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THE INTERPLAY BETWEEN EXPLORATION AND EXPLOITATION

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Exploration and exploitation have emerged as the twin concepts underpinning organizational adaptation research, yet some central issues related to them remain ambiguous. We address four related questions here: What do exploration and exploitation mean? Are they two ends of a continuum or orthogonal to each other? How should organizations achieve balance between exploration and exploitation—via ambidexterity or punctuated equilibrium? Finally, must all organizations strive for a balance, or is specialization in exploitation or exploration sometimes sufficient for long-run success? We summarize the contributions of the work in this special research forum and highlight important directions for future research.

Since the publication of March's (1991) pioneering article, the terms "exploration" and "exploitation" have increasingly come to dominate organizational analyses of technological innovation, organization design, organizational adaptation, organizational learning, competitive advantage and, indeed, organizational survival (e.g., Benner & Tushman, 2003; Burgelman, 2002; Holmqvist, 2004; Katila & Ahuja, 2002; Lee, Lee, & Lee, 2003; McGrath, 2001; Sigglekow & Levinthal, 2003). Notwithstanding the growing reliance of organizational research on these twin concepts, an examination of the literature indicates that the answers contained there to the central questions on this subject remain incomplete, at times contradictory, and at best ambiguous. We use the term "central questions" to refer to the following four issues.

The first issue pertains to *definitions and connotations*. What do exploration and exploitation really mean? There appears to be consensus around the view that exploration refers to learning and innovation (i.e., the pursuit and acquisition of new knowledge). However, a similar consensus is lacking on the question of whether exploitation refers solely to the use of past knowledge or whether it also refers to the pursuit and acquisition of new knowledge, albeit of a kind different from that associated with exploration. For scholars to build a truly informative and significant body of research in this area, it is critical that they be clear on definitional issues. Also, it is important to ensure that the way exploration and exploitation are empirically defined is consistent with and appropriate to their conceptual definitions.

The second issue pertains to *orthogonality versus continuity*. Are exploration and exploitation two ends of a continuum, or two different and orthogonal aspects of organizational behavior? In part, the answer to this question depends on the conceptual definition of the terms "exploration" and "exploitation." However, the salience of this question goes far beyond mere definitions. Theories about the ease or difficulty with which an organization can pursue both exploration and exploitation depend crucially on whether these two tasks are treated as competing or complementary aspects of organizational decisions and actions. In addition to theory development, empirical tests of predictions regarding the impact of "balance" between exploration and exploitation on organizational performance would need to be different depending on whether these two concepts are viewed as mutually antithetical or complementary.

The third issue pertains to *ambidexterity versus punctuated equilibrium*. Building on March's initial premise that organizational "adaptation requires both exploitation and exploration to achieve persistent success" (1991: 205), some studies have concluded that the answer lies in "ambidexterity" (Benner & Tushman, 2003), whereas others have concluded that the answer lies in "punctuated equilibrium" (Burgelman, 2002). *Ambidexterity* refers to the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits or individuals, each of which specializes in either exploration or exploitation. In contrast, *punctuated equilibrium* refers to temporal rather than organizational differentiation and sug-

gests that cycling through periods of exploration and exploitation is a more viable approach than a simultaneous pursuit of the two. As may be clear, ambidexterity and punctuated equilibrium are radically different mechanisms. Existing literature is silent on the questions of whether these two mechanisms are equally viable, so that an organization can pick one or the other at will, and whether exogenous or endogenous contextual factors should drive the choice between the two mechanisms.

Finally, the fourth issue pertains to *duality versus specialization*. Echoing March's (1991) arguments about the need for balance between exploration and exploitation, there is near consensus in the literature that, notwithstanding their radically different dynamics, organizations must learn to excel at both tasks. We wonder, however, if such a consensus may be somewhat premature and not necessarily logical in all contexts.

