Beyond Bowling Together: SocioTechnical Capital

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Abstract

Social resources like trust and shared identity make it easier for people to work and play together. Such social resources are sometimes referred to as social capital. Thirty years ago, Americans built social capital as a side effect of participation in civic organizations and social activities, including bowling leagues. Today, they do so far less frequently (Putnam 2000). HCI researchers and practitioners need to find new ways for people to interact that will generate even more social capital than bowling together does. A new theoretical construct, SocioTechnical Capital, provides a framework for generating and evaluating technology-mediated social relations.

Introduction

The notion of capital suggests a resource that can be accumulated and whose availability allows people to create value for themselves or others. People can do more when they have access to physical resources like buildings and tools, which are usually referred to as physical capital. Money, or financial capital, allows people to acquire many other kinds of resources. In the latter half of the 20th century, economists began to think about education as human capital. People who have more knowledge and skills can do produce more, so it makes sense to think about spending on education as a form of investment rather than consumption (Schultz 1961).

Productive resources can reside not just in things and in people, but also in social relations among people (Coleman 1988; Putnam 1993). A network of people who have developed communication patterns and trust can accomplish much more than a bunch of strangers, even if the two sets of people have similar human, physical, and financial capital available. The productive capacity can be used to benefit individuals, the network as a whole, or society at large. Typically, productive social structures and dynamics emerge as a by-product of interactions that occur naturally in the course of work or recreation. Conceptualizing such resources as "social capital" suggests, however, that it is also possible to make conscious investments to develop resources that inhere in social relations.

A growing body of literature has confirmed that social capital is correlated with positive individual and collective outcomes in areas such as better health (Lochner, Kawachi et al. 1999; Parker, Lichtenstein et al. 2000), lower crime (Sampson, Raudenbush et al. 1997), better educational outcomes (Putnam 2000, ch. 17), economic development (Putnam 1993; Knack and Keefer 1997; Putnam 2000, ch. 19), and good government (Putnam 1993). These studies either measure social capital directly, usually through survey questions about attitudes and expectations of others' behavior, or indirectly by measuring the amounts of certain activities that are thought to produce social capital, such as attendance at meetings. The measures of social capital are then

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correlated with the outcome variables. For example, in his study of regional differences in Italy, Putnam found that participation in choral societies and soccer clubs, activity which might be expected to generate social capital, was the best predictor of regional variation in economic development and political corruption (Putnam 1993).

Social capital is a residual or side effect of social interactions, and an enabler of future interactions, as shown in Figure 1. For example, a neighborhood trash pickup has the direct effect of leaving a cleaner neighborhood. If many people participate in the pickup, there may also be side effects on their stock of social capital. They may meet each other and develop ties that make it easier to organize a block party or arrange shared babysitting in the future. The may begin to share information about crime incidents and feel a sense of emotional support. They may become more able to mobilize in response to perceived external threats such as noise from airplanes. This example illustrates that social capital, like many other aspects of social life, is not only produced but also reproduced. Use doesn't use it up; when a group draws on its social capital to act collectively, it will often generate even more social capital. Conversely, if a group tries to mobilize but fails to act collectively, some of its social capital may dissipate as members lose faith in each other.

Information and communication technologies (ICTs) should also increase people's ability to act together, which has prompted large investments in such technologies. Surprisingly, economists' initial studies failed to find productivity increases resulting from those investments (Brynjolfsson 1993), which spurred a call for more efforts in the field of human-computer interaction (Landauer 1995). More recent studies have demonstrated productivity gains (Brynjolfsson and Hitt 1998). The challenge remains, however, for human-computer interaction research and development to maximize the productive value of investments in information and communications technology.

It is especially interesting to think about interaction effects between social relations and technology (computing and communications resources, to be more precise). Some communication services may be useful only to groups of people who have already developed strong social ties and who develop certain norms for how to use it. Other groups of people might find the same communication service a nuisance rather than a helpful tool. Conversely, some social practices might be productive only in the presence of particular communication and computational tools. For example, a convention of broadcasting event announcements to large groups of people, only a few of whom will be interested, may be productive if most of the people have sophisticated tools for filtering their messages, but unproductive otherwise. I will use the term "sociotechnical capital" to refer to productive combinations of social relations and

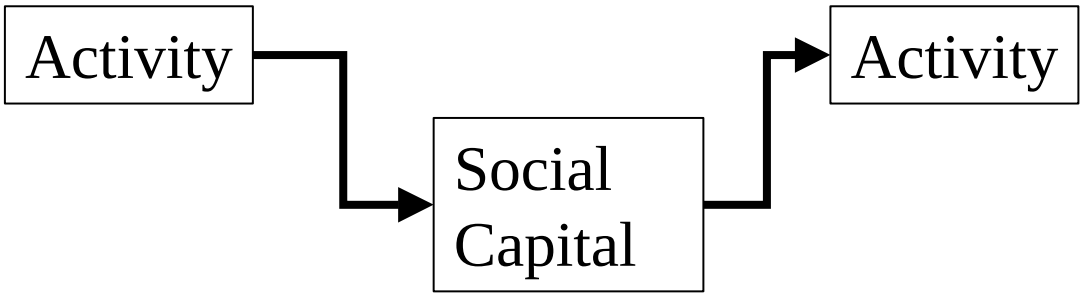

Figure 1: Social capital as a side effect of previous activities and enabler of future activities.

information and communication technology.[2] It is thus a special case, a subset of social capital, but an important one because technological advances have opened many new opportunities that have not been examined from the social capital perspective.

The field of human-computer interaction deals frequently with systems that combine technology and social practices. Previous work on "sociotechnical systems" has emphasized dynamic co-evolution between technical and social subsystems (e.g., (Bikson and Eveland 1996)). The emphasis here is not so much on how the social and technical affect each other, but how they jointly influence the ability of people to act together.

The novel conceptual lens here is that of capital, a resource that can be accumulated over time through deliberate investment. As with purely social capital, resources are accumulated as a side effect of previous interactions. The resources may consist of artifacts created during the earlier interactions, or social ties and practices that developed. They constitute capital if they help a group of people to accomplish more together, improving the routing of information, the exchange of resources, the provision of emotional support, or the ability to coordinate and to mobilize for collective action. The resources are sociotechnical in nature if their production or use requires a combination of social relations and information and communications technologies.

