GROUP COGNITION AND CREATIVITY IN ORGANIZATIONS

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ABSTRACT

Groups play a central role in organizational creativity, a role that becomes evident when these interactions are viewed as part of a larger organizational context. Research on creativity and innovation in organizations has traditionally focused on the role of groups as context for individual cognition and action. This paper draws from recent research on highly innovative organizations to suggest that groups act as agents and not simply arenas of creative action in those organizational contexts where social interactions can trigger the recognition and recombination of diverse individual knowledge. Field data and relevant theories from social and cognitive psychology are used to explicate how group interactions elicit relevant theories from social and cognitive psychology are used to explicate how group interactions elicit relevant though often non-obvious knowledge from individuals regarding the cur- rent situation or past experiences and trigger creative ways of combining those ideas to solve new problems. In essence, groups often create novel and unexpected combinations of an organization's past knowledge in ways that individuals or more for- mal organizational structures do not. This chapter describes how this group process is supportedby'1he larger organizational context and discusses why, despite research suggesting group efforts at creativity are less efficient than individual ones, such processes continue to playa central role in organizational creativity.

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In 1988, Reebok approached an engineering consulting firm, Design Continuum, to develop a successful response to the introduction by Nike of their Air ™ technology, a heel cushion and "active energy return system." Instead, Design Continuum created the Pump ™ shoe concept. The concept produced a form-fitting shoe by incorporating an inflatable air bladder into the sides of an athletic shoe. A solution that first emerged when one of the designers, who had previously designed an inflatable splint, recognized how such splints might *prevent* injuries by building ankle support into a basketball shoe. Another on the team had worked on medical equipment and, familiar with IV bags, saw how these small sealed bags could be modified to provide the oddly-shaped air bladders necessary to make this "splint-in-a-shoe" concept work. Still, the problem remained of how customers could easily inflate and deflate the shoe. Others in the firm became involved, several having worked with diagnostic instruments and the little pumps, tubing and valve components that made up those products. When they recognized how such components could be adapted to fit in the tongue of the shoe, the major ideas of the concept were in place. Eighteen months after introduction, The Reebok Pump ™ Shoe accounted for over $1 billion in revenue in the highly competitive athletic shoe market and gained wide praise in the business press for its creativity. This paper focuses on the creative process that led to this solution, and on the role of problem solving groups in that process.

Groups play a central role in organizational creativity, a role that becomes evident when their interactions are viewed in an organizational and environmental context. Yet research on creativity and innovation in organizations has tradition- ally limited their role to merely providing the context for individual cognition and action. Amabile, for example, recognizes the presence of small groups, but focuses her model on "the influence of organizational factors on individual creativity" (1988, p. 123). Kanter asserts that "Undeniably, innovation stems from individual talent and creativity" (1988, p. 205). And Woodward, Sawyer, and Griffin (1993, p. 303) describe how, in their model of organizational creativity, "The group constitutes the social context in which the creative behavior occurs." Was the group merely an arena for individual creative action at Design Continuum? The project team's ultimate solution depended on the group and its interactions to recognize and combine diverse ideas. No one designer held the necessary information either to recognize the value of others' knowledge or to create the ultimate solution. Instead, this recognition and creativity depended on and was triggered by the social interactions that constitute the group.

Groups act as agents and not simply arenas of creative action in organizational contexts when social interactions trigger the recognition and recombination of diverse individual knowledge. One such context is described by recent research on knowledge brokering organizations (Hargadon & Sutton, 1997; Hargadon, 1998a, 1998b). Knowledge brokers represent a set of organizations that routinely innovate by exploiting their network position spanning multiple domains to recognize and transfer ideas from where they are known to where they are not. In so

doing, knowledge brokers develop creative solutions by combining old ideas seen elsewhere-a definition of creativity described by Weick (1979, p. 252) as "put- ting new things in old combinations and old things in new combinations." Design Continuum, for example, innovated in the Reebok Pump TM solution by combining ideas its designers had seen before while designing medical products, instrumentation, and inflatable splints. By working in such diverse domains, individuals in knowledge brokering firms develop valuable and diverse inventories of past ideas that could contribute to creative solutions for new projects in other domains. What bring these diverse ideas together in new and valuable combinations are the interactions of the project team. Group interactions elicit relevant (and often non-obvious) knowledge from individuals regarding the current situation or past experiences and trigger creative ways of combining those ideas to solve new problems. This group-level cognition depends on the organizational context, because from this larger context flow the past ideas and new problems that comprise it.