In the balance of this paper, we address each of these four issues and then provide an overview of the seven papers that comprise this special research forum on managing exploration and exploitation. Finally, we offer a set of research questions and research questions to guide future research.

DEFINITIONS AND CONNOTATIONS

As noted, the central ambiguity regarding the definition and implications of exploration and exploitation lies in whether the two are distinguished by differences in the type of learning or by the presence versus the absence of learning. Baum, Li, and Usher (2000), Benner and Tushman (2002), and He and Wong (2004) are illustrative of studies that explicitly embrace the idea that both exploration and exploitation are associated with learning and innovation, albeit of different types. Baum, Li, and Usher suggested that "exploitation refers to learning gained via local search, experiential refinement, and selection and reuse of existing routines. Exploration refers to learning gained through processes of concerted variation, planned experimentation, and play" (2000: 768). According to Benner and Tushman, "Exploitative innovations involve improvements in existing components and build on the existing technological trajectory, whereas exploratory innovation involves a shift to a different technological trajectory" (2002: 679). Along the same lines, He and Wong (2004: 483) defined exploitative innovation as "technological innovation activities aimed at improving existing product-market domains" and exploratory innovation as "technological innovation aimed at entering new product-market domains." As is evident, in all of these

studies, learning, improvement, and acquisition of new knowledge are central to both exploitation and exploration. At the same time, the differences between the two concepts pertain to whether the new learning occurs along the same trajectory as the old one or along an entirely different trajectory.

In contrast, other studies (e.g., Rosenkopf & Nerkar, 2001; Vassolo, Anand, & Folta, 2004; Vermeulen & Barkema, 2001) appear to treat all activities associated with learning and innovation as instances of exploration and to reserve the term "exploitation" for activities in which the central goal is using past knowledge rather than moving down any kind of a learning trajectory. This approach to conceptual interpretation appears explicit in Rosenkopf and Nerkar's (2001) study of the impact of local and nonlocal knowledge search on the quality of resulting patents. In the case of patents that were informed exclusively or largely by local knowledge, they accepted the possibility that "some readers might consider this a form of exploitation rather than local exploration" (2001: 289). However, noting that their study focused entirely on the R&D process and patenting activity, they preferred to term such cases "the most localized form of exploration" rather than "exploitation." Similarly, in their study of firms' international expansion decisions, Vermeulen and Barkema (2001: 459) defined exploration as the "search for new knowledge" and exploitation as the "ongoing use of a firm's knowledge base." Building on these definitions, they treated all acquisitions as representing exploration and all greenfield investments as representing exploitation.

Reflecting on these somewhat different approaches to defining exploration and exploitation, our conclusion is to build on March's (1991) logic and to argue that all activity includes at least some learning. Even when an organization is attempting to do nothing more than replicate past actions, it accumulates experience and goes down the learning curve, albeit in an incremental manner (Yelle, 1979). Thus, for social systems, there is no such thing as perfect replication. There is always some learning, even if it is relatively little and serves only to reduce variation around the historical mean. As March noted, "The essence of exploitation is the refinement and extension of existing competencies, technologies, and paradigms. . . . The essence of exploration is experimentation with new alternatives" (1991: 85). To sum up, we would argue that it is more logical to differentiate between exploration and exploitation by focusing on the type or amount of learning rather than on the presence or absence of learning. Defining these concepts in terms of the presence or absence runs at

least two kind of risks. One, many activities that, by March's (1991) definition, should be viewed as exploitative would instead be counted and coded as exploratory. Two, for activities coded as exploitative, researchers may overlook the reliability-enhancing learning that results from all human and organizational attempts to replicate past routines.