For HCI designers, the lens of sociotechnical capital suggests a new place to look for the success factors behind information systems deployments. It may be that a system can be used effectively only after its users have developed trust in each, a shared identity, or some other form of social capital.[3]

Perhaps more importantly, the lens also suggests a new definition of success for system deployments, one that accounts for sociotechnical capital side effects as well as direct impacts on immediate tasks. If, for example, a system allows a worker to find information on her own without consulting colleagues, there is a positive time efficiency gain. There is also a negative effect from losing opportunities to build and maintain ties with her colleagues, which might be useful for other reasons beyond the immediate task. In some cases, the tradeoffs may be worth it, in other cases not. Moreover, an alternative design of the system might improve immediate productivity and the formation of sociotechnical capital as well, once we set that as a goal.

The Civic Challenge

The conceptual lens of sociotechnical capital can inform design and evaluation of systems that support work and education, which have been the traditional domains of HCI. Recent research on social capital, however, suggests that supporting civic activity is of special importance and that new forms of social capital are needed to replace older forms that are declining. This is a special challenge that human-computer interaction as a field should rise to meet.

At least in the United States, many of the formal and informal activities that produce social capital have been declining in the last few decades, as documented in Putnam's recent book,

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[2] I thank Tora Bikson for an analogy to interaction terms in regression models, which led to this formulation.

[3] (Olson and Olson 2001) suggest that "readiness to collaborate" is an important precondition for effective use of group communication. I would argue that social capital is the key determinant of such readiness.

Bowling Alone (Putnam 2000). Participation in clubs and civic organizations has been cut by more than half over the last 25 years. Church attendance is down by roughly one third since the 1960s. Participation in bowling leagues is down. Even family dinners and vacations are way down.[4] As expected, this decline in the generators of social capital is matched by declines in attitudinal and behavioral indicators of social capital. Americans vote less, are less trusting of institutions and each other, and are less civil to each other (witness road rage).

There are many possible explanations for these declines, including differential generational coming-of-age experiences (Strauss and Howe 1992), changing residential and work patterns, and changing media consumption. If individual technology use were to be seriously implicated as a culprit, it would have to be TV (and perhaps radio and telephones) rather than Internet, since the Internet is too recent a phenomenon. Still, there is cause for concern that the Internet may make things worse. Though not definitive, the best study to date suggests that among new users of the Internet, heavier users experienced more negative changes in their level of social isolation than light users, as measured by loneliness and depression survey questions (Kraut, Patterson et al. 1998).[5]

Rather than assessing blame, this essay explores how technology, when paired with certain social practices, might help to reverse declining social capital in the civic sector. One approach is to try to reinvigorate the organizations and activities that have been sources of social capital in the past, by reducing the costs of coordinating and publicizing activities, or making the activities themselves more lively and exciting. Perhaps participation in the Boy Scouts, religious services, and even bowling leagues could be increased. For example, scheduling tools or even just email might reduce the costs of arranging meetings. Desktop publishing and web sites might provide new avenues for publicizing organizations and their activities and thus recruiting new members. Video screens and automatic scoring might even make bowling more fun. While this approach is certainly worth pursuing, it's unlikely that what we now consider traditional social capital building activities will regain the popularity they had in 1960.

A second approach is to try to invent new forms of togetherness that may be more suited to current lifestyles. Perhaps, with the aid of technology, it is possible to go beyond bowling together,[6] to form even more productive social relations even more conveniently. For example, a dormant email list may provide a just-in-case communication channel, allowing quick mobilization of a group when necessary, without creating any burdens during off-times. Feedback and reputation systems may enable trust to develop quickly in large groups. Technologies that enable lurking and catching up (e.g., FAQs or well-indexed meeting notes)

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[4] Some skeptics might argue that this is a spurious result of mis-measurement (e.g., surveys might not ask about new informal activities and people may answer survey questions differently than they did 30 years ago). The preponderance of data, however, from many different sources, all yielding trends in the same direction have convinced the author of this essay that the overall declines are real.

[5] Preliminary data from a follow-on study suggest that heavy use of the Internet acts more as a magnifier of underlying personality traits: the lonely get lonelier but the connected get even more connected (Bob Kraut, personal communication, July 8, 2000).

[6] This phrasing is inspired by an influential paper titled, "Beyond Being There", which suggested that computer-mediated communication could aspire to improve on face-to-face, not merely approximate it (Hollan and Stornetta 1992).

may enable peripheral participation without disrupting central activities. Introducer systems may enable just-in-time expansion of social networks.

Around the turn of the last century, social innovators created many new organizations, including Kiwanis, the Boy Scouts, and labor unions, in response to changing social conditions (factory work, immigration, urbanization). For a 21st century information society, an analogous spree of sociotechnical innovation will be needed.

In our own day, there are already some promising developments. Community networks are helping to publicize local organizations and activities, and are creating new spaces for public deliberation about civic matters (Schuler 2001). Sites like myfamily.com help people to rebuild extended kinship networks frayed by geographic dispersion. Sites like evite.com make it easier to invite people to social events and keep track of their responses. Additionally, by putting entertaining online, it helps to lend an aura of modernity to something that many people had viewed as passe. Webgrrls and other New Economy networking sites are jumping off the screen into face to face local chapter meetings.

This essay provides a conceptual framework, some examples, and a research agenda for understanding and generating sociotechnical capital, in the civic sector, but also in education and the workplace. The next two sections dissect the idea of social capital in more detail, first examining the kinds of productive activity it enables and then the kinds of social relations in which it inheres. Sections 4 and 5 explore the space of sociotechnical opportunities, including new kinds of interactions and new ways of capturing and managing the residuals of interactions. Section 6 provides a research agenda on understanding what features of sociotechnical relations are productive and measuring those features.

How Social Capital Works

It is clear that social capital makes a difference at a macro scale, but at a micro scale, how does it work? What can people who have social capital do together that otherwise would be difficult for them to do?

First, social capital can facilitate information routing. In an era of information overload, this cannot be accomplished simply by increasing flows of information. It requires selective highlighting of what is important, so that the people who can benefit from it will attend to it. Social capital can help in this regard. People who have interacted previously learn something about each other's interests, and can bring useful information to each other's attention. Prior interactions can also help decide which sources of information are worth attending to. For example, someone searching for a job will get better leads from people more familiar with the candidate and will be more likely to follow leads from people whose prior leads were valuable.