Evidence gathered during field studies within 8 knowledge brokering organizations suggests group interactions are central to the creative process and offers insights into how these group interactions resemble and differ from individual cognition in creativity. I begin by describing the program of research that guides and grounds these findings, then integrate existing literature-on groups, creativity and innovation and cognitive psychology together with the evidence gathered to explain how groups create new combinations of an organization's past knowledge. I describe how this process differs from similar actions by individuals and how it finds support in its larger organizational context. Finally, I discuss the implications of such a perspective for future research on groups and their role in organizational creativity.

RESEARCH SETTING AND METHODS

This paper presents evidence from a study of eight organizations to characterize the role of group level interactions in the process of organizational creativity. The original intent of this research was to understand how the new product or process development process occurred in organizations whose primary task was to innovate. To do this I studied organizations, or groups within organizations, that did not produce pre-determined goods or services but rather created solutions to novel problems presented by their external (or internal) customers. For these organizations, the ability to consistently innovate is less a long-term strategic goal than a short-term necessity.

Research Setting

This research perspective first emerged over 18 months while Robert I. Sutton and I observed an engineering design consulting firm, IDEO Product development. We interviewed practically everyone in the firm, from the CEO to newly hired engineers, we observed teams at work and in meetings, and we collected evidence through questionnaires and other secondary data. Descriptions of new product and process innovations suggested that knowledge brokering may occur in a wide range of industries and organizational forms. To investigate this range, I added evidence from the in-depth study of seven organizations that appear to routinely create new combinations of existing ideas. Here I developed case studies based on interviews with managers and project team members, observations of work, and primary and secondary documents detailing the organizations. These organizations fell into three categories: product design consulting firms with clients in multiple industries, management consulting firms with clients in multiple industries, and large manufacturing firms that operate divisions in multiple industries. Because the focus of this study was the process of routine innovation, the sites were chosen because they shared similar environmental conditions (i.e., each held network positions as brokers connecting relatively disconnected domains) and shared similar outputs (i.e., each described their output as new combinations of existing ideas). The logic behind their selection follows.

Product Design Consultants

Two product design consulting firms participated in this research, IDEO Product Development and Design Continuum. IDEO is headquartered in Palo Alto, California while Design Continuum is located in Boston. These two firms are, in order, the two largest product design consulting firms in the country. Product design consultants provide engineering or industrial design services, or both, to client organizations. My study focused primarily on the process of engineering design, which in these firms ranges from conceptual work on possible product lines to detailed engineering drafting or analysis.

In addition to "live" case studies, I investigated the role of past product design consulting organizations in knowledge brokering. These firms were Edison's Menlo Park Laboratory and Elmer Sperry's work as a consultant during the early years of his career. In both cases, these firms incorporated new electro-magnetic technologies into products for industries that had little or no previous experience with such knowledge or created industries around new combinations of these ideas. Research on these organizations involved gathering primary and secondary source materials, analysis of technical artifacts, and interviews with scholars familiar with the subject. [1]

Management Consultants

Two management consulting firms participated in this study: McKinsey & Co. and Andersen Consulting. Like IDEO and Design Continuum, these two firms are among the largest management consulting organizations in the country, and are known for their ability to consistently provide innovative solutions for their clients.

Manufacturing Firms

The two multi-divisional firms in this study were Hewlett-Packard and Boeing. These large manufacturing firms often have internalized access to the technologies and market needs of different industries and often organize by division around these different industries. This study focused on a set of internal consulting groups and their ability to create innovative solutions by recognizing and transferring ideas between the different divisions of their host organization.

Research Methods and Data Analysis

This research used qualitative methods to gather data from multiple sources within each organization. Gathering evidence from multiple data sources addresses potential problems of construct validity within a case study because these different sources "provide for multiple measures of the same phenomenon" (Yin, 1994, p. 92). These multiple measures allow for triangulation, a process of data evaluation that builds support for any findings or conclusions from the convergence of multiple, independent observations. This research gathered data from six sources: inter- views with key informants, project post-mortems, observations of work, tracking of particular projects (whether "live" or retrospectively), documents about the organization, and technological artifacts of the organization.