In keeping with March (1991), in this discussion of what exploration and exploitation mean, we have treated the organization as the unit of analysis. However, variations in the unit of analysis may well affect the answer to our questions, What is exploration and What is exploitation? That is, whether learning differs by type or by presence versus absence could very well depend on whether one is focused on the individual level, the team level, or a more macro organization level. For example, an engineer might search and experiment to discover a new method of producing a product, but the organization in which he/she is employed might then exploit this new innovation for profit. Similarly, it is entirely possible that repetitious routines of exploitation may not involve much learning at the individual level (e.g., a machine operator producing the same widget each day). However, such an absence of learning is less likely at the group or organizational level simply because of variation in skills, knowledge, and experience across individuals. In other words, at a group or more macro level, it is more likely that some learning from experience will take place because of differences among individuals. Consequently, what one individual or organization may view as exploratory and experimental learning, another team or individual may view as exploitative or incremental learning. The above discussion highlights the need for researchers to carefully specify a unit of analysis in defining exploration and exploitation.

CONTINUITY VERSUS ORTHOGONALITY

March (1991) appeared very clear in his theorization that, even though both exploration and exploitation are essential for long-run adaptation, the two are fundamentally incompatible. March (1991, 1996, 2006) provided several arguments in favor of this incompatibility. First, exploration and exploitation compete for scarce organizational resources. Thus, by definition, more resources devoted to exploitation imply fewer resources left over for exploration, and vice versa. Second, and assuming all else equal, both types of actions are iteratively self-reinforcing. Because of the broad dispersion in the range of possible outcomes, exploration often leads to failure, which in turn promotes the search for even newer ideas and thus more exploration,

thereby creating a "failure trap." In contrast, exploitation often leads to early success, which in turn reinforces further exploitation along the same trajectory, thereby creating a "success trap." In short, exploration often leads to more exploration, and exploitation to more exploitation. Third, the mind-sets and organizational routines needed for exploration are radically different from those needed for exploitation, making the simultaneous pursuit of both all but impossible. As March noted, "Exploiting interesting ideas often thrives on commitment more than thoughtfulness, narrowness more than breadth, cohesiveness more than openness" (1996: 280). To summarize March's arguments, notwithstanding the adaptation benefits of both exploration and exploitation, the interplay between the two occurs in the form of a zero-sum game where exploration and exploitation compete for scarce resources, attention, and organizational routines; accordingly, logic dictates that exploration and exploitation be viewed as two ends of a continuum.

It is all but impossible to dispute March's logic. However, it is possible to question some of his key assumptions. Consider his arguments about the scarcity of resources. Although it is generally true that most organizational resources are finite, this need not be so for all types of resources. Some resources, such as information and knowledge, may be infinite (Shapiro & Varian, 1998). Also, organizations often have access not only to the resources that they own but also to resources in their external environments (Powell, Koput, & Smith-Doerr, 1996). Access to such external resources may come about either because these resources constitute public goods (e.g., articles published in journals) or because the focal organization has established strategic alliances with other stakeholders who privately own or control complementary resources. Access to external resources considerably eases the constraint imposed on organizations by the scarcity of internal resources. Katila and Ahuja's (2002) conceptualization of exploration and exploitation provides a nice example of what happens to these concepts when the relevant resources do not suffer from the constraint of scarcity. In keeping with March's (1991) arguments about the beneficial effects of pursuing both exploration and exploitation, Katila and Ahuja (2002) found empirical support for their prediction that the interaction between exploration and exploitation will have a positive impact on new-product development. At the same time, departing from March's notion of exploration and exploitation as competing phenomena, Katila and Ahuja (2002) conceptualized these as orthogonal variables. Exploration was operationalized as search scope (i.e., the propensity to cite different patents), whereas exploitation was operationalized as

search depth (i.e., the propensity to cite certain patents repeatedly). Since the number of patents an organization may cite is unlimited, and the marginal cost of accessing the knowledge embedded in one more patent is highly likely to be modest, it seems reasonable to conclude that exploitative versus explorative search (as reflected in patent citation data) does not suffer from severe resource constraints. Nerkar's (2003) study on the antecedents of why some patents have greater future impact than others provides an interesting parallel to Katila and Ahuja (2002). Nerkar looked at the main as well as the interactive effects of exploration and exploitation in the knowledge search underlying patents. He measured exploration as the time spread of past knowledge and exploitation as the recency of past knowledge, and he left open the possibility that a specific patent might exhibit high or low levels of both exploration and exploitation.

