A Relational View of Information Seeking and Learning in Social Networks

Stephen P. Borgatti • Rob Cross
Carroll School of Management, Boston College, Chestnut Hill, Massachusetts 02467
McIntire School of Commerce, University of Virginia, Charlottesville, Virginia 22904
borgatts@bc.edu • robcross@virginia.edu

Research in organizational learning has demonstrated processes and occasionally performance implications of acquisition of declarative (know-what) and procedural (know-how) knowledge. However, considerably less attention has been paid to learned characteristics of relationships that affect the decision to seek information from other people. Based on a review of the social network, information processing, and organizational learning literatures, along with the results of a previous qualitative study, we propose a formal model of information seeking in which the probability of seeking information from another person is a function of (1) knowing what that person knows; (2) valuing what that person knows; (3) being able to gain timely access to that person's thinking; and (4) perceiving that seeking information from that person would not be too costly. We also hypothesize that the knowing, access, and cost variables mediate the relationship between physical proximity and information seeking. The model is tested using two separate research sites to provide replication. The results indicate strong support for the model and the mediation hypothesis (with the exception of the cost variable). Implications are drawn for the study of both transactive memory and organizational learning, as well as for management practice.
(*Information; Social Networks; Organizational Learning; Transactive Knowledge*)

"So the call came in late on Thursday afternoon and right away I wished I hadn't answered the phone. We had received a last-second opportunity to bid on a sizable piece of work that the partner on the other end of the line really wanted to pursue. I had no clue how to even begin looking for relevant methodologies or case examples, so my first move was to tap into my network to find some relevant info and leads to other people or databases. And I relied pretty heavily on this group over the next couple of days. Seth was great for pointing me to other people and relevant information, Paul provided ideas on the technical content of the project while Jeff really helped in showing me how to frame the client's issues in ways that we could sell. He also helped navigate and get buy-in from the client given his knowledge of their operations and politics . . . I mean the whole game is just being the person that can get the client what they need with [the firm's] resources behind you. This almost always seems to mean knowing who knows what and figuring out a way to bring them to bear on your client's issue."—(Anonymous Interviewee)[1]

Introduction

A significant and growing body of literature addressing the topic of organizational learning has evolved over the past 30 years. Foundational work focused on learning as either a cognitive process (e.g., Argyris and Schon 1978, Daft and Weick 1984) or a function of behavioral change occurring through modification of an organization's programs, goals, deci-

[1] Vignette from Cross et al. (2001b, p. 100).

0025-1909/03/4904/0432$05.00
1526-5501 electronic ISSN

sion rules, or routines (e.g., Cyert and March 1963, Nelson and Winter 1982). More recently, scholars have developed midrange theories of how organizational learning occurs and/or impacts organizational performance.[2] However, to date the bulk of this research has focused on declarative (know-what) or procedural (know-how) knowledge with little inquiry into organizational learning as a function of relationships (know-who). This is surprising given the importance of social relationships for acquiring information (e.g., Granovetter 1973, Allen 1977, Burt 1992), learning how to do one's work (e.g., Lave and Wenger 1991, Brown and Duguid 1991, Orr 1996) and collectively solving cognitively complex tasks (e.g., Weick and Roberts 1993, Hutchins 1991, Moreland et al. 1996, Hollingshead 1998).

Answering Miner and Mezias' (1996) call for new approaches to the study of organizational learning, we suggest that a social network perspective can enrich our understanding of both dyadic and collective learning in organizations. However, rather than simply measuring communication flows among network nodes, we seek to model learned characteristics of relationships that underlie information seeking and sharing. In doing so, we break somewhat with mainstream social network research that has heavily focused on structural properties of networks (e.g., identifying cliques or measuring centrality), and paid less attention to relational characteristics (e.g., how different aspects of relationships affect the individuals involved) (Monge and Contractor 2000). While important, the structural tradition provides no explanatory mechanism relating what people learn about each other to information-seeking behavior. The opening vignette, drawn from preliminary interviews leading to the present study, provides a real-world illustration of the importance of this distinction for network actors. This manager, and by extension his organization, was successful because he was able to leverage the expertise of others in an accurate and timely fashion. This was not so much the result of the structure of current information flows, but of properties of the relationships he had with others that allowed him to rapidly leverage their expertise to respond to this opportunity.

Huber (1991, p. 89) claimed that an organization learns when "through its processing of information its range of potential behaviors has changed." At a dyadic level, qualitative research suggests that perceptions of another person are formed through direct interaction, observation, and/or third-party commentary (Cross and Borgatti 2000). We believe that these perceptions affect the likelihood of seeking information from them in the future. For example, learning someone's level of expertise or determining how to gain timely access to them affects the probability of seeking that person out for information in the future. At a collective level, the structure of these perceptual relations reflects learning and the potential of a network to identify and react to new issues or opportunities requiring coordinated effort or integration of disparate expertise. As members of one region of a network become aware of and able to leverage the expertise of those in other regions, they become individually capable of doing more while the entire network's potential to sense and respond to new opportunities is also enhanced.

To date, aside from findings relating information seeking to the closeness or strength of a relationship (Granovetter 1973), we know little about the ways in which kinds of relationships (in contrast to structural properties) condition information flow and learning in networks. This paper seeks to contribute to the organizational learning literature by proposing a model of cognitive and effective aspects of relationships that are learned and affect information seeking. We will present results from testing this model in two different organizations and conclude with a discussion of findings and implications for future research.

Relational Characteristics Influencing Information Seeking

What characteristics of a relationship are learned and affect future information seeking? Few studies have

[2] For example, we have evidence of learning from operating experience (e.g., Argote et al. 1990, Epple et al. 1996), innovation efforts (e.g., Van de Ven and Polley 1990, Pisano 1994); unique events (March et al. 1991), teams (Edmondson 1999), improvement initiatives (e.g., Leonard-Barton 1992, Winter 1996), and individuals (Cohen and Bacdayan 1994).

specifically addressed this though there are more general results that have bearing on the question. For example, research on homophily indicates that people are more likely to have social ties (especially strong ones) with those similar to themselves on socially important attributes such as race, sex, education, and age (e.g., Marsden 1990; Zenger and Lawrence 1989; Ibarra 1992, 1995; Brass 1995). We also have consistent evidence that physical proximity affects the likelihood of communication between a pair of actors (Allen 1977, Zahn 1991, Krackhardt 1994), presumably by increasing the probability of serendipitous interactions (Monge et al. 1985).