I used an iterative process to develop the inferences about group level interactions and creativity in organizations. Following Glaser and Strauss (1967) and Miles and Hubennan (1994), a set of iterations usually began with a hunch inspired by the data or literature (e.g., I observed a group problem solving session in which the current project was compared to a variety of past projects, suggesting groups made sense of current problems based on past diverse experiences). Then, to see if a hunch could be grounded, I compiled pertinent evidence from all eight cases studies (e.g., I looked for evidence that an organization's experience in a wide range of domains provided its members with an inventory of valuable problem definitions and solutions). These analyses led me to abandon, modify, or maintain each inference (e.g., I retained the inference that individuals working in multiple industries learned of new problems and solutions and that the group interactions were where the relevance of these individual experiences was recognized. If the inference was retained, I then wrote up my inferences regarding each

retained consequence, weaving together conceptual arguments, additional evidence, and citations to pertinent literature.

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This paper proposes and offers preliminary support that group interactions do more than provide the context for individual cognition in creative problem solving. Rather, these interactions uncover how diverse past knowledge held by some members might solve current problems faced by others. In the case of the Reebok Pump TM shoe, for example, this chapter explains how members of the design team came to recognize that their own knowledge of inflatable splints and IV bags were relevant to designing a better basketball shoe. Further, this chapter describes how once these ideas emerged the designers found others outside the team who had relevant, but unexpectedly so, knowledge of valves, pumps, and other useful technologies. This recognition and recombination of diverse past knowledge is neither trivial nor routine in organizations. As one Boeing manager explained,

> There are cases where the person who has the knowledge can be sitting right next to you and it goes unnoticed and you plow a lot of ground that you didn't necessarily have to. There's still a lot of duplication of effort. There just isn't any way that I know of to really make that happen so that all knowledge that has ever been done on something is available to the person at the time in which they need it. It's all a matter of getting the right knowledge into the right hands at the right time.

Or, as a manager at Hewlett-Packard quoted an old lament, "If HP only knew what HP knew." Organizations often contain a rich and diverse knowledge base, but this i does not guarantee that the relevant knowledge will be available at the right time: to the right people. The case studies reveal that, in the context of knowledge-brokering organizations, group interactions uncover how past knowledge held by one set of individuals can solve new and problematic situations faced by others.

These group interactions demonstrate a process of analogic reasoning that cognitive psychologists have studied in individual problem solving. Analogic reasoning involves recognizing links between the current, problematic situation, and recalled past problems and their solutions. Framing the current situation (the tar- get problem) in terms of a past problem (the base analogue) identifies a set of past solutions that can be adapted to fit the new situation (Gick & Holyoak, 1980; Gentner & Gentner, 1983; Reeves & Weisberg, 1993, 1994). For example, Reeves and Weisberg (1993, p. 246) argue that "people often solve problems by appeal to previously learned problems rather than through the use of abstract rules that can be applied to a broad range of problems." Neustadt and May (1986), Schon (1993), and Hargadon and Sutton (1997) have argued that analogies play a critical

role in organizational problem solving because they allow problem solving groups to create innovative solutions by linking their inventory of past experiences to the current situations they face. Hargadon and Sutton (1997) and Hargadon (1998a, 1998b) further argued that the range of past experiences held by the group represents the variety of possible base analogues that may be considered in developing new solutions.

The process of analogic reasoning works in part because *it* allows problem solvers to consider new definitions of the problems they are facing by linking their current situation to past ones they have seen before. While problem solving and idea generation receive most of the attention in studies of creativity and innovation, problem setting exerts an equal, and possibly stronger, influence on the creative process in an organization context. Weick argues, for instance, "In real-world practice, problems do not present themselves to the practitioners as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain" (1995, p. 9). Further, Lave (1988, p. 42) argues "Whether to have a problem or not, and the specification of what constitutes the problem, are commonly choices made by problem solvers." And Schon (1983, p. *40)* describes how,

> Although problem setting is a necessary condition for technical problem solving, it is not itself a technical problem. When we set the problem, we select what we will treat as the "things" of the situation, we set the boundaries of our attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situation needs to be changed. Problem setting is a process in which, interactively, we name the things to which we will attend and frame the context in which we will attend to them.

Framing involves "embedding observed events in a context that gives them meaning" (Beach, 1997, p. 17). The framing of problematic situations provides an interpretation of the problem at hand and identifies a set of solutions normally associated with that problem, and it does so by interpreting the problematic situation through analogies to previously known problems.