Scarcity of resources as well as conflicts over mind-sets and organizational routines are also non-issues when a researcher's interest lies in analyzing exploration versus exploitation in two different domains that are either loosely connected or connected via standardized/modular interfaces. For instance, consider a firm such as Cisco. The technologies and designs embedded in Cisco's products suffer from a high rate of obsolescence, making it imperative that the company pursue a highly exploratory strategy with respect to technology and product development. At the same time, even radically new and different products can be manufactured, sold, and serviced via a preexisting commercialization infrastructure that evolves relatively slowly (Rangan, 2005). In other words, the interfaces between product R&D on the one hand and manufacturing, sales, and service on the other are relatively standardized. Note that, in this case, the resources needed for product R&D are fundamentally different from those needed for complementary downstream activities. As such, it is easy to imagine that Cisco could simultaneously engage in a high degree of exploration in product R&D and a high rate of exploitation in complementary domains such as manufacturing, sales, and service.

Several recent studies have examined the idea that organizations operate in multiple domains, not all of which are tightly coupled via specialized interfaces. These studies have chosen to treat exploration and exploitation as simultaneously achievable and thus, for all practical purposes, orthogonal. Some illustrative examples are Baum, Li, and Usher (2000), Beckman, Haunschild, and Phillips (2004), Koza and Lewin (1998), and Rothaermel (2001). Baum and his colleagues (2000) viewed an organization's learning from its own experience as exploitation and its learn-

ing from others' experience as exploration; since both these types of learning are potentially unlimited, they treated the two as orthogonal. Beckman and her colleagues (2004: 259) analyzed interorganizational relationships and treated "relationships with new partners" as a form of exploration and "additional relationships with existing partners" as a form of exploitation; here too, given that the number of interfirm relationships has no well-defined limit, the authors treated exploration and exploitation as orthogonal. Koza and Lewin (1998) and Rothaermel (2001) focused on interfirm alliances and adopted a similar logic. According to them, any firm can engage in a multiplicity of alliances, and any one of these alliances can be classified as exploratory or exploitative.

Answering the question of continuity or orthogonality may further depend on the level of analysis. For example, with division of labor and allocation of resources, it may be easier for a group, organization, or larger system to simultaneously excel at exploration and exploitation than it is for individuals to do so. As noted, the learning, resources, and routines necessary for exploration and exploitation are different. As such, they may be delegated within a group or organization so that both can be achieved simultaneously. In this case, management controls the allocation of decision rights to exploit or explore. It also may be easier for a group or organization to switch between exploration and exploitation when appropriate change routines are in place and management recognizes the need for change. For example, Gilson, Mathieu, Shalley, and Ruddy (2005) found that teams that felt empowered by their organization to use creative problem solving as well as standardized routines and procedures had the highest levels of team effectiveness. In contrast, one can imagine that it would be difficult for an individual to develop routines to excel simultaneously at both exploration and exploitation. Further, given the substantial differences in routines and focus on learning, it may be very difficult for an individual to even switch between routines of exploration and exploitation. Amabile (1996) suggested that individuals who focus on creativity, exploration, and experimentation are quite different from those who emphasize appropriate actions. For example, those focused on creativity may be intrinsically motivated, whereas individuals focused on acting appropriately, especially for rewards, may be extrinsically motivated. Fiske and Taylor (1991) further described how well-developed belief systems resist change and how individuals persevere despite information suggesting that change is necessary, a conclusion also reached by Audia, Locke, and Smith (2000).