Social network researchers have examined the role of weak versus strong ties in the acquisition of novel information. Granovetter (1973) theorized that weak ties are more likely than strong ties to be bridges to socially distant regions of a network and, therefore, new information. Subsequent research on the importance of weak ties has demonstrated that they can be instrumental to finding a job (Granovetter 1973; Lin 1982, 1988), individual advancement (Burt 1992, 1997, 2000), and diffusion of ideas (Granovetter 1982, Rogers 1995). More recently, however, attention has shifted to the role of strong ties (Krackhardt 1992). Hansen (1999), for example, has demonstrated the importance of strong ties in transferring tacit, complex knowledge across departmental boundaries in an organization.

While providing insight into the way in which communication networks might emerge or how information might move between people, the above literatures have not addressed directly learned relational characteristics that affect who seeks whom for information. Based in part on the results of qualitative work by Cross and Borgatti (2000), we propose that the intentional search for information in an organizational setting can be seen as a dynamic choice process. The decision to seek information from a specific other is informed by characteristics of the relationship between the seeker and a set of other people he or she might turn to. In turn, actual information-seeking episodes (as well as third-party interaction) update the seeker's perception of another person with respect to these characteristics. Specifically, we propose that information seeking is a function of (1) the extent to which a person knows and values the expertise of another, (2) the accessibility of this person, and (3) the potential costs incurred in seeking information from this person. Each of these variables is discussed below.

Knowing. The decision to seek information from someone in the face of a new problem or opportunity is likely affected by one's perception of another person's expertise.[3] A baseline condition for turning to a given individual for information is awareness of that individual as a possible source in light of a current problem or opportunity. That is, actor *i* must have some understanding of actor *j*'s knowledge and skills. Recent work in transactive memory and distributed cognition has begun to shed light on this issue by exploring the existence and performance implications of distributed knowledge systems (Weick and Roberts 1993, Moreland et al. 1996, Hollingshead 1998, Rulke and Galaskiewicz 2000). Knowledge of another person's expertise is a standard variable in the transactive memory literature, which identifies knowing where information is stored as a basic requirement of performance in distributed knowledge systems. We simply propose here that individuals are more likely to seek information from those whose areas of expertise are known to them.

Hypothesis 1. *The extent to which actor i seeks information from actor j is a positive function of the extent to which actor i* knows *what actor j's areas of expertise are.*

Value. It is also important that a knowledge seeker positively evaluate the knowledge and skills of the person sought out in relation to the problem the seeker is attempting to solve. That is, if actor *i* knows with a great deal of certainty that actor *j* is a poor source of information regarding a certain topic, then the probability that *i* will go to *j* for information on that topic is lowered. While obvious, this variable has not been previously identified in the transactive memory literature, perhaps because empirical study of this phenomenon has largely been conducted in laboratory settings where the quality of knowledge is

[3] This, of course, is subject to bias (Fiske and Taylor 1984). However, a person's perception of others' knowledge and skills, even if inaccurate, informs who they turn to for what.

held constant and only the location is experimentally manipulated. The variable has surfaced in other contexts, however. For example, in his study of how individuals employ various forms of information in their work, O'Reilly (1982) found that in choosing among impersonal sources (e.g., files or procedure manuals), people largely made their decisions based on accessibility, but when tapping coworkers, people took into account source quality.

Hypothesis 2. *The extent to which actor i seeks information from actor j is a positive function of the extent to which actor i* positively evaluates *actor j's knowledge and skills in domains relevant to his or her work.*

Access. Knowing that someone else has valuable expertise is important, but their knowledge is really helpful only if they are accessible.[4] Accessibility is, in part, a question of timeliness: actor *i* must be able to bring actor *j*'s expertise to bear on his or her problem in a timely fashion to be of any real benefit. Particularly, in today's time-constrained world, access alone may dictate whether and how knowledgeable others are tapped. We rarely, if ever, make fully informed decisions but rather satisfice (March and Simon 1958). Further, the extent to which we satisfice is a function of the ease with which solutions are located. As solutions are harder to find, standards of search fall (Cohen et al. 1972, Perrow 1986). Accessibility is also an issue of engagement: when actor *i* does not know the exact question he or she needs to ask, access means getting actor *j* to mindfully focus on the totality of *i*'s problem to give *i* the information he or she really needs.

With the widespread diffusion of advanced communications technology, we can expect technical barriers to access to become less important. Rather, access barriers are increasingly likely to be a product of the relational energy one has to expend. As outlined by Krackhardt (1994, p. 212) "the constraint ... is that the recipients of these requests will not have the personal resources to handle all the traffic." Further, cultural issues might also play a role if access is a product of status or influenced by power inhering in positions of formal authority (Astley and Sachdeva 1984) or informal structure (Brass 1984, Burkhardt and Brass 1990). As a result, we can expect that a person's perception of another person's accessibility will affect the decision to seek information from that person.

Hypothesis 3. *The extent to which actor i seeks information from actor j is a positive function of the extent to which actor i perceives he or she has* access *to actor j's thinking.*

Cost. Finally, we suggest there are costs involved in asking others for assistance. That is, actor *i* must believe that seeking information from actor *j* is not too costly in terms of either interpersonal risks or obligations incurred. A potentially significant cost of seeking information from others in organizational settings lies with the interpersonal risks an individual takes by admitting ignorance on a given topic. Esteem and reputation issues come into play in seeking help from others as we are motivated to maintain positive self-images and so often seek out information that confirms a positive sense of self (Lee 1997, Kelley and Thibaut 1979, Janis 1972). One's trust in another is likely to shape the extent to which people will be forthcoming about their lack of knowledge.[5]

Obligations resulting from an exchange can also be considered a form of cost. Due to norms of reciprocity, asking contacts for significant amounts of help may place a person in their debt (Blau 1986; Coleman 1988, 1990; Fiske 1991). How much debt is incurred will vary from contact to contact depending on such factors as relative status (how valuable is the contact's time?) and attitude (some contacts will begrudge the imposition and demand "payment," while others might enjoy the interaction). However, we can expect that one's perception of the extent of

[4] At first glance, accessibility of a contact may seem like a personal attribute of the contact rather than a relation between the seeker and the contact. However, a given contact can vary in their accessibility to others depending on who the seeker is to others. The classic example is the person who has time for high-status people, but not for others.