Second, social capital can help people to exchange other resources besides information. In a frictionless market, whenever one person valued a good more than another person did, an exchange would occur, creating a net increase in value for them. But many transaction costs can intervene to hinder such exchanges. First, the two parties must be aware of the exchange opportunity. Second, it may be difficult to quantify the value of the resources exchanged (consider, for example, small favors that neighbors or co-workers do for each other). The costs of accounting could easily consume the entire surplus from trade. Third, there may be difficult negotiations over division of the surplus from trade, with posturing during negotiation causing some valuable trades to be missed.[7] Finally, there may be risks in the consummation of trade. For example, a seller may take the buyer's money but not provide the expected good or service.

People who have social capital can reduce some of these transaction costs, and thus accomplish more beneficial resource exchanges. For example, people who know each other well may provide gifts or favors without payments or maintenance of explicit accounts. They also may be more willing to accept risks in trading with each other.[8]

Third, social capital makes it easier for people to provide emotional support to each other. People who know and trust each other are more likely to share personal information. If they have a background of shared experience, they can more easily convey that information, and responses are more likely to be interpreted as supportive.

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[7] Economists have demonstrated that there is no mechanism for two-party price negotiation that will induce rational negotiators to trade whenever such a trade would be beneficial. Rational efforts to capture the surplus will, of necessity, sometimes lead to dissipation of that surplus (Myerson and Satterthwaite 1983).

[8] It is interesting to note that taking risks and exchanging without keeping accounts also have feedback effects on the stock of social capital. If these interactions turn out well for all parties, they are more likely to do them again in the future. Conversely, Amy Tan's novel, The Joy Luck Club, includes a cautionary tale of the detrimental effects of strict accounting on a couple's social capital. Because they divide household costs based on actual use of resources, right down to the last spoonful of ice cream, they do not develop the trust and habits of sharing necessary to navigate more difficult problems.

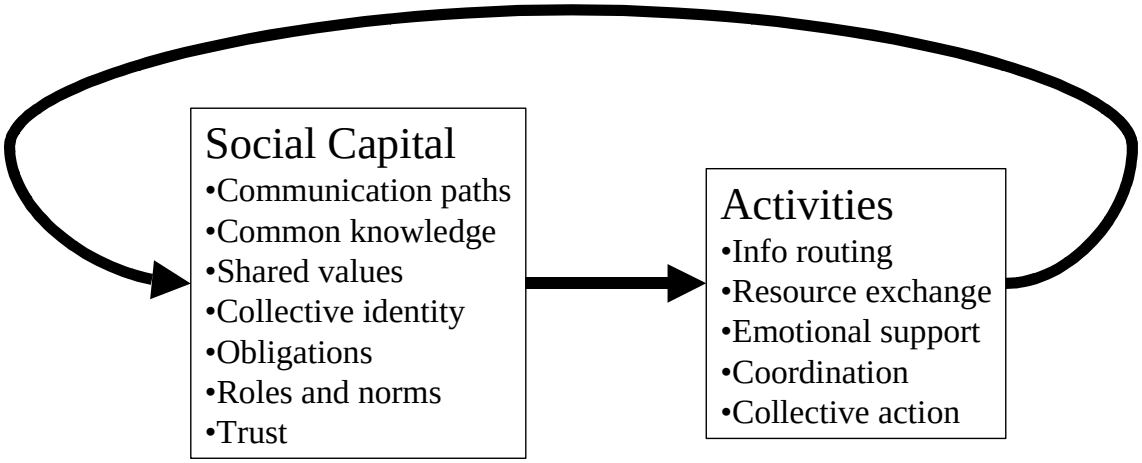

Figure 2: The forms of social capital and the kinds of interactions they enable.

Fourth, social capital enables coordination of interdependent actions. To complete a large project, some tasks may need to be completed before others, or undertaken simultaneously. (For a comprehensive taxonomy of dependencies that require coordination, see (Malone, Crowston et al. 1999).) Groups of people who have social capital are better able to schedule their activities and use of shared resources in a way that respects these interdependencies.

Finally, social capital can help people overcome dilemmas of collective action. One collective action problem is procurement of public goods, where people might free ride, hoping that others will supply them.[9] A related problem is the overuse of common pool resources, where individuals might consume more than their fair share, creating a "tragedy of the commons" such as overgrazing a shared pasture (Hardin 1968). Another related dilemma of collective action is social mobilization, where everyone may realize that all will benefit if they all act, but individuals who act without others will fare badly, and no one acts out of fear that others will not join. Starting a labor strike (Kollock and O'Brien 1992) or starting the dancing at a party are examples of this problem.

One solution to these dilemmas of collection action is to rely on some outside agent, a Leviathan, to force individuals to act collectively (Olson 1965). For example, governments force people to pay taxes to build and maintain roads. A second solution is to privatize the problem, for example by fencing in common grazing lands as a set of private grazing areas. The last solution is to rely on social capital, through social norms and sanctioning mechanisms that a group can enforce itself without the aid of an outside Leviathan (Ostrom 1990).

[9] Economists define a public good as one that is *non-rival*, meaning that everyone can enjoy it without reducing the benefit it provides to others, and *non-excludable*, meaning that if procured, it is available to everyone, regardless of their contribution to its procurement. Examples include roads, public safety, and radio and TV broadcasts.

The Anatomy of Social Capital

Thus far, social capital has served as a metaphor, defined as productive resources that inhere in social relations, as a residual of previous interactions. What exactly are these resources that develop in a social network over time, and why are they productive?

The first productive resource is communication paths. Prior (useful) communication from one person to another often establishes a path for future information flow as well: not only may it be easier for the sender to send but the receiver will be more likely to attend to the information sent. These communication paths can be represented as a graph, with people as nodes and communications paths between people as links. Coleman has argued that graphs with closure provide a better base for collective action (Coleman 1988). Here, closure means roughly that the people that person A interacts with interact with each other. Sometimes the closure need not be so direct, as when an adult's children's friends are also the adult's friends' children. Behavior monitoring, social support, and reciprocal aid are more likely to occur in such networks. Sometimes these within group ties are referred to as *bonding* social capital. Granovetter and others have noted that information flows better when there are bridging, or weak ties (Granovetter 1973). In contrast, if a clique is very tight, then members of the clique are less likely to have access to information or resources from outside the clique. These two arguments about desirable social network structure are somewhat at odds with each other, suggesting that different structures may be productive in different ways. Recent research has suggested that graphs that have significant closure (i.e., mostly cliques) with just a few bridging links can still exhibit a small-world phenomenon where everyone is only a few links away from everyone else (Watts 1999). So perhaps these two desirable features, closure and bridging ties, can both be achieved.

