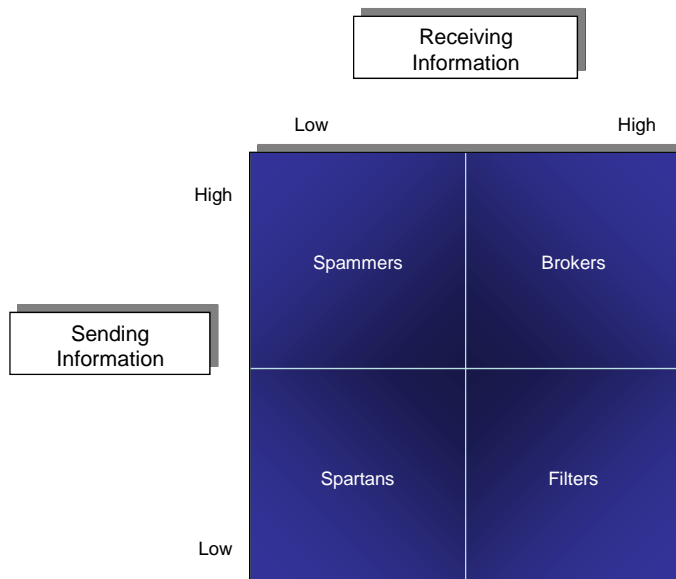
Figure 5: Received and Sent Information