[5] Trust writ large is a multifaceted construct in organization studies that in its entirety goes beyond the scope of this effort (see Gambetta 1988, Mayer et al. 1995, Kramer and Tyler 1996 for reviews). While trust can refer to the ability to accurately predict another's behavior, we use trust to mean the belief that one will not be taken advantage of (Porter et al. 1975).

such future demands will negatively affect information seeking from that contact.

HYPOTHESIS 4. *The extent to which actor i seeks information from actor j is a negative function of the* costs *that actor i believes he or she will incur as a result of asking j for help.*

A well-known finding in communication research is the importance of physical proximity (e.g., Allen 1977, Monge et al. 1985). Studies suggest that proximity promotes the likelihood of communication by increasing the probability of serendipitous interaction. However, we suggest that for purposeful information seeking the effect of proximity is indirect. Proximity leads to chance meetings in which people gradually come to learn about each other, become comfortable with each other, and develop bonds that enable future access. Thus, we suggest that knowing, access, and cost relations mediate the relationship between physical proximity and information seeking.

HYPOTHESIS 5. *Knowing, access, and cost relations mediate the relationship between physical proximity and information seeking.*

Methods

To test the hypotheses, we collected social network data on groups in two different organizations. The first was a group of 37 information scientists (16 men and 21 women) in a global pharmaceutical organization whose primary function was to conduct secondary research to support drug development. Preliminary interviews indicated that this group relied on each other for informational purposes in solving various problems and finding information for research scientists. Furthermore, this group was distributed approximately equally across four different geographic locations, thus providing an opportunity to test the extent to which relational variables mediated the relationship between physical proximity and information seeking.

The second group comprised a genomic research function in a different global pharmaceutical organization. This was a group of 35 researchers (16 men and 19 women) whose primary function was to develop new pharmaceutical applications. Again, preliminary interviews indicated that this group relied on each other for informational purposes in solving various problems. This group was also distributed approximately equally across four different geographic locations, thus providing a similar opportunity to test the extent to which relational variables mediated the relationship between physical proximity and information seeking.

Surveys were conducted via electronic mail and were initially sent out along with a cover letter from the sponsor of our study. Surveys were returned directly to the researchers who also sent two follow-up e-mails to increase response rate. In aggregate, all of the information scientists completed the survey, but one of the genomic researchers declined due to maternity leave. Each group was asked the same set of network questions, corresponding to the relational variables in our model. The exact item wording and scales are given in Table 1. As is typical in network research, each independent variable was measured by using a single network question (e.g., Ibarra 1992, 1995). While some have faulted the practice of asking a single sociometric question to measure each theoretical variable (Rogers and Kincaid 1981), a review by Marsden (1990) suggests that these indices are largely reliable when appropriate procedures are followed to help individuals accurately report their network links. Measures taken in this instance included pretesting and constructing question items that were highly specific, and which elicited typical or long-term patterns of interaction rather than one-time events (Rogers and Kincaid 1981, Freeman et al. 1987).

It is important to note that the unit of analysis in this study is the relationship between pairs of persons so all of the variables are dyadic. For each pair, we have measured the extent to which person *i* seeks information from person *j* ("information seeking," regarded as a dependent variable), as well as the extent to which *i* believes they know what *j*'s expertise is ("knowing"), how much *i* values *j*'s expertise ("value"), how accessible *j* is to *i* ("access"), and the extent to which *i* feels it is costly to seek information from *j* ("cost"). The cost variable was reverse coded to facilitate interpretation of the regression results. The data are cross sectional, meaning that all of the

Table 1 Questionnaire Items for Relational Variables

Variable name	Question
Knowing (K)	I understand this person's knowledge and skills. This does not necessarily mean that I have these skills or am knowledgeable in these domains, but that I understand what skills this person has and domains they are knowledgeable in. 1 = Strongly disagree, 5 = Strongly agree, 0 = I do not know this person.
Value (V)	This person has expertise in areas that are important in the kind of work I do. 1 = Strongly disagree, 5 = Strongly agree, 0 = I do not know this person.
Access (A)	One issue in getting information or advice from others is your ability to gain access to their thinking. The extent to which you can access another person's thinking and knowledge is a continuum. At one end of the spectrum are people who do not make themselves available to you quickly enough to help solve your problem. At the other end of the spectrum are those who are willing to engage actively in problem solving with you in a timely fashion. With this continuum in mind, how would you rate your overall ability to access this person's thinking and knowledge? 1 = Extremely weak, 5 = Extremely strong, 0 = I do not know this person.
Cost (C)	Seeking information or advice from other people can be costly. For example, with some people you may not feel comfortable revealing your own lack of knowledge on a given topic. Alternatively, people you ask for information may make you feel excessively indebted to them. In light of such interpersonal risks and obligations, please indicate the extent to which you feel that seeking information or advice from this person is costly. 1 = Very costly, 5 = Not at all costly, 0 = I do not know this person.
Information (I)	(GetInfo) Please indicate how often you have turned to this person for information or knowledge on work-related topics in the past 3 months. 1 = Never, 5 = Very frequently, 0 = I do not know this person. (GiveInfo) Please indicate how often this person has turned to you for information or knowledge on work-related topics in the past 3 months. 1 = Never, 5 = Very frequently, 0 = I do not know this person.

variables were collected at the same point in time. It is assumed that the independent variables refer to aspects of enduring and ongoing relationships with others, while the dependent variable refers to discrete transitory events that recently occurred.[6]

Respondents were not required to rate their relationships with people they did not know. Thus, not every person has ratings for every other person in the network. These pairs were coded with missing values. In addition, to facilitate interpretation, all variables were standardized. Because each of our variables is an $N \times N$ matrix, this means that, for each one, the average of all nonmissing cells in the entire matrix (excluding the diagonal) is zero and the standard deviation is one. Obviously, standardization does not affect significance levels or r-squared values.

An important issue in network data collection concerns respondent accuracy. Research has shown that respondents have difficulty accurately recalling with whom they did what with in a specific time period (Bernard et al. 1982). For example, no matter what time period is being asked about, respondents tend to bias answers toward long-run frequencies (Freeman et al. 1987). This is of some concern in measuring our dependent variable, information seeking, because our objective is to predict who really went to whom for information (rather than perception of information seeking). To mitigate accuracy problems, we used an estimate pooling technique. Instead of asking only: How often did you turn to X for information? (GetInfo), we also asked: How often has X turned to you for information? (GiveInfo). Then, to construct the dependent variable, we took the average of the GetInfo variable and the transpose of the GiveInfo variable (Borgatti et al. 1999). In other words, to evaluate the extent to which person i sought information from person j, we took the average of two estimates: (1) the amount i claimed to seek information from j, and (2) the amount that j indicated that he or she was sought out by i.