The following conclusions summarize our arguments:

1. The scarcer the resources needed to pursue both exploration and exploitation, the greater the likelihood that the two will be mutually exclusive—that is, high values of one will necessarily imply low values of the other.
2. Within a single domain (i.e., an individual or a subsystem), exploration and exploitation will generally be mutually exclusive.
3. Across different and loosely coupled domains (i.e., individuals or subsystems), exploration and exploitation will generally be orthogonal, in that high levels of exploration or exploitation in one domain may coexist with high levels of exploration or exploitation in the other domain.

As the above conclusions indicate, we do not believe that a universal argument can be made in favor of either continuity or orthogonality. The relationship between exploration and exploitation depends very much on whether the two compete for scarce resources and whether or not the analysis focuses on a single or on multiple domains. Accordingly, it is important for researchers to ensure that their chosen premise (i.e., continuity or orthogonality) rests on a foundation of logic and theory.

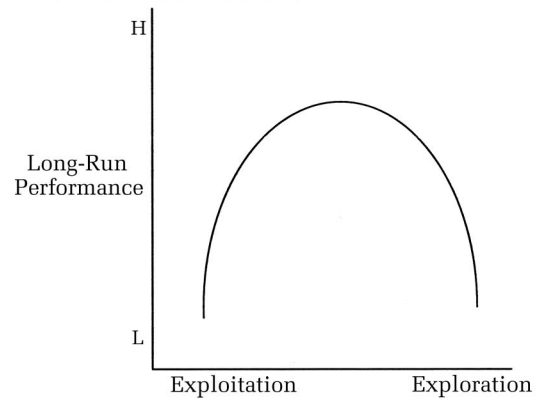
It also is important to note that starting premises regarding continuity or orthogonality will have direct implications for how researchers test for the performance implications of pursuing both exploration and exploitation. If the premise is that exploration and exploitation are two ends of a continuum (and thus mutually exclusive), then the correct test for the beneficial effects of balance would be to test for an inverted U-shaped relationship between degree of exploration (or exploitation) and organizational performance. On the other hand, if the premise is that exploration and exploitation are orthogonal, then the correct test for the beneficial effects of balance would be to test for a positive interaction effect of the two types of learning on organizational performance. Figure 1 depicts these arguments in graphical form.

AMBIDEXTERITY VERSUS PUNCTUATED EQUILIBRIUM

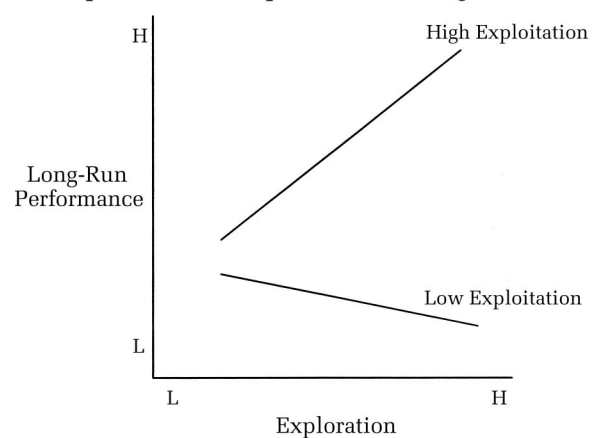
Arguments in favor of the need for both exploration and exploitation are well established and accepted (Ancona, Goodman, Lawrence, & Tushman, 2001; Benner & Tushman, 2002; Dougherty, 1992; Eisenhardt & Martin, 2000; Feinberg & Gupta, 2004; Levinthal & March, 1993; March, 1991, 1996, 2006). As March noted, “Adaptive systems that engage in exploration to the exclusion of exploitation are likely to find that they suffer the costs of experi-

FIGURE 1
Testing for the Performance Effects of a Balance between Exploitation and Exploration

(1a) Exploitation and Exploration as Two Ends of a Continuum



(1b) Exploitation and Exploration as Orthogonal



mentation without gaining many of the benefits. They exhibit too many undeveloped new ideas and too little distinctive competence. Conversely, systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibria” (1991: 71).