The second productive resource is shared knowledge. This can include not only knowledge of facts, events, or stories, but also a shared vocabulary and repertoire of ways of interacting (Wenger 1998). These make it easier to communicate and negotiate shared meaning in new situations. Shared knowledge can also contribute to a sense of emotional support, if people sense that others "understand" them.

The third productive resource is shared values. People with shared values find it easier to unite for a common purpose, and thus overcome problems of collective action. It is especially helpful if the shared values have been articulated explicitly, as this then permits explicit appeals to those shared values when exhorting people to act together.

The fourth productive resource is a shared sense of collective identity (Wenger 1998). Identity results from the interplay of three related factors: whether one considers oneself part of a group, whether other group members treat one as a member, and whether people outside the group do (Minow 1997). An individual who feels herself to be a member of a group may internalize the group's utility as part of her own preferences, which will help overcome problems of collective action and barriers to resource exchange. For example, parents who make personal sacrifices for the good of their children may not experience the actions as a sacrifice. An individual who is treated by other members as part of a group may be included in information and resource exchanges or be offered emotional support. Finally, if outsiders treat an individual as a member of a group, the welfare of that group becomes important to the individual, even if the individual does not otherwise personally identify with the group. Again, this can internalize group welfare into individual preferences, alleviating problems of collective action.

The fifth productive resource is obligations, debts that have been incurred during prior interactions. The obligations may be explicitly acknowledged, or implicit. In either case, the fulfillment of these obligations will create value for the group in the future.[10]

The sixth productive resource is roles and norms of behavior for people playing those roles. For example, someone playing the lecturer role does most of the talking, while people playing the audience member role are expected to signal a desire to speak and wait until the lecturer recognizes them. Well-defined roles create clear expectations of what people will do, enabling them to route information and exchange resources more efficiently. These roles and expectations can be codified into routines, patterns of behavior that become so automatic that people do not have to consciously decide to follow them (Nelson and Winter 1982). For example, a basketball team can execute a fast break if players know the roles involved. The person dribbling the ball knows where the other players will go, not because of who they are but because of their relative position on the court, which defines the role they will play this time down the court.

Certain norms can be especially productive. For example, a norm of joining in when someone takes a risky action can enable a group to overcome the collective action problem of mobilizing. The norm of reciprocity creates an expectation that an individual who receives a favor will feel obliged to pass it on, back to the original source (direct reciprocity) or to someone else (indirect, or generalized reciprocity). A norm of reciprocity is especially useful for resource exchange when the transaction costs of explicit accounting would be high. Exchanges based on a norm of reciprocity also have the side benefit of creating a feeling of emotional support, since it is validating to one's self-worth to receive something without an expectation of immediate, direct payback.

The seventh and final productive resource is trust. Trust is an expectation that others will act in a way favorable to one's interests, even if they have an opportunity to do otherwise. If, in fact, the people in one's environment are trustworthy, trust is productive because it enables risk-taking in resource exchange and in overcoming dilemmas of collective action.[11] Trust also colors how an individual interprets the actions of others, so that information from trusted sources is more likely to be heeded and aid from trusted people is more likely to create a sense of emotional support.

An expectation of continued interaction in the future is helpful in maintaining trust. A person might reason as follows. If I make myself vulnerable, my interaction partner might take advantage of me. That will help him in the short run, but will harm his reputation, so that he will be treated badly in the future. This "shadow of the future" (Axelrod 1984) will prevent him from taking advantage of me, and thus it is safe to trust him. Future consequences of current actions are essential to this reasoning. Thus, spread of reputational information can enable trust, because other members of the group can carry out retaliation against someone who is opportunistic. For a similar reason, multivalent or multiplex relations, where the same people interact in multiple roles or contexts, also enable trust. If my plumber also plays tennis with me, he is less likely to overcharge for plumbing work, since I might not only stop calling on his professional services but also stop calling him for tennis.

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[10] This suggests a curious inversion of the adage, "Neither a borrower nor a lender be." When I move into a new neighborhood or a new work environment, I take every opportunity to borrow and lend.

[11] Of course, if others are not trustworthy, then trust is actually counter-productive, and not sustainable.

In summary, social capital is both a residual of previous interactions and an enabler of future interactions. The residuals can include: activatable communication paths; shared knowledge and values; identities, obligations, and norms that people take on; and expectations that people form about others' behavior. These residuals are a resource that help people route information, exchange resources, provide emotional support, coordinate activity, and overcome dilemmas of collective action.

No comprehensive theory of how social capital grows or erodes has come to my attention and I have not yet been able to develop an adequate one. It is clear, however, that that the shadow of the future created by repeated interaction is a necessary condition. It is also clear that the generation and use of social capital act in a virtuous or vicious cycle. Successful collective action typically generates social capital while inaction or failed attempts to act together make it even harder to do so in the future.

SocioTechnical Capital Opportunities

Given this background on how social capital works, it is now possible to explore the new opportunities and pitfalls that ICTs present. In the absence of a comprehensive theory of how social capital builds and erodes, the exploration is organized around categories of technological affordances rather than social capital needs.

Removing Barriers to Interaction

The first and most obvious affordance of ICTs is that they enable interactions that would otherwise be cumbersome or impossible, as summarized in Table 1. Researchers in computer-supported cooperative work long ago noted that computer-mediated communication enables communication at a distance and communication across time. In addition, technology can present information in unobtrusive ways, so that interaction can take place without unduly disturbing other activities.

Interaction of some kind is a necessary condition for building social capital, so using ICTs to overcome these barriers to interaction is a potential opportunity. But interaction is not a sufficient condition. A long line of research has investigated various limitations of computer mediated interactions (Turoff, Hiltz et al. 2001) and there are good arguments that there may be inherent limitations to interaction at a distance that technology will never overcome (Olson and Olson 2001). Moreover, there are opportunity costs: if mediated interactions use time that would otherwise be used in face-to-face interactions, the net effect could be to reduce social capital. On the other hand, if the displaced activities are driving and television watching, or if the mediated interactions are in some way better than face-to-face at building social capital, the effect could be positive.