We also collected demographic data, including each person's hierarchical position in the organization, tenure within the group (in months), gender, and

[6] In network analysis, this is known as the backcloth/traffic distinction (Atkin 1972).

physical location (which office they worked in). All of these were used to construct control variables. In the case of hierarchical position and tenure, for each ordered pair of persons, we subtracted the second person's value (such as number of months in the organization) from the first person's. In the case of gender and location, we constructed dyadic variables X in which $X_{ij} = 1$ if persons i and j had the same value on gender (or location), and $X_{ij} = 0$ otherwise. Hierarchy difference was included because of the possibility that it affects both access (lower-ranking members are more accessible) and information seeking. Tenure difference was included because, according to the communities of practice literature (Lave and Wenger 1991, Wenger 1998), newer members should know less and, therefore, be less likely to be sought for information. Gender homophily and physical proximity are well-established factors affecting communication frequency.

To test the model statistically, we used network correlation and regression. Network data do not satisfy assumptions of statistical inference in classical regression because the observations are not independent. Consequently, special procedures known as quadratic assignment procedure (QAP) and multiple regression quadratic assignment procedure (MRQAP) (Baker and Hubert 1981, Krackhardt 1988, Borgatti et al. 1999) were used to run the correlations and multiple regressions, respectively. QAP and MRQAP are identical to their nonnetwork counterparts with respect to parameter estimates, but use a randomization/permutation technique (Edgington 1969, Noreen 1989) to construct significance tests. Significance levels for correlations and regressions are based on distributions generated from 10,000 random permutations.

Results

As an introduction to the results, Table 2 gives the matrix of correlations among all variables in each site. Beginning with the information scientists (Table 2a), several observations may be made. First, correlations involving the control variables are virtually nonexistent, with proximity being the only control variable correlated with information seeking. Second, except for cost, all of the independent variables are positively and strongly correlated with the dependent variable. Third, a few of the correlations among the independent variables are fairly large but well within acceptable limits for joint inclusion in a regression model (Nunnally 1978). Turning our attention to the genomic researchers (Table 2b), we can observe a similar pattern of correlations. In fact, a QAP correlation between the two correlation matrices is 0.749, indicating that the two sites yield similar patterns of intercorrelation among variables, which attests to the reliability and stability of the constructs in different settings.

Table 3a gives the regression results for the information scientists. The coefficients presented in the table are standardized regression coefficients. In the first model, we enter only the four control variables. The results show that, as a set, the controls have little effect on information seeking (the percent of variance accounted for is 3%), but proximity and sameness of gender are significant (with the negative coefficient indicating a tendency to seek out the other gender). In the fourth model, we simultaneously add the knowing, value, access, and cost relations and find that the variance accounted for substantially improves to 56%. The results provide clear support for Hypothesis 1 (knowing another's expertise leads to seeking information from them), Hypothesis 2 (valuing another's expertise in relation to one's work leads to seeking information from them), and Hypothesis 3 (access to another's thinking leads to seeking information from them). However, Hypothesis 4 (low cost of interaction leads to seeking information) was not supported.

We now turn to the regressions for the genomic researchers in Table 3b. The first model includes only the control variables. As with the information scientists, proximity and gender are significant, but in this case, there is a tendency to turn to people of the same rather than different gender. In the fourth model, we simultaneously add the knowing, value, access, and cost relations and find once again that variance accounted for substantially improves to 34%. Consistent with the information scientists, the results provide clear support for Hypothesis 1 (knowing), Hypothesis 2 (valuing), and Hypothesis 3 (access), but do not support Hypothesis 4 (cost).

Per Hypothesis 5, we were also interested in assessing whether our variables mediated the relationship

Table 2 Correlations of Control, Relational Variables, and Information Seeking

	H	T	G	P	K	V	A	C	I
(a) Information scientists									
H	1.00								
T	−0.06	1.00							
G	0.00	0.00	1.00						
P	0.00	0.00	0.01	1.00					
K	−0.04	0.08	−0.04	0.10**	1.00				
V	−0.06	0.03	−0.06	0.05**	0.64**	1.00			
A	−0.08	0.01	−0.07	0.20**	0.61**	0.63**	1.00		
C	−0.14	0.03	−0.02	0.17**	0.50**	0.46**	0.66**	1.00	
I	0.01	0.00	−0.07	0.17**	0.65**	0.68**	0.63**	0.45**	1.00
Mean					3.63	3.46	3.67	3.96	2.22
(SD)					1.08	1.18	1.09	0.99	1.32
(b) Genomic researchers									
H	1.00								
T	0.26	1.00							
G	0.00	0.00	1.00						
P	0.00	0.00	0.07	1.00					
K	−0.09	0.05	0.09**	0.17**	1.00				
V	−0.13	−0.07	0.09*	0.07**	0.51**	1.00			
A	0.18*	0.04	0.10*	0.12**	0.27**	0.34**	1.00		
C	0.25*	0.11	−0.01	0.08**	0.07**	0.16*	0.57**	1.00	
I	−0.18	−0.02	0.17**	0.17**	0.42**	0.39**	0.47**	0.22**	1.00
Mean					3.14	3.89	3.80	4.10	2.63
(SD)					1.40	1.04	1.06	0.97	1.20

* $= p < 0.05$, ** $= p < 0.01$.