Although near consensus exists on the need for balance, there is considerably less clarity on how this balance can be achieved. As mechanisms to help organizations realize this balance, the two primary contenders are ambidexterity (Benner & Tushman, 2003; Burgelman, 1991; Christensen, 1998; Levinthal, 1997; Weick, 1976) and punctuated equilibrium (Burgelman, 2002; Levinthal & March, 1993; Siggelkow & Levinthal, 2003; Tushman & Romanelli, 1985; Vermeulen & Barkema, 2001). Benner and Tushman provided an excellent articulation of the logic behind ambidexterity:

Ambidextrous organization designs are composed of highly differentiated but weakly integrated subunits. While the exploratory units are small and

decentralized, with loose cultures and processes, the exploitation units are larger and more centralized, with tight cultures and processes. Exploratory units succeed by experimenting—by frequently creating small wins and losses (Sitkin, 1992). Because process management tends to drive out experimentation, it must be prevented from migrating into exploratory units and processes. In contrast, exploitation units that succeed by reducing variability and maximizing efficiency and control are an ideal location for the tight coordination associated with process management efforts. (2003: 252)

As noted above, ambidexterity is not the only possible solution to the quest for balance between exploration and exploitation. Punctuated equilibrium, or temporal cycling between long periods of exploitation and short bursts of exploration, have been identified as an alternative balancing mechanism that may be both logical and practical. As Levinthal and March argued, “Less prominent in the normative literature on strategy and organizations, but prominent in more descriptive accounts (Cyert & March, 1992), is the sequential allocation of attention to divergent goals. While the sequential allocation of attention is generally viewed as an outcome of goal conflict and bounded rationality, it also results in a simplification of experiments in organizational change” (2003: 98). Following similar lines, and drawing on his detailed analysis of Andy Grove’s 1987–98 reign as CEO of Intel Corporation, Burgelman (2002) appeared to suggest that punctuated equilibrium is a more viable mechanism than ambidexterity:

Does optimal long-run adaptation follow a punctuated equilibrium pattern (e.g., Tushman and Romanelli, 1985), perhaps involving a series of discrete periods, each focused on maximally exploiting the available opportunities, rather than a more continuous evolutionary process of balancing exploitation of available opportunities at a given time with preparing the ground for future growth opportunities? . . . This study’s findings raise the question of whether induced and autonomous strategy processes are fundamentally at odds with one another or can be effectively pursued simultaneously. Maintaining the simultaneity of induced (variation reducing) and autonomous (variation increasing) strategy processes may involve difficulties similar to maintaining a balance between exploration and exploitation in organizational learning (March, 1991). (Burgelman, 2002: 354)

Given that ambidexterity and punctuated equilibrium are very different yet both logical and viable ways to achieve balance between exploration and exploitation, an obvious question surfaces: Are the two mechanisms equal substitutes, or is the appropriateness of each mechanism a function of

environmental and organizational context? In addressing this question, we would argue that the contingency perspective has considerable merit. If one is analyzing exploration and exploitation within a single domain (i.e., an individual OR a subsystem), and exploration and exploitation are rightly conceptualized as the mutually exclusive ends of a continuum, ambidexterity is simply not an option, and the individual or subsystem must resort to punctuated equilibrium. In the language of systems (Henderson & Clark, 1990), this would be the case when one’s focus is on innovation in system-level architecture. By definition, system-level architecture encompasses an entire system and constitutes a single domain. Thus, long-term adaptation at the level of architecture requires sequential attention to exploitation and exploration—that is, punctuated equilibrium. Intel Corporation, viewed from the perspective of its CEO, fitted this model (Burgelman, 2002). In contrast, as argued earlier, if one is analyzing exploration and exploitation in multiple, loosely connected domains, the two become orthogonal tasks, and it becomes entirely feasible (and perhaps desirable) to pursue ambidexterity. In the language of systems design, exploration can be pursued in one module of a modular system while exploitation is pursued in another.