The data support the perspective that analogic reasoning plays a significant role in creating new products or services from seemingly unrelated past projects and solutions. To this day we screw in light bulbs the way we do because one of Edi- son's lab assistants saw a similarity between keeping the newly developed light bulbs in their sockets and the screw top cap of a kerosene bottle. As another example, a project at Design Continuum involved a pulsed lavage, a medical product ' used in emergency rooms for cleansing wounds, that had to provide a pulsed flow of saline solution, had to meet medical product guidelines for cleanliness and safety, and had to be low-cost and disposable. The design team recognized similarities between the demands of the pulsed lavage project and those of a previous product they had developed years earlier, a battery powered squirt gun. On the surface, an emergency room tool and a children's toy seem unrelated. But by recognizing the non-obvious similarities between the requirements of the two prod-

ucts, Design Continuum's engineers were able to rapidly combine the low-cost electric pump and battery of the toy squirt gun with the materials and design guidelines of medical products to develop a successful new pulsed lavage. In another project, IDEO designers attempting to develop a spill-proof nozzle for a bicycle water bottle recognized and exploited similarities between the problems of the water bottle design and a previous project designing a shampoo bottle able to hang upside-down.

In these examples the ultimate solution built on the principles that were identified through these analogies, but not all analogies become part of the finished design. Designers will use analogies to generate a wide range of alternatives to choose from. One brainstorming session at IDEO on "ways to deep-clean car- pets" elicited analogies to tank treads, street sweepers, tractor combines, hair removal devices, shavers, whips, vibrating combs, squids and Velcro. Another brainstorm, on designing a "portable kitchen counter," generated analogies to jet fighter wings, plastic coolers, children's furniture, washing machines, bent wood chairs, surfboards and skis. Elements on these lists may appear unrelated, but each analogy was used to frame aspects of the current project in the context of other, past experiences.

The context of knowledge brokering organizations, where diverse experiences of individuals are *routinely* brought to bear on a range of new problems, makes visible the central role of problem setting and analogic reasoning in organizational creativity. For example, a McKinsey partner described how this process was fundamental to her work,

> challenges are parallel. It's often helpful, in working with clients, to bring those analogies out and say "Gee, by the way, this problem you're facing is the same one we faced when working with frozen foods."

Because McKinsey consultants, like other knowledge brokers, have access to a broad range of industries and the problems and solutions that exist within each, they are in a better position to recognize when these problems might exist elsewhere.

> The difficulty with problem definition is the function of presumed problem solution possibilities [it leaves you with]. ... You'll never define a new problem if you start off in the traditional way that people do.

By generating a range of problem definitions to choose from, these problem solvers make available an even wider range of solutions to consider.

While existing research on analogic reasoning has focused on individual problem solving efforts, groups appear to engage in these same activities. And though analogic reasoning plays a central role in group-level creativity, it does so in ways

that differ from the mere aggregation of individual-level analogic reasoning. In many of the instances of innovation within this study, one person had knowledge of the current project while another had knowledge of non-obvious but ultimately relevant conceptions of the problem (and their associated solutions). The analogic connection that occurred in these cases developed across people, through an evolving dialogue, rather than within a single individual. A manager at Andersen Consulting described how their Center for Strategic Technology enables these analogic connections:

> First of all you have to acknowledge that this isn't a deterministic effect. There's a dynamic that's happening in the room. More often than not we try to build these presentations so that we can meet them halfway in the jump from our solution to their specific business situation in industry. We want the visiting clients and partners to be actively drawing the connections as well. . . [For example] I've had a head for health care organization see the same model, the demand chain manager model. But what do slurry pumps have to do with illness and health care? And he put the whole thing together at the end. I said so what do you think, how does this apply to your industry? He goes 'It's no different. If you substitute patients for customers and what you're doing here in terms of forecasting demand and the network of physicians, this is my industry and this is where we need to go.' That's what we also want to try to do here, in the workshop side of things, we're trying to make those cross-industry jumps.

Similarly, a McKinsey partner described her experiences working on a problem in a group:

> It tends to be less that the client has come and said, you know, I need exactly "x" and we say all right, well here's an "x" on the shelf and therefore we'll pull it off and deliver it to you. It's much more a conversation in that we're reflecting with the client about, for example, what would it take for them to improve their performance or, thinking longer term, what would it take for them to become a more effective institution. And, out of those kinds of conversations then flow some key issues that they're wrestling with and we'll develop-either on our own or with them-some perspectives on those key issues and then frame that into a project that says, you know, let's tackle this defined set of key issues.