Affordance	Description	Examples
Distant communication	The sender and receiver need not be collocated.	Video conferencing, email, instant messaging, webcam
Asynchronous communication	The recipient of communication accesses it at a later time.	Voice mail, email
Peripheral presentation	An interaction need not take the user's full attention, and may not come to the attention of other people who are co-present.	Vibrating beeper, headphones, heads-up display in automobile

Table 1: How technology can remove barriers to interaction.

Expanding Interaction Networks

ICTs make it possible to interact with much larger social networks. Messages can routinely reach hundreds or thousands of people on mailing lists and computers can help people monitor and aggregate information from many sources. Again, the social capital impacts are ambiguous: if weak ties with a larger social network displace stronger ties with a few people, there are both gains and losses to social capital.

Affordance	Description	Examples
Large fan-out	One sender can send information to a large number of recipients.	Email lists, news groups, Web sites
Large fan-in	One recipient can receive information from many sources, and have them automatically aggregated.	Voting; information filtering and summarization; shopbots

Table 2. How technology can expand interaction networks.

Restricting Information Flows

A third opportunity is to use ICTs to restrict information flows. Interactions where people are not informed about each other's identity can sometimes allow people to transcend their stereotypes or take productive risks (Turoff, Hiltz et al. 2001). Similarly, the suppression of certain sensory information (smell, tone of voice, facial expressions) can, in some circumstances, allow people to transcend emotional reactions that would interfere with working together.

Access controls (e.g., an email list where moderators approve new members and new messages) are another example of restricting information flows. This can help build social capital in two ways. First, it can create a sense of boundaries, reducing the risks of participation and fostering a group identity among those who do have access. Second, according people different access privileges can reify roles. For example, when someone has moderator privileges, other people may interact with them in certain ways, triggering them to enact the role of moderator in whatever way is customary for the group.

Affordance	Description	Examples
Anonymity	Information about the identity of interaction partners may be partially or completely hidden.	Anonymous remailers; pseudonyms
Restricted modality	Communication may not have the full richness and nuance of face-to-face communication.	Text-only for email messages; voice-only for voice mail; no smell in video conferencing
Access controls	Some people may be prevented from reading or writing information or interacting with certain people or services.	Password-restricted areas on Web sites; firewalls; moderated email lists

Table 3: How technology can restrict information flows.

Managing Dependencies

Technology support can be incorporated into routines for managing dependencies. Calendar programs remind people of appointments and notification services alert them when messages arrive or other events occur. Concurrency controls help people work in parallel, preventing them from interfering with each other's work or alerting them when potential conflicts have occurred.

Affordance	Description	Examples
Notification	When an event occurs, the user is notified, so that user need not keep checking to see whether the event has occurred yet.	Beeper, smoke alarm
Concurrency controls	When people work together, technology can prevent them from overwriting each other's work, either by preventing simultaneous access or by merging changes that result from simultaneous access.	Transaction processing; check-out, check-in and merge features in RCS and CVS for software source code

Table 4. How technology can help manage dependencies.

Maintaining History

Technology is also useful in maintaining history, making the residuals of previous interactions visible in some way. History can be useful in several ways, contributing to common knowledge (people can consult an archive or FAQ), to the development of roles and a sense of collective identity (people can reflect on past patterns of interactions) and to trust (the visibility of interaction logs and explicit feedback can create accountability).

Affordance	Description	Examples
Document versioning	Track the history of all previous versions of a document, and note forks in the version tree where versions diverged from a common ancestor.	CVS for code versioning; "Track changes" feature in MS Word
Interaction logs	If interactions are mediated, the mediating computer logs user behaviors.	Web log files, email logs; purchasing history
Explicit feedback	People comment on the quality of information or interactions.	Buyer and seller feedback about each other on eBay; epinions.com
Network maps	Group members can reflect on their own interaction patterns, by looking at a visual representation of the graph of connections between members.	IKNOW (Contractor, Zink et al. 1998), Krackplot (Krackhardt, Blythe et al. 1995)

Table 5: How technology can maintain history.

Naming

Finally, ICTs can contribute to social capital through indirection in naming. Names can reify roles. For example, when a person sends email to editor@journal.org and it automatically forwards to the current editor, the sender is likely to interact with the recipient as editor, even if the two might interact in different ways in other contexts. Similarly, a named email lists can help establish a group identity: the group's membership can change over time, and individuals need not even be aware of the current membership when they send messages, but the name persists and acts as a marker of a single, collective identity.

Affordance	Description	Examples
Local names with late binding	People refer to information and other people by names that are resolved at the last possible moment. Thus, the referent can change dynamically and the user need not even be aware of its exact binding.	URLs for web pages; email groups such as listservs which are addressable by name but whose membership can change over time

Table 6: how technology contributes to establishing names for roles and groups.

Summary

Of course, none of these technology-mediated interactions or residuals will improve the social capital of all groups in all situations. For example, a webcam may enable peripheral participation, but it may also engender distrust, if people feel that they are being spied on. The purpose of the inventory of affordances is merely to spark the imagination about promising new sociotechnical relations that are worth exploring.

Examples of New SocioTechnical Relations

Given these building blocks, what new kinds of social relations seem like promising forms of sociotechnical capital? There are a few categories of opportunities, including enhanced group self-awareness, reliance on brief and intermittent itneractions, low-maintenance (in terms of time) social ties, support for collective action in large groups, and just-in-time introductions.

Enhanced Group Self-Awareness

Groups can use captured traces as a basis for reflection on their own activities. For example, visualizations of who knows or interacts with whom (Contractor, Zink et al. 1998) or of overlaps in mailing-list subscriptions (Donath 1995) can highlight connections among people. Greater awareness may lead to greater investment in activities that build these networks, creating a positive feedback loop. Both visual representations of activity and assigning a name to a group may also aid in formation of a sense of group identity.

Brief interactions

Lee Sproull and John Patterson have noted a serious limitation of traditional civic activities: they almost all require synchronous, co-located participation in 2-3 hour chunks of time (Sproull and Patterson 2000). Perhaps there is another way. People can engage in short interactions, if the setup for each interaction is easy enough. Setup can involve costs of coordinating schedules and locations, and cognitive costs of recalling the context of previous interactions. Technology-mediated communication can eliminate the need for co-location, reducing transportation costs. Monitoring and notification technologies can make it easy to coordinate schedules, and use of asynchronous communication can eliminate the need to coordinate schedules entirely. Technology-mediated histories can help people recall the context of previous interactions.