H = Difference in hierarchical level; T = Difference in tenure; G = Sameness of gender; P = Physical proximity; K = Knowing other's expertise; V = Valuing other's expertise; A = Access to other; C = Cost of seeking other's assistance; I = Seeking information from other.

between physical proximity and information seeking. To establish mediation, three conditions must hold (Baron and Kenney 1986). First, physical proximity must predict the mediating variables (knowing, access, and cost). For the information scientists, proximity was a significant predictor of knowing ($p < 0.05$), access ($p < 0.001$), and cost ($p < 0.001$). Similarly, for the genomic researchers, proximity was a significant predictor of knowing ($p < 0.001$), access ($p < 0.001$), and cost ($p < 0.05$). Second, physical proximity must predict the dependent variable (information seeking). In Model 1 of Table 3, we show that physical proximity predicted information seeking for both the information scientists ($p < 0.001$) and the genomic researchers ($p < 0.001$). Finally, the coefficient for proximity must become nonsignificant when we control for mediating variables. As shown in Table 3, the results from the information scientists are consistent with the mediation hypothesis for two of the four relations. Specifically, the knowing and access relations mediate the effect of proximity on information seeking. Value was not hypothesized to relate to proximity, and cost fails because, as we have already seen, it does not predict information seeking. Turning to the genomic researchers, results again are consistent with the mediation hypothesis via the knowing and access relations.

A summary of findings with respect to each hypothesis is given in Table 4. We find that three of the relations—knowing, value, and access—consistently predict information seeking. In contrast, the cost relation does not. With respect to the mediation hypothesis, there was support for proximity being mediated by knowing and access relations.

Table 3 Predicting Information Seeking: Regression Results

Variable	Model 1	Model 2a	Model 2b	Model 2c	Model 2d	Model 3	Model 4
(a) Information scientists							
H (Hierarchy)	0.012	0.013	0.036*	0.045*	0.067*	0.036*	0.042*
T (Tenure)	0.005	−0.026	0.018	0.029	0.030*	−0.012*	−0.003
G (Gender)	−0.078*	−0.052	−0.041	−0.039	−0.071	−0.038	−0.031
P (Proximity)	0.172***	0.087	0.126*	0.044	0.087	0.043	0.066
K (Knowing)		0.641***				0.419***	0.231***
V (Value)			0.672***				0.336***
A (Access)				0.624***		0.368***	0.276***
C (Low Cost)					0.440***		−0.012
Adj. *R*-Squared	0.033	0.431	0.478	0.404	0.215	0.501	0.555
N	1,234	1,151	1,159	1,143	1,147	1,130	1,125
(b) Genomic researchers							
H (Hierarchy)	−0.016	0.045**	0.028	−0.092***	−0.083***	−0.034	−0.015
T (Tenure)	−0.013	−0.038**	−0.017	−0.008	−0.033	−0.035	−0.033
G (Gender)	0.158***	0.127**	0.128**	0.137**	0.171**	0.114*	0.105*
P (Proximity)	0.161***	0.100	0.155**	0.095	0.135*	0.091	0.090
K (Knowing)		0.408***				0.298***	0.229***
V (Value)			0.376***				0.170***
A (Access)				0.459***		0.386***	0.351***
C (Low Cost)					0.236***		−0.010
Adj. *R*-Squared	0.051	0.211	0.192	0.255	0.103	0.304	0.338
N	944	943	914	901	889	900	871

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
All significance based on 10,000 permutations.

Table 4 Summary of Hypotheses and Findings

Hypothesis	Support
Hypothesis 1 (Knowing): The extent to which actor *i* seeks information from actor *j* is a positive function of the extent to which actor *i* *knows* what actor *j*'s areas of expertise are.	Full
Hypothesis 2 (Value): The extent to which actor *i* seeks information from actor *j* is a positive function of the extent to which actor *i* positively evaluates actor *j*'s knowledge and skills in domains relevant to his or her work.	Full
Hypothesis 3 (Access): The extent to which actor *i* seeks information from actor *j* is a positive function of the extent to which actor *i* has *access* to actor *j*'s thinking.	Full
Hypothesis 4 (Cost): The extent to which actor *i* seeks information from actor *j* is a negative function of the *costs* that actor *i* believes he or she will incur as a result of asking *j* for help.	No
Hypothesis 5 (Mediation): Knowing, access, and cost relations mediate the relationship between physical proximity and information seeking.	Partial (Cost is not significant)

Discussion and Conclusion

We have known for some time that relationships are important for acquisition of information (Granovetter 1973, Allen 1977, Burt 1992) and that the creation of knowledge is a social process (Mead 1934, Wittgenstein 1953, Berger and Luckman 1966). Yet despite the importance of social interaction as a vehicle for knowledge acquisition, we know little about the learned relational characteristics that facilitate information seeking. Our study offers evidence of at least three enduring relational characteristics that are predictive of the behavior of information seeking: (1) knowing what another person knows, (2) valuing what that other person knows in relation to one's work, and (3) being able to gain timely access to that person's thinking.

Interestingly, although cost emerged as an important factor in prior qualitative work (Cross and Borgatti 2000), it was not statistically significant in either research site. This could be a product of response bias—an unwillingness to say negative

things about others. However, we took several measures to ensure against this in the survey process (e.g., guarantee of nondisclosure and responses sent directly to third-party researchers). Rather, we believe one of two explanations could account for this finding. First, from a cultural perspective, it could be that cost functions as a characteristic of a group as a whole, affecting whether or how often people seek information from others in general, rather than as a determinant of who is sought out.[7] This line of reasoning is consistent with Edmondson's (1999) findings in relation to psychological safety as a collective property of teams, and represents an interesting avenue for further research.

Alternatively, the answer could lie in the choice of dependent variable. We sought to predict the behavior of information seeking and so asked about frequency of interaction rather than effectiveness. In today's time constrained world, people might be forced to seek out available others out of necessity and pay little heed to costs of interaction. Thus, cost might not affect the behavior of information seeking, but might come into play in terms of learning in the interaction. Low-cost relations might promote learning via willingness to expose lack of knowledge and explore alternative solutions. This explanation is consistent with the finding in Cross et al. (2001a) that dyadic trust matters in problem-framing interactions but not for simple information exchange.

A second point of interest in this work is the finding that knowing and access variables mediate the relationship between physical proximity and information seeking. This extends the literature on proximity by identifying relational mechanisms through which physical propinquity leads to information exchange. As organizations consider open spaces or other environments to promote interaction among employees, it is important that social interventions develop knowledge and access relations as they are the factors that ultimately inform information seeking. Virtual work might also benefit from these findings. While staging of face-to-face interactions during the course of a given project is important, alternative means can also be employed to develop relational conditions of knowing and access (e.g., skill profiling systems, developmental staffing practices, or action-learning techniques).

One of the strengths of this study is that we have replicated the findings by testing the model with data from two separate organizations. The great bulk of work in the social network tradition has largely drawn conclusions based on a single social network within one organization in one industry. This research has tested our model in two organizations on groups engaged in seemingly different forms of work and found consistent results.