The analogic connections that link past ideas with new problems at Andersen Consulting, McKinsey, and other knowledge brokers take place as a social process. While the imposition of a problem definition, or frame, on a problematic situation occurs at the individual level, the invocation, negotiation, and ultimate acceptance of one or several frames are activities that occur through group interactions. By bringing together individuals with a variety of experiences and extracting the knowledge of each, group analogic reasoning may impose a broader variety of meanings onto a given situation than could individuals acting alone.

Such a description of how the analogic reasoning process occurs in groups may offer a new perspective on the nature of problem solving in organizations. The evidence suggests that group-level analogic reasoning differs from individual level analogic reasoning in three important ways: it draws on more diverse back- grounds; it builds on itself in exploring new interpretations and analogies; and it is observable and plays a central role in supporting the organization's culture.

First, group-level analogic reasoning, while replicating the mechanism of identifying underlying similarities between present and past problem, differs from individual level reasoning by bringing more diverse background knowledge into play. This can be seen in a justification given to us by a manager in Hewlett-Packard's SPaM Group for his emphasis on teamwork:

> Let's say each engineer knows three problems and three solutions. That mean, in theory, they could come up with 9 possible problem solution combinations. But if those engineers work together, and share what they know, then a three-person group has the potential to generate 81 ideas, not 27. [3 people x 9 problem-solution combinations versus 9 problems linking with 9 solutions].

The designers at IDEO recognized this distinction as well. One designer described how she shared her project's problems with others in the organization because "[By] planting those seeds allover the place,… the wider you can plant it the more stuff that keeps coming in." Another said, "When you get a lot of people thinking about the issues, you multiply the chances that somebody will come back with an idea or article that's pertinent." As analogic reasoning moves from the individual level to the group level, the ability to recognize how past knowledge is relevant to a current problem (or the organization's set of current problems) may under certain conditions increase exponentially.

Second, analogic reasoning differs at the group level from the aggregation of individual level reasoning because, through the interaction of diverse individuals, it builds on itself in exploring new interpretations and distant analogies. Gian Zaccai, CEO of Design Continuum, recognizes this difference:

> You pick two people, with different experiences and maybe even different training and put them together and you've got that kind of a synergy, an exchange of ideas. Because whatever this person says will provoke a hundred different ideas in this other one and a hundred different memories.

Similarly, Nicole, an engineer at Design Continuum, described how the brain- storms they regularly conduct produce unexpected ideas by pooling expertise and ideas from a variety of sources. In one meeting, designers were searching for solutions to a complex valve mechanism for a gardening application:

> You get to the brainstorming session and say 'Well I remember a product that you could just plug into the faucet, it wasn't electric and it pulsed the water flow. You know this

Water Pik thing that you just shoved on the faucet. How did that work?' And Don will say 'Oh, it's got a little spring mast thing in there and a valve that moves back and forth.' He's an electrical engineer. How did he know that? Well, Don happens to know all kinds of stuff like that so he's a great person to have at a brainstorming session.

Nicole and Don, individually, may not have arrived at the potential value of a spring mast for solving the gardening project. But together, over a brief inter- change, Nicole's initial suggestion prompted Don to recall past knowledge that had until then not seemed relevant. And even this connection emerged only after the prompting and new perspectives generated by previous analogies that arose over the course of the meeting.

The interaction between Nicole and Don entailed more than an aggregation of two individuals listing potential problem definitions. One suggested frame shifts awareness in ways that make another visible. Fiske and Taylor (1991) argue that "once cued, schemas [or frames] affect how quickly we perceive, what we notice, how we interpret what we notice, and what we perceive as similar and different" (p. 122). Further, research has shown that "a shift in schemas allows one to recall details not easily recalled from the other [original] perspective" (Fiske & Taylor, 1991, p. 125). The introduction of an alternative frame makes salient different aspects of the situation which, in turn, may prompt insights into other potential frames. Such a process may occur at the individual level but group interactions increase the ability of its members to generate and shift between alternative frames of a given situation.