For example, some people are using buddy lists and instant messaging to maintain frequent, brief contacts with their friends or co-workers throughout the day (Nardi, Whittaker et al. 2000). Similarly, people are using pagers and text messaging features in cell phones to exchange very brief messages. On a larger time scale, some college students today are exchanging short email messages with their parents, siblings, and high school friends, enabling them to maintain relations that likely would have atrophied when their counterparts went to college two decades ago.

Maintaining Ties While Spending Less Time

People can maintain ties while effectively using less time, either by actually spending less time interacting, or by doing other things while interacting. This can either free up time for other activities, or allow people to maintain more interaction overall.

Technology can reduce the time-burden that initiating newcomers places on other group members. The FAQ document[12] is becoming an accepted norm for on-line discussion spaces (news groups, email lists, and Web sites). A social norm is emerging that newcomers to any group should read the FAQ (and other documentation) before posting a request for help. The availability of a FAQ, together with the social convention of checking it, allows a group to welcome newcomers without having them hold back the conversation or other activity of veteran participants.

Some people are always more active than others in any group. Previous theories have emphasized peripheral participation as an important stepping stone toward full membership in a

[12] FAQ stands for Frequently Asked Questions. The questions act as an index to the answers, which provide important information for newcomers. Sometimes the questions truly have been asked frequently, but even new groups will provide an FAQ document, reflecting questions that the authors think newcomers might ask, if the FAQ weren't available.

community of practice (Lave and Wenger 1991). But technology may enable people to maintain membership in a group while spending less time on the group's activities than would otherwise be necessary to stay comfortably and productively at the periphery. For example, if records of meetings are captured and easily accessed, a person who only rarely attends meetings may still be able to participate fully in those meetings she attends. If speech recognition improves, computers might scan records of conversations and highlight the parts that were relevant to particular people. It might even be possible to monitor conversations in real time and notify participants when they should tune in. For example, in large software development projects, there are often people present at meetings just in case something comes up that will affect their organization or functional area. They could perhaps participate more peripherally and just as effectively.

Rather than occasional activity from some members, the group as a whole may be dormant for a long period of time, but activatable just in case it's needed. Dormant groups can be difficult to reactivate, but technology may make this easier to do. For example, a year ago I created an email list for the people who live on my block. It's almost never used (about one message a month), and only a few people have posted messages, so by conventional HCI evaluation methods it would be considered a failure. However, it turned out to be extremely useful on a few occasions, for arranging a block party, announcing funeral arrangements for a neighbor, and alerting people to a car break-in. People don't often have messages they want to broadcast to the block, but the list is there just in case.

Multi-tasking is another way to stretch the available time. Lawyers have long had more than 24 (billable) hours in a day, and everyone else seems to be catching on to the practice of doing more than one thing at a time. Cell phones have made it possible to talk while walking or, unfortunately, driving. Teenagers are apt to talk on the phone while watching TV.[13] At my health club, people watch TV, listen to music, or read a book while exercising. People often take advantage of multi-tasking to negotiate possible interactions (Nardi, Whittaker et al. 2000), for example sending a text message to someone who may be in a meeting. Instant messaging and vibrating pagers or handhelds make this possible without interrupting the meeting.

Support for large groups

New forms of sociotechnical relations may be especially useful for large groups of people, groups so large that it's impossible for everyone to know everyone else. In larger groups, there are more opportunities for information and resource sharing, but it's difficult to coordinate these, and it is also difficult to overcome problems of collection action. SocioTechnical Capital may enable productive activity in these larger groups.

Word of mouth normally travels from person to person in a social network. Recommender systems (Resnick and Varian 1997) can supercharge this process, allowing recommendation sharing among people who may not know each other or be explicitly aware of each other's interests. Computers provide support for gathering feedback, about information, products, or even people, either in the form of explicit ratings or traces of behavior such as clickstream or purchasing data. For example, amazon.com gathers explicit book reviews from readers and also

[13] Jorge Schement (personal communication) relays an amusing story about his observation of a teenage relative who had the TV on, as well as an active chat window and a phone conversation. When asked, "What are you doing?" she replied, of course, "Watching TV with my friend."

mines purchasing behavior to generate bestseller lists and links from individual books to other related books. Recommender systems can aggregate feedback from multiple people in a personalized way, identifying people who have similar interests and then weighting their feedback more heavily. One potential downside to recommender systems is social fragmentation, if people only share information with others who are like-minded (mathematical models suggest this could occur even if each individual has only a slight preference for homogeneity (Van Alstyne and Brynjolfsson 1996)). That is, communication paths might form cliques rather than bridging ties, thus destroying the social capital benefits that come from the small-world phenomenon. Terveen and Hill (Terveen and Hill 2001) explore the future of recommender systems in more detail.

In large groups, it is hard for individuals to determine who to trust, and hard for the groups as a whole to encourage trustworthy behavior. This acts as an inhibitor to transactions that require risk-taking and to collective mobilization whenever there is an opportunity for free-riding. A reputation system gathers information about people's past behavior and makes it available to others. For example, at eBay and other auction sites, a buyer and seller can leave comments about each other after completing a transaction and these comments are visible to future buyers and sellers.

If people regularly provide honest feedback, and those with more positive feedback are treated better in the future, this can enable the maintenance of trust in a large on-line interaction environment (Resnick, Zeckhauser et al. 2000). Game-theoretic analysis suggests that this can be fairly effective, though not optimal, even if people remain anonymous and thus have the option of shedding bad reputations and starting over (Friedman and Resnick in press). Preliminary empirical analysis of eBay auctions in several categories suggests that social practices have indeed evolved at eBay that reward sellers who have better reputations with higher prices for their goods (Bajari and Hortascu 2000; Lucking-Reiley, Bryan et al. 2000).

One of the most exciting trends in software development is the success of open-source projects (Raymond 1999). Much has been made of the surprising economic viability of these projects, given that users of the software don't pay for it. The interesting feature from the sociotechnical capital perspective is the ability of a large group of people, most of whom will never meet each other, to together create really good software. Each project has a central coordinating body that maintains the recognized "source tree", including a version history and, in some cases, alternate versions (e.g., updates to the official release version may not be reflected in the code people are working on for the next release). Anyone can check out a copy of code files and contribute updated files or new files as candidates for inclusion in the official source tree. Concurrency control features make it easy to merge changes from several people who have worked in parallel, and to identify any conflicting changes they have proposed. Over time, contributors can develop reputations for writing good code, and their suggested code is more likely to be included in the official versions.