We can now summarize the above arguments in the form of the following conclusions:

1. When analysis is confined to a single domain (i.e., individual or subsystem) and exploration and exploitation are conceptualized as two ends of a common continuum, logic dictates that punctuated equilibrium be viewed as the appropriate adaptation mechanism for balancing the need for both exploration and exploitation.
2. When analysis involves action in multiple and loosely connected domains and exploration and exploitation are conceptualized as orthogonal, logic dictates that ambidexterity be viewed as the appropriate adaptation mechanism for balancing the need for both exploration and exploitation.
3. Ambidexterity and punctuated equilibrium may be easier to achieve at an organizational or system level than at an individual or subsystem level of analysis.

These conclusions are not as disparate as they may at first appear to be. Consider a system comprised of two loosely coupled individuals or subsystems, A and B. At time t_1 , subsystem A may be pursuing exploration while B pursues exploitation. At time t_2 , subsystem A may switch to exploitation, while B switches to exploration. Thus, within each subsystem (i.e., each single domain), long-run adaptation occurs via punctuated equilibrium. However,

across the two domains, long-run adaptation occurs via ambidexterity. Finally, if the two subsystems are tightly rather than loosely coupled, then long-run adaptation even at the level of the entire system would require punctuated equilibrium and not ambidexterity. As Benner and Tushman (2003) noted, ambidexterity is not a viable option for tightly coupled systems.

DUALITY VERSUS SPECIALIZATION

The analysis we have described so far was built on an acceptance of March's (1991) arguments regarding the need for every organization to pursue both exploration and exploitation. We now examine in more detail whether it might be logical to predict that, under certain conditions, long-term survival may be feasible without balance—that is, by dedicating an organization or system solely to exploration or solely to exploitation.

We start with the everyday observation that organizations operate within a broader social system and as such are interdependent with many other organizations (Pfeffer & Salancik, 1978; Thompson, 1967). Looking through this lens, it may be possible to predict that, under certain conditions, the balance between exploration and exploitation could be achieved at the level of the broader social system rather than at the level of individual organizations. If so, then some organizations may specialize in exploration, some others in exploitation, while the balance between the two is achieved via a market (or quasi-market) interface. Such a scenario is nothing other than the logic of ambidexterity extended and generalized from the context of single organizations (Benner & Tushman, 2003) to the context of the broader social system. Building on the logic of ambidexterity, we would argue that the specialization strategy is likely to be effective only if the following conditions are met: (1) The two organizations A and B, where A specializes in exploration and B in exploitation, control mutually complementary resources. Such complementarity would ensure that the output of A's exploration is not entirely wasted and that the promising ideas can be handed over to B for exploitation. Conversely, even though B focuses solely on exploitation, it has a constant supply of radically new ideas available from A. (2) The domain in which organization A operates is highly dynamic, whereas the domain in which organization B operates is highly stable. This variation in the dynamism of environments would ensure that A faces a persistent need for exploration, whereas B faces a persistent need for exploitation. (3) The degree of mutual cospecialization in the two sets of resources is low. In the presence of

low cospecialization, a market relationship between A and B is likely to be a sufficient and stable means of ensuring that each gets compensated adequately for its contribution (Teece, 1992; Williamson, 1985).

The semiconductor industry, which is experiencing ongoing disaggregation into "fabless" semiconductor companies (which only do product R&D) and fabrication companies (which only do contract manufacturing), is a good example of an industry where the above three conditions appear to be simultaneously valid. The complementarity between semiconductor R&D and semiconductor production is obvious. Also, with a relatively modest degree of coordination, most fabrication companies can manufacture the differing and time-varying products of fabless companies; thus, cospecialization in the tangible resources as well as intangible capabilities of the two sets of organizations tends to be relatively low.¹ Finally, in the semiconductor industry, product technologies become obsolete very rapidly; in contrast, given the extreme capital intensity of manufacturing