Finally, analogic reasoning is a more observable cognitive phenomenon when it occurs at the group level than when it occurs in individuals. This not only affects researchers studying the process, but also the participants themselves. As described by Sutton and Hargadon (1996), brainstorming and other problem solving sessions may serve to both maintain organizational norms and values for decision making and creativity, and socialize newcomers to those norms and values. Individuals participating in these group problems solving sessions may learn to look for analogies and experiment with alternative problem frames when working ...J alone. For example, designers at IDEO referred to "real" brainstorms as scheduled meetings in conference rooms led by a facilitator, but described IDEO as "one long brainstorm that never stops" and brainstorming "as a way of life." They did so because the way they interacted in brainstorms shaped and reflected more general expectations for thought and action. Further, group interactions also may sup- port norms and values that encourage individuals to seek the help of others in framing and solving the problems they face in their individual work. One senior designer described the attitude at IDEO:

We are all very smart people, but given the complexity and constant tradeoffs associated with the design process, brilliance comes from the minds of lots of smart people

rather than the actions of one brilliant designer. A true genius wouldn't be happy here. But I don't know if they exist.

Another engineer at IDEO described how, when he arrived at IDEO, he learned to seek the knowledge held by others in the organization:

Where I worked before, you just didn't ask for help. It was a sign of weakness… [At IDEO] We don't have time to screw around. At the first hint I don't know something, I'll ask "Does anyone know about this?" The whole thing here is you've got to leverage as much as possible. You ask for help. You are expected to ask for help here.

At Design Continuum, one engineer described the learning process that occurs after participating in these problem solving groups:

You have that different perspective partially through the experience of just being exposed to all different kinds of programs directly but also just getting in the habit of doing that. You can see that you need to apply other manufacturing processes to places that have never heard of them.

And a McKinsey consultant described, "[It's] a cultural thing. It is assumed that you will use [the knowledge directory] and assumed that you will make those calls. It kind of says 'In this area this person's the expert.'" In this way, group-level analogic reasoning not only provides a separate mechanism for generating solutions, it may also instruct and support the process of individual-level analogic reasoning and the process of seeking out the knowledge of others in these organizations.

DISCUSSION

Sharing the organization's knowledge through interpersonal connections appears too many to be an inefficient and random process. For example, Mullen, Johnson, and Salas (1991, p. 18) concluded from their meta-analysis of the Brainstorming research: "It appears particularly difficult to justify brainstorming techniques in terms of any performance outcomes, and the long-lived popularity of brainstorm- ing techniques is unequivocally and substantially misguided." Why, then, would individual problem-solvers in organizations turn to these methods early and often in the face of their project's problems? Why, when individual performance appears to be more effective than group interactions, would problem solvers actively seek the help of others in the organization? To answ~r these questions, it is useful to consider the alternative means these organizations used to link their diverse past knowledge to the new situations they face.

All of the organizations studied had invested, sometimes heavily, in databases to codify the vast and clearly valuable experiences of the organization's members.

IDEO and Design Continuum have shelves of project binder~/intended to serve as records of past thinking and the solutions generated. McKinsey, Andersen, and Boeing have firm-wide databases, into which people are expected to enter information about completed projects, including both lessons learned and abstracts of potential interest to others. Hewlett-Packard's SPaM group maintains a common server that holds all of the past models that were created, including documentation of different aspects of each program. As consistently as these organizations adopted such databases, however, their organizational members described their ineffectiveness. As one Hewlett-Packard informant described, "It's all in people's heads. It's out there. The model's out there somewhere but there's so many models that are out there in the network drive that if you didn't know, you'd spend days trying to find out what you were looking for." And at Design Continuum, an engineer recounted how,

> We had this library where different people were supposed to maintain a library of different things like this person was going to maintain a library of glues. And this person was going to maintain a library of plastic parts and it just completely fell apart. It didn't go two weeks before it was completely fallen apart cause there was no real mechanism to insure that it happened.

So while considerable organizational effort and investment had gone into providing a means to capture and codify individual knowledge to make it avail- able to all in the organization, these efforts were not valued by the very people they were intended to serve.

Most informants described how, when faced with a problem, they would first attempt to tap the organization's knowledge through direct, interactive communication with others. These interactions are neither well-defined nor predictable. Typically, they involve open-ended searches, producing names of other people to talk to more often than producing answers. Moreover, they tend to result in as many ways to define the question, or frame the problem, as they result in possible answers. A Boeing engineer explained:

> The way we find out about [possible solutions] is normally engineer to engineer. People knowing people. It is a human network that basically is where the real knowledge transfer occurs right now.