Of course, this study has significant limitations as well. First, our theoretical model is temporally ordered in the sense that we believe that the independent variables (knowing, valuing, access, and cost) enable the dependent variable (information seeking). Yet, because our data are cross sectional, we can only test for the existence of a statistical relationship among the variables and cannot draw conclusions about the direction of causality. Thus, the test of the model is valid because nonsignificant results would have falsified the theory, but it is also a weak test because the results are consistent not only with our proposed model but others as well (e.g., that information seeking affects knowing, valuing, access, and cost, and not the other way around). However, prior qualitative research (Cross and Borgatti 2000) found that informants choose who to seek information from based on their perceptions of and relationships with others, indicating causality in the hypothesized direction.

Our model is also incomplete in the sense that we did not account for potentially moderating firmwide variables such as organizational climate. For example, as footnoted previously, we found that the cost variable had little variance and was not significantly related to information seeking, however, it is possible that this is a product of cultural norms making information-seeking behavior acceptable. Theoretically, this suggests a more complicated model in which some dyadic variables take on greater importance in the absence of cultural attributes.

Despite these empirical limitations, we feel that the study provides a platform for further theoriz-

[7] In fact, the variance of the cost variable was the lowest of all the relational variables.

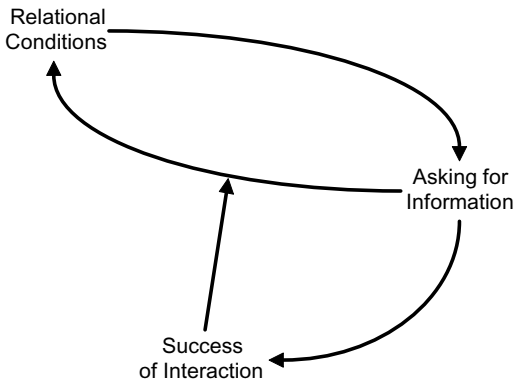
ing on transactive memory, social capital, and organizational learning. In terms of transactive memory, a key question is: What relationships need to exist for a group to leverage its collective expertise? The largely laboratory-based research to date has focused on the knowing relation in demonstrating performance implications of collective agreement on "who knows what."[8] As this work moves into field settings—where temporal pacing of tasks, interdependence of jobs, physical location of workers, and definition of problem or goal are not controlled by the researcher—other relational characteristics will likely need to be accounted for to ensure that a group leverages its collective expertise. We hope future research on transactive memory will assess ways in which network structure and relational features, such as valuing and access, affect the ability of a group to benefit from distributed expertise.

Finally, we feel our results hold the potential to further theorizing on organizational learning concepts of absorptive capacity and path dependence. In terms of absorptive capacity, employing social network analysis to map the above relations could offer insight into central individuals or cliques that disproportionately account for an organization's ability to recognize valuable new information, assimilate it, and apply it to new ends. Theorists originally suggested that an organization's "absorptive capacity"—its ability to take in and make use of new knowledge—is a product of both the "character and distribution of expertise within the organization" (Cohen and Levinthal 1990, p. 132). To date, few have focused on the latter issue of the distribution of expertise (Zahra and George 2002). We suggest that the construct of absorptive capacity should be framed in a way that accounts for both existing knowledge and the relations that facilitate information exchange in light of new problems. We can use knowing, value, and access relations to identify central individuals (Freeman 1979) or coalitions (Everett and Borgatti 1999) whose knowledge is likely to be influential in absorbing new information.

In addition, we suggest that a dynamic extension of the model presented here could, in future research, provide new insight into path dependence in organizational learning (e.g., Cohen and Levinthal 1990, March 1991). We noted earlier that qualitative research (Cross and Borgatti 2000) had indicated that the knowing, valuing, access, and cost relations enabled information seeking. However, the same research also found that when we do engage with others (e.g., when seeking information from them), we recalibrate our understanding of their skills and knowledge, as well as how to gain access to them most effectively and what the potential costs might be of interacting with them. As we update our understanding of others, we affect our probability of interacting with them in the future, creating a dynamic feedback system (as shown in Figure 1).

For example, discovering that a person is not helpful, reduces the probability of interacting with them, which means that knowledge of their expertise and how best to access them begins to fade. In contrast, having a positive interaction may reduce access barriers and lead to future interactions, increasing knowledge of that source's expertise. Over time, people may lock in to a limited set of people with whom they frequently interact, which might be efficient but yield suboptimal information if other people are better sources. This extended network model might provide a formal explanation of the mechanism underlying path dependence in information search and, therefore, organizational learning. Given the importance of people as critical sources of knowledge and information, we hope future research on organizational learning will consider the role of both structural and relational attributes of networks in understanding absorptive capacity and path dependence.

Figure 1 Dynamic Model of Learning in Intentional Search



[8] See Rulke and Galaskiewicz (2000) for a discussion.

Finally, our relational model also holds the potential to inform management practice. Mapping information seeking alone does not necessarily provide a clear path to intervention. For example, we may find that one group has no information-seeking ties with another, but without knowing why it is difficult to suggest interventions. However, if we regard information seeking as resulting from relational characteristics we propose, then we can assess which relation or combination of relations is the problem for a given network. For example, if the problem in a group lies with it not "knowing what it knows," we might suggest action learning, developmental staffing practices, or skill profiling systems to help create knowledge of "who knows what." In contrast, if a group is having problems with access, we might consider performance metrics that encourage people to be accessible to others in combination with peer feedback processes to ensure that this happens. On the technical front, one might consider distributed or wireless technologies to allow people the ability to access each other. By examining the relations we have proposed, we can begin to diagnose a network and design interventions with greater accuracy than if we just assessed existing information networks.

References

Allen, T. 1977. *Managing the Flow of Technology*. MIT Press, Cambridge, MA.

Argote, L. 1999. *Organizational Learning: Creating, Retaining and Transferring Knowledge*. Kluwer Academic Publishers, Norwell, MA.

——, S. L. Beckman, D. Epple. 1990. The persistence and transfer of learning in industrial settings. *Management Sci.* **36**(2) 140–154.

Argyris, C., D. Schon. 1978. *Organizational Learning: Theory, Method and Practice*. Addison-Wesley, Reading, MA.

Astley, G., P. Sachdeva. 1984. Structural source of intraorganizational power: A theoretical synthesis. *Acad. Management Rev.* **9** 104–113.