Software is not the only mass-collaboration authoring happening on the Internet. For example, the on-line documentation for the programming language PHP allows anyone to add a question or comment to the bottom of any page in the manual (see php.net). The reader contributions tend to be quite helpful, clearing up infelicities and omissions in the original and providing useful code samples that official documentation writers might otherwise be expected to provide. The site BetterTogether.org applies this widely distributed authoring idea recursively to the topic of

building social capital. It invites readers to contribute stories about new ways of building social capital, or to add comments about others' stories.

New technology and social practices can also support conversation in very large groups. The division of netnews into a hierarchy of topics, with response threads within each topic, was an early way of structuring large conversations. Some of the early work on recommendation sharing was motivated by the need to find personally relevant messages in netnews (Resnick, Iacovou et al. 1994). Recent work explores visual representations of social networks and topic relations as a way to keep conversations manageable as the number of participants grows. (Sack in progress).

Introducer systems: just-in-time social ties

In everyday life, people introduce friends and colleagues to each other. In larger, more diffuse groups, computer technology can assist in this social process. Some of the early writings on recommender systems suggested that people who shared tastes in movies or music should be introduced to each other (Hill, Stead et al. 1995). The site sixdegrees.com explicitly represents social networks and then automatically passes on messages to "friends-of-friends", a form of automatic introduction. ReferralWeb automatically finds paths in social networks, suggesting a sequence of intermediaries could serve as personal introducers in order to make a connection with someone else (Kautz, Selman et al. 1997). Modern personal ads, which seem to be quite popular based on their volume in local papers, introduce people to each other and mediate the exchange of messages (often through voice mail) while people decide whether they want to strike up a relationship. The Yenta system takes this cloaking of identities to the next level, making matches based on common interests (personal or professional) while providing cryptographic guarantees of anonymity until participants decide to reveal their identities or other personal information (Foner 1999).

Documents can act as interesting focal points for introducing people. Common interest in a document suggests that an introduction might be worthwhile, and the document itself can act as a natural first topic for conversation. For example, in the BetterTogether.org story collector mentioned above, each story has the potential to act as a focal point for introducing readers to each other.

Finally, directories can help to break the ice among people who are members of new or loosely-knit groups. The directories can include photos, contact information, offers or requests for resources, and something fun or personal that acts as a conversation starter when people meet. Neighborhoods, church groups, civic organizations, and even entering classes of graduate schools are all good candidates (see, for example, www.whothat.org).

Research Agenda

The examples above suggest that there are rich opportunities for new sociotechnical relations. Research is needed in several areas to better understand which kinds of sociotechnical relations can properly be called sociotechnical capital.

Measurement of SocioTechnical Capital

First, research is needed on ways of measuring sociotechnical capital. Social capital is an intermediate outcome, both a residual of some activities and an enabler of others. Thus, social

capital metrics need to function in some studies as independent variables. For example, in Putnam's study of Italy, regions with greater social capital in the late 19th century had better political and economic outcomes in the late 20th century, even controlling for political and economic conditions in the earlier period (Putnam 1993). For designers and evaluators of information systems, however, social capital metrics will more often serve as a dependent variable. If the social capital metrics increase as a result of a group of people adopting certain technology and social practices, it is a marker of success of that combination.

Some traditional social capital metrics will be appropriate for sociotechnical capital as well. But some are based on implicit assumptions about what social relations are productive and what activities generate them, assumptions that may not hold when information and communication technologies are available. The inventory below pays special attention to potential limitations and suggests avenues for development of new metrics. Previous social capital metrics measure activities, attitudes, and networks. Consider each of these in turn.

Activity-based social capital measures include membership in organizations, participation in elections, and attendance at meetings and other face-to-face events. For example, Putnam reports survey data about how often Americans attend club meetings, participate in neighborhood activities, play cards, go on picnics, eat dinner with friends (Putnam 2000).[14] These measures, however, would miss trends in interactions that are not face-to-face. It may be that these other forms of interactions are not as good at building social capital, but that needs to be determined independently, using some metric of social capital that does not privilege face-to-face interaction.

Attitude-based social capital measures focus on people's dispositions and their expectations about how others will act. These are typically measured through surveys, and include measures of collective efficacy (members' belief in the ability of the collective to act effectively), psychological sense of community, and neighborhood cohesion (Lochner, Kawachi et al. 1999). There have also been attempts to develop behavioral measures of these attitudes. For example, experimental economists ask subjects how much they would be willing to pay the experimenter to have the experimenter drop on their street an unsealed envelope with $10 in it and with the subject's name written on it (Gleaser, Laibson et al. 1999). This measures the subject's level of trust in the people on that street to return the money to her.

Some attitude-based measures are situational, reflecting who a person is expecting to interact with and in what context; others measure more universal dispositions, such as the general social survey question, "Most people can be trusted-- or you can't be too careful dealing with people." The measures of universal dispositions are generally more useful when social capital is an independent variable, because one would not expect them to change quickly in response to adoption of new information systems or social practices. Contextualized measures will be quite useful in studying sociotechnical capital, but need to be adapted to reflect situations where people expect information systems to be available and used in particular ways. Thus, for example, in measuring the sociotechnical capital resulting from eBay's feedback system, it is not enough to inquire about participants' beliefs in how trustworthy sellers are in general. What matters is how trustworthy they are, given their reputations, given the ability of the buyer to provide feedback at the end of transaction, and given the expectation that others will look at that feedback in the future.

[14] Some of the data sets are available for download at bowlingalone.com.

Finally, network measures of social capital reflect which people know each other and tend to interact with each other. Networks are usually represented as graphs, with people as nodes and links between nodes if the people know each other or tend to interact with each other. Many metrics can be computed over these graphs. For example, the diameter of the graph is an indicator of how quickly information might spread through the network (Watts 1999). The presence of cliques or near-cliques may indicate a group with strong ties, and the absence of links connecting subgraphs is an indicator of boundaries where information or trust might stop (Burt 1995).

When using network measures of sociotechnical capital, extreme care must be taken. As suggested in the previous section, one of the new and productive forms of sociotechnical relations may be dormant but activatable social ties. Other ties may be latent, with introducer systems making it possible to connect people when the need arises. Metrics on graphs may still be useful, but only after creative definition of links between nodes that takes into account the potential for future interaction and not simply the history of past interaction.