Searches take the form, for example, of ad hoc conversations (in hallways and on the telephone), formal brainstorms and other meetings, and tapping into personal or organizational networks. A McKinsey partner explained how these searches unfold,

> If I had a problem that was outside of my experience base I wouldn't know who to go to. What I would logically do is the most comfortable thing for me to do, which was to go to somebody who's in the practice who I know from the office and say 'I'm running

into some issues about IT cost production, how do you think about that and who's the best person to call?' They would say 'Oh you really ought to talk to so and so.'

Similarly, a Design Continuum manager described their typical search for solutions:

You get to a point in the project where you realize that the group you've got there of which you're a member just doesn't quite have that special ability. You feel like there must be this solution there but none of you is breaking through and you go get some- body else to help out. Sure there are brainstorming sessions, or it can be as casual as a hallway conversation or dropping by and "Can you think about this problem for a few minutes with me? Am I overlooking something here? I mean how could we solve this problem?" And the person might say, might be able to cough up a solution on the spot or he might say here's the direction I would take.

IDEO, Design Continuum, and McKinsey also relied heavily on formalized meetings such as brainstorms (Osborn, 1957; Sutton & Hargadon, 1996) or other problem solving sessions to generate links between current problems and past solutions. A Design Continuum engineer described,

The reason to have collaboration and brainstorming is because you could invite a bunch of people to a brainstorming session and not know what they're going to bring from their experience and their kind of internalized data base and all that stuff-How things are done.

IDEO's "Methodology Handbook," written to help new employees understand their design practices, tells project leaders: "Set up at least two major introductory brainstorms to get the best minds in the company, the collective consciousness of the office, working on your problem."

Most of the firms also supported this process of interpersonal interactions through formalized efforts to generate contact between individuals across the organization. McKinsey, for example, publishes a "yellow pages" that identifies individuals in the organization and what past experiences they have had:

We call it the Knowledge Resource Directory. Which basically is just a list of all the different areas of specialization and all the people who could be experts in it. And, you know, I have no problem and even as a brand new associate I had no problem just going in there, identifying the person, and calling them up and saying "I saw you in the Knowledge Resource Directory. Here's my question. Can you help me out?"

Further, the managers in these organizations were often expected to act as resources not only of their own past information, but also of who else in the organization might know something relevant to a particular problem. Another McKinsey consultant described how,

The senior people obviously have a broader perspective on the resources available and all of that. I find that one of my main jobs is saying, "Hey, I know these three people who know these things about this. Have you talked to them yet?" That's like one of the big sentences that comes out of my mouth a lot.

Similarly, an engineer at Design Continuum described how they relied on managers and the older employees for help in figuring out where to find help,

We try and remember who worked on what and you try to go to the people that have been here a long time, which mayor may not be managers, but in most instances, it is a manager.

One IDEO informant described the value of an upper level manager, "Peter was the best 'hub' of information; he is involved in all of the projects and knows what everyone is working on." Edison himself served this role. Millard (1990, p. 37) recounts how,

Each afternoon, [Edison] would tour the laboratory, going up to each man at the work- bench, questioning him about what he had done, discussing the results, and deciding what to do next. An extremely observant man with an excellent memory, he never lost track of an experimental project and could remember previous experiments that might provide useful information.

In these organizations, the role of manager was not so much not to coordinate or control work, but to foster and initiate interpersonal interactions between their subordinates and others in the organization who might hold valuable knowledge. Within knowledge brokering firms, members search for useful new solutions by relying on activities that allow them to find non-obvious connections between past problems and their current problems. From this perspective, we may see one answer to why technical knowledge management efforts often fall short of expectations. Formal databases codify knowledge, storing it in ways that could be easily retrieved using known and expected keywords. When problems are well known, these systems provide effective storage of the solutions that are typically associated with those problems. But the very efficiency of database "deposit-and-withdrawal mechanisms" makes them difficult tools for finding non-obvious links between ideas.[2] Individuals often chose search activities that retain the equivocality of the organization's past knowledge, the multiple meanings that can be considered and re-applied in the new context. As one HP engineer described,

When you read about somebody's experience and then actually go in there and talk to them about it you find out that the level of knowledge is so much deeper than what can be transferred through a paper or through an hour-long talk. There's a wealth of knowledge that's hidden that's a result of the struggles, the agonizing they went through to try to figure out what's the right way to proceed rather than the wrong way.

By maintaining the multiple meanings of past knowledge, problem solvers maintain flexibility in creating new analogic connections between that past knowledge and current projects. This flexibility enables them to generate a range of alternative problem definitions to describe a particular situation and, from this range of problems and the solutions associated with each, the participants can consider and pursue ideas that might not have emerged otherwise.

CONCLUSION

Weick (1995) argues that attributions of individual cognition and action in organizations can be misleading as they result in individualist explanations for what may be social processes. This paper has presented evidence suggesting group analogic reasoning plays a central role in organizational creativity and innovation, particularly in those organizations that innovate by creating new combinations of existing ideas. But why study analogic reasoning in groups? Because it occurred in formal and informal group meetings in every organization I observed. Because it is a cognitive process of creativity that is visible-you can see people talking but you can't hear them thinking. Because group level analogic reasoning may differ from the same process as it has been studied at the individual level. And, finally, because the context in which the group operates, by giving value to the diverse knowledge of its members, can be seen influencing both the process and outcome of creative efforts.

The nature of qualitative and inductive research is to identify and motivate potential new research directions. The process of analogic reasoning in groups, as well as the importance of the context in which those groups operate, are examples of areas that would benefit from quantitative, theoretically-deductive efforts aimed at confirming or disconfirming the ideas presented here. The creative process has long been the province of individual level researchers, whether in cognitive psychology or in micro-organizational behavior. Consider, for example, the substantial research buttressing the conclusion that brainstorming meetings fail to produce more (or better) ideas than would the same number of individuals working alone (Mullen, Johnson, & Salas, 1991; Stroebe & Diehl, 1994; Paulus, Brown, & Ortega, 1996). These studies reify the presumption that grollps act only as the context for individual creativity, particularly when they are shown to be relatively poor contexts for such creativity. In organizations, where creativity is often a process of recombination and where problem setting is often as critical as problem solving, the interactions of groups extend beyond mere arenas for individual creativity. As Lacey et al. describe in their paper in this book, "Groups are locations where the introduction of new practices from the outside environment is recognized, adapted, and their implementation is initiated." Whether as ongoing teams, as temporary groups in brainstorms and other problem solving meetings, or as momentary dyads in hallway or telephone conversations, group

interactions generate creative ideas as often as they provide a context for individual creativity.

A perspective that values these group-level outputs without insisting on individualist attributions may open new avenues for understanding how knowledge is shared and created in organizations. For example, how and where does problem setting occur *as a social process* in other organizations and settings? Under what conditions do group interactions focus on generating alternative frames for problematic situations rather than alternative solutions for a single problem definition? And, perhaps more importantly, under what conditions do individuals seek group interactions rather than individual efforts to solve problems?

With the diversity they bring to bear on any problematic situation, the interactive explorations they can produce, and the visibility and socialization they pro- vide, group interactions influence organizational creativity beyond merely providing the context for individual creativity. The perpetuation of a research focus on individual creative actions will continue to distract from the insights into how groups "act" in the primarily social processes of problem setting and recombination. The attention given to individual creative accomplishment in culture and in academic research may affect how those pursuing innovation in organizations go about their work, how they later describe that work, and how we as scientists ultimately choose to describe and measure their work. The data from this research offer a glimpse into how group interactions influence organizational creativity. Francis Jehl, one of Edison's long time assistants, once explained that, "Edison is in reality a collective noun and means the work of many men." The study of creativity and innovation in organizations might benefit from more such collective nouns in our vocabulary.

NOTES

1. History has often distorted the innovation process; for instance creating heroes in Edison, Bell, and Ford when the major inventions that came from them often came from the talented, but nameless, individuals in their organizations. Comparing current organizations and their innovation processes to past organizations allows us to consider the historic role of organizations in what has been predominantly seen as an individual creative process.

2. The more formal databases took on new roles in some of these organizations, particularly as a means for stressing the importance of interpersonal communication and for respecting (and searching out) the knowledge held by others. A McKinsey senior associate explained,

Both formal and informal mechanisms for linking are critical. I think the formal connections rein- force how important knowledge sharing is in the institution and it allows informal connections to actually be legitimized in my view. That helps you one, recognize the importance of knowledge sharing and, two, the informal sharing becomes a forum by which you build informal networks right and so it increases the breadth of your footprint in the firm of how many people you've interacted with on how many different topics.

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