Atkin, R. H. 1972. From cohomology in physics to q-connectivity in social science. *Internat. J. Man-Machine Stud.* **4** 139–167.

Baker, F., L. Hubert. 1981. The analysis of social interaction data. *Soc. Methods Res.* **9** 339–361.

Baron, R., D. Kenny. 1986. The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *J. Personality Soc. Psych.* **31**(6) 1173–1182.

Berger, P., T. Luckman. 1966. *The Social Construction of Reality*. Anchor Books, New York.

Bernard, H. R., P. Killworth, L. Sailer. 1982. Informant accuracy in social network data V: An experimental attempt to predict actual communication from recall data. *Soc. Sci. Res.* **11** 30–66.

Blau, P. 1986. *Exchange and Power in Social Life*. Transaction Publishers, New Brunswick, NJ.

Bonacich, P. 1972. Factoring and weighting approaches to status scores and clique identification. K. F. Schuessler, ed. *Soc. Methodology* **2** 113–120.

Borgatti, S., M. Everett, L. Freeman. 1999. *UCINET 5 for Windows: Software for Social Network Analysis*. Analytic Technologies, Inc., Natick, MA.

Brass, D. 1984. Being in the right place: A structural analysis of individual influence in an organization. *Admin. Sci. Quart.* **29** 518–539.

——. 1995. A social network perspective on human resources personnel. *Research in Personnel and Human Resources Management*, Vol. 13. JAI Press, Greenwich, CT, 39–79.

Brown, J. S., P. Duguid. 1991. Organizational learning and communities of practice: Toward a unified view of working, learning and innovation. *Organ. Sci.* **2**(1) 40–57.

Burkhardt, M., D. Brass. 1990. Changing patterns or patterns of change: The effects of a change in technology on social network structure and power. *Admin. Sci. Quart.* **35** 104–127.

Burt, R. 1992. *Structural Holes*. Harvard University Press, Cambridge, MA.

——. 1997. The contingent value of social capital. *Admin. Sci. Quart.* **42** 339–365.

——. 1999. Entrepreneurs, distrust and third parties: A strategic look at the dark side of dense networks. L. Thompson, J. Levine, D. Messick, eds. *Shared Cognition in Organizations*. Lawrence Erlbaum Associates, Inc., Mahwah, NJ.

——. 2000. The network structure of social capital. B. Staw, R. Sutton, eds. *Research in Organizational Behavior*, Vol. 22. JAI Press, Greenwich, CT.

Cohen, M. P. Bacdayan. 1994. Organizational routines are stored as procedural memory: Evidence from a laboratory study. *Organ. Sci.* **5**(4) 554–568.

——, D. Levinthal. 1990. Absorptive capacity: A new perspective on learning and innovation. *Admin. Sci. Quart.* **35** 128–152.

——, J. March, J. Olsen. 1972. A garbage can model of organizational choice. *Admin. Sci. Quart.* **17** 1–25.

Coleman, J. 1988. Social capital in the creation of human capital. *Amer. J. Soc.* **94** S95–S120.

——. 1990. *Foundations of Social Theory*. Harvard University Press, Cambridge, MA.

Cross, R., S. Borgatti. 2000. The ties that share: Relational characteristics that facilitate knowledge transfer and organizational learning. Paper presented at the 2000 INSNA Social Networks Conference, Vancouver, Canada.

——, R. Rice, A. Parker. 2001a. Information seeking in social context: Structural influences and receipt of informational benefits. *IEEE Trans.* **31**(4) 438–448.

——, A. Parker, L. Prusak, S. Borgatti. 2001b. Knowing what we know: Supporting knowledge creation and sharing in social networks. *Organ. Dynam.* **3**(2) 100–120.

Cyert, R. M., J. G. March. 1963. *A Behavioral Theory of the Firm*. Prentice-Hall, Englewood Cliffs, NJ.

Daft, R., K. Weick. 1984. Toward a model of organizations as interpretive systems. *Acad. Management Rev.* **9**(2) 284–295.

Edgington, E. S. 1969. Approximate randomization tests. *J. Psych.* **72** 143–149.

Edmondson, A. 1999. Psychological safety and learning behavior in work teams. *Admin. Sci. Quart.* **44**(2) 350–383.

Epple, D., L. Argote, K. Murphy. 1996. An empirical investigation of the microstructure of knowledge acquisition and transfer through learning by doing. *Oper. Res.* **44**(1) 77–86.

Everett, M. G., S. P. Borgatti. 1999. The centrality of groups and classes. *J. Math. Soc.* **23**(3) 181–201.

Fiske, A. 1991. *Structures of Social Life: The Four Elementary Forms of Human Relations*. Free Press, New York.

——, S. Taylor. 1984. *Social Cognition*. McGraw-Hill, New York.

Freeman, L. C. 1979. Centrality in social networks: I. Conceptual clarification. *Soc. Networks* **1** 215–239.

——, A. K. Romney, S. Freeman. 1987. Cognitive structure and informant accuracy. *Amer. Anthropologist* **89** 310–325.

Gambetta, D. 1988. *Trust: Making and Breaking Cooperative Relations*. Basil Blackwell, Oxford, U.K.

Granovetter, M. 1973. The strength of weak ties. *Amer. J. Soc.* **78** 1360–1380.

——. 1982. The strength of weak ties: A network theory revisited. P. Marsden, N. Lin, eds. *Social Structure and Network Analysis*. Sage Publishers, Beverly Hills, CA, 105–130.

Hansen, M. 1999. The search-transfer problem: The role of weak ties in sharing knowledge across organizational subunits. *Admin. Sci. Quart.* **44** 82–111.

Harary, F. 1969. *Graph Theory*. Addison-Wesley, Reading, MA.

Hollingshead, A. 1998. Retrieval processes in transactive memory systems. *J. Personality Soc. Psych.* **74**(3) 659–671.

Huber, G. 1991. Organizational learning: The contributing processes and literatures. *Organ. Sci.* **2**(1) 88–115.

Hutchins, E. 1991. Organizing work by adaptation. *Organ. Sci.* **2**(1) 14–29.

Ibarra, H. 1992. Homophily and differential returns: Sex differences in network structure and access in an advertising firm. *Admin. Sci. Quart.* **37** 422–447.

——. 1995. Race, opportunity and diversity of social circles in managerial networks. *Acad. Management J.* **38** 673–703.