Creating and validating metrics of sociotechnical capital is an important research problem. When appropriate, it is advantageous to use existing measures of social capital, because many of these measures have already been validated through correlation with positive final outcomes such as health, education, and crime reduction. In some cases, however, new measures may be needed. There may also be opportunities for new kinds of metrics. For example, it may be possible to mine transactional or clickstream data (e.g., bidding behavior at eBay) to determine behavioral measures of trust. It may also be possible to have a group conduct a stylized activity on-line (e.g., play a social dilemma or negotiation game (Rocco 1998)) to determine how effectively the group can act together. Any new metrics, however, will have to be validated, either by showing a correlation with existing metrics or by showing a correlation with the ability of a group to achieve desirable individual or collective outcomes.

Case Studies of New SocioTechnical Relations

A second line of research is further exploration of new forms of sociotechnical relations. The examples above of new ways that people might interact and the new kinds of residuals they might rely on only scratch the surface of what is possible. Concerted efforts are required to imagine new technologies and social practices that plausibly could enhance the capability of a collective to serve individual and collective needs. Similar effort is required to evaluate social capital impacts, both controlled experiments testing interventions and natural experiments where new social relations are emerging without the experimenter's intervention. This process will yield a set of case studies that are fodder for more systematic theorizing.

One case study that I have been working on measures the impact of a photo directory and email list on the way that neighbors interact with each other. The intervention is for a block captain to interview his or her neighbors, create an email list, and distribute paper directories with names, contact information, hobbies or interests, and photos, to everyone who wants to participate. Before and after the intervention, everyone on the block is asked to complete a survey with a number of social capital questions. Details can be found at www.whothat.org.

Codification of the Opportunity Space and Determining Which Features are Productive.

More systematic theorizing needs to begin with a codification of the space of opportunities for new sociotechnical relations. Ideally, this codification would identify basic building blocks, independent features of sociotechnical relations whose utility could be evaluated semi-independently of other features. This is a common goal in characterizing the design space for technical systems. One strategy is to collect examples of different designs and ask what they have in common and how they differ. The ways that they differ often fall naturally onto one or more independent dimensions. For this strategy, a large collection of case studies is especially useful.

One approach would be to consider features of technology and features of social practices separately. This is unlikely to be fruitful, however, if the evenutal goal is to make claims about the utility of different configurations. As suggested in the introduction, the most interesting forms of sociotechnical capital are likely to be those where there is an interaction effect between the technology and the social practices. For example, the practice of allowing a group to go dormant when there is nothing it needs to do may only be effective if technology mechanisms are available that make it easy to reassemble the group when it is needed. Thus, the research challenge is to break down the space of opportunities along dimensions that capture both technical and social aspects and which have identifiable impacts on the ability of a collective to act effectively.

It would also be helpful to develop a grand theory of how social capital builds and is destroyed. As mentioned above, repetition and reputation are important preconditions, and successful use of existing social capital is often a way to build more. A more comprehensive theory, however, would account for the permeability of boundaries, the effects of homogeneity and heterogeneity in group composition, and many other factors.

With a characterization of both the opportunity space and the sources of social capital, it may then be possible to make claims about the social capital effects of various sociotechnical features. For example, a long line of research has investigated the effects of restricted communication modalities (e.g., text only, voice+text, video) on the ability of a pair or group to carry out specific tasks, such as design, negotiation, or cooperation in a social dilemma (Rocco 1998; Olson and Olson 2001). Similarly, if periodically dormant communication channels were one of the dimensions of the space of opportunities, a research goal would be to make claims about the extent to which that kind of sociotechnical relation supports various kinds of collective activity (information routing, resource exchange, emotional support, coordination, public goods production).

Even if researchers are successful in identifying types of sociotechnical relations that are resources people can use to act together, it will not follow automatically that these sociotechnical relations will emerge naturally. Further research will be necessary to identify ways to introduce technology and seed practices so that the desired sociotechnical capital will grow.

Conclusion

This essay has suggested a reorientation of researchers' attention away from immediate ability of people to complete tasks, toward the longer term effects on their ability to act collectively. But long-term effects are distant and highly contingent. The concept of social capital provides a way

of thinking about intermediate states, immediate effects of people's interactions that have long-term consequences. This makes social capital a good focal point for research, especially for HCI designers and evaluators.

First, social capital effects may appear sooner and be easier to measure than some of the long-term outcomes that we might care about, such as organizational productivity or improved health. Thus, social capital measures can be useful outcome variables in evaluations of information system interventions. Do networks become denser? Do ties form between groups? Do people interact more frequently and share more information when they do? Do they provide more favors for others without keeping strict accounts, thus indicating a norm of reciprocity? Do they trust one another more or feel a greater sense of belonging?

Second, information systems designers may have a special role to play in helping to resolve social science controversies about whether observed correlations between social capital measures and positive outcomes are actually causal. Few previous studies have made causal claims. It is possible in some cases to argue causality from the temporal sequence of observed changes in social capital variables and end outcomes (e.g., Putnam's study of Italy (Putnam 1993)). But it is rare to find such natural experiments and still rarer to find sufficient data about them to yield strong conclusions. If information systems interventions can be found that reliably cause changes in certain measures of social capital, these interventions can be used to manipulate social capital as an independent variable in experimental or quasi-experimental studies, and hence study their causal impact on end outcomes.

Technology is not just a creator (and destroyer) of old forms of social capital. New forms of social relations can emerge that would be infeasible without computers mediating interactions and managing the interaction traces and artifacts that are created during interactions. The challenge for activist researchers is to identify and promote those new social relations that truly are productive. There seem to be some promising opportunities, including maintaining ties with occasional, short, or peripheral interactions, and loosely coupled collective activity in large groups. Some variants of these social relations seem to be beneficial while seemingly similar variants leave people feeling disconnected and unable to act collectively.

Exploring and codifying the space of opportunities, and evaluating the effects of various options on sociotechnical capital, is extremely important work. It is clear that society is changing, and that older forms of togetherness that generated social capital no longer draw people in the way they once did. The pure entertainment value of computer-based interactions is another lure away from face-to-face interactions. If we do not succeed in generating new forms of sociotechnical capital from these on-line interactions, our society will decline in its ability to provide emotional support to its members, to overcome transaction costs that hinder resource exchange, and to overcome dilemmas of collective action. In the long run, our economy, our health, and our safety may all be at stake. The future needs us to succeed in identifying and promoting new forms of sociotechnical capital, in the workplace, in learning environments, and especially in civic life. Are we up to the challenge?

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