Janis, I. 1972. *Victims of Groupthink*. Houghton-Mifflin, Boston, MA.

Kelley, H., J. Thibaut. 1979. *Interpersonal Relations*. John Wiley and Sons, New York.

Krackhardt, D. 1988. Predicting with social networks: Nonparametric multiple regression analysis of dyadic data. *Soc. Networks* **10** 359–382.

——. 1992. The strength of strong ties: The importance of philos. N. Nohria, R. Eccles, eds. *Networks and Organizations: Structures, Form and Action*. Harvard Business Press, Boston, MA, 216–239.

——. 1994. Constraints on the interactive organization as an ideal type. C. Heckscher, A. Donnellon, eds. *The Post-Bureaucratic Organization: New Perspective on Organizational Change*. Sage Publications, Thousand Oaks, CA, 211–222.

Kramer, R., T. Tyler, eds. 1996. *Trust in Organizations: Frontiers of Theory and Research*. Sage Publications, Thousand Oaks, CA.

Lave, J., E. Wenger. 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge University Press, Cambridge, U.K.

Lee, F. 1997. When the going gets tough, do the tough ask for help? Help seeking and power motivation in organizations. *Organ. Behavior Human Decision Processes* **72**(3) 336–363.

Leonard-Barton, D. 1992. The factory as a learning laboratory. *Sloan Management Rev.* (Fall) 23–38.

Liang, D., R. Moreland, L. Argote. 1995. Group versus individual training and group performance: The mediating role of transactive memory. *Personality Soc. Psych. Bull.* **21**(4) 384–393.

Lin, N. 1982. Social resources and instrumental action. P. Marsden, N. Lin, eds. *Social Structure and Network Analysis*. Sage, Beverly Hills, CA, 131–145.

——. 1988. Social resources and social mobility: A structural theory of status attainment. R. Breiger, ed. *Social Mobility and Social Structure*. Cambridge University Press, Cambridge, U.K.

March, J. 1991. Exploration and exploitation in organizational learning. *Organ. Sci.* **2**(1) 71–87.

——, H. Simon. 1958. *Organizations*. John Wiley and Sons, New York.

——, L. Sproull, M. Tamuz. 1991. Learning from samples of one or fewer. *Organ. Sci.* **2**(1) 1–13.

Marsden, P. 1990. Network data and measurement. *Ann. Rev. Soc.* **16** 435–463.

Mayer, R., J. Davis, F. Schoorman. 1995. An integrative model of organizational trust. *Acad. Management Rev.* **20**(3) 709–734.

Mead, M. 1934. *Mind, Self and Society*. University of Chicago Press, Chicago, IL.

Miner, A., S. Mezias. 1996. Ugly duckling no more: Pasts and futures of organizational learning research. *Organ. Sci.* **7**(1) 88–99.

Monge, P., N. Contractor. 2000. Emergence of communication networks. F. Jablin, L. Putnam, eds. *Second Handbook of Organizational Communication*. Sage Publications, Thousand Oaks, CA.

——, L. Rothman, E. Eisenberg, K. Miller, K. Kirste. 1985. The dynamics of organizational proximity. *Management Sci.* **31** 1129–1141.

Moreland, R., L. Argote, R. Krishnan. 1996. Socially shared cognition at work: Transactive memory and group performance. J. Nye, A. Brower, eds. *What's Social About Social Cognition*. Sage Publications, Thousand Oaks, CA, 57–85.

Nelson, R., S. Winter. 1982. *An Evolutionary Theory of Economic Change*. Belknap Press, Cambridge, MA.

Noreen, E. 1989. *Computer Intensive Methods for Testing Hypotheses: An Introduction*. John Wiley & Sons, New York.

Nunnally, J. 1978. *Psychometric Theory*, 2nd ed. McGraw-Hill, New York.

O'Reilly, C. 1982. Variations in decision-makers use of information sources: The impact of quality and accessibility of information. *Acad. Management J.* **25** 756–771.

Orr, J. E. 1996. *Talking About Machines: An Ethnography of a Modern Job*. Cornell University Press, Ithaca, NY.

Perrow, C. 1986. *Complex Organizations: A Critical Essay*. McGraw-Hill, New York, 119–156.

Pisano, G. 1994. Knowledge integration and the locus of learning: An empirical analysis. *Strategic Management J.* **15** 85–100.

Porter, L., E. Lawler, J. Hackman. 1975. *Behavior in Organizations.* McGraw Hill, New York.

Rogers, E. 1995. *Diffusion of Innovations*, 4th ed. Free Press, New York.

——, D. Kincaid. 1981. *Communication Networks*. Free Press, New York.

Rulke, D. L., J. Galaskiewicz. 2000. Distribution of knowledge, group network structure, and group performances. *Management Sci.* **46**(5) 612–626.

Simonin, B. 1999. Ambiguity and the process of knowledge transfer in strategic alliances. *Strategic Management J.* **20** 595–623.

Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practices within the firm. *Strategic Management J.* **17**(Winter Special Issue) 27–43.

Van de Ven, A., D. Polley. 1990. Learning while innovating. *Organ. Sci.* **3**(1) 92–116.

Weick, K., K. Roberts. 1993. Collective mind in organizations: Heedful interrelating on flight decks. *Admin. Sci. Quart.* **38** 357–381.

Wenger, E. 1998. *Communities of Practice: Learning, Meaning, and Identity.* Cambridge University Press, New York.

Winter, S. 1996. Organizing for continuous improvement: Evolutionary theory meets the quality revolution. M. D. Cohen, L. S. Sproull, eds. *Organ. Learning*. Sage Publications, Thousand Oaks, CA.

Wittgenstein, L. 1953. *Philosophical Investigations*. Macmillan Company, New York.

Zahn, G. L. 1991. Face-to-face communication in an office setting: The effects of position, proximity, and exposure. *Comm. Res.* **18** 737–754.

Zenger, T., B. Lawrence. 1989. Organizational demography: The differential effects of age and tenure distributions on technical communication. *Acad. Management J.* **32** 353–376.

Zahra, S., G. George. 2002. Absorptive capacity: A review, reconceptualization, and extension. *Acad. Management Rev.* **27**(2) 185–203.

Accepted by Linda Argote, William McEvily, and Ray Reagans; received February 2001. This paper was with the authors 5 months for 2 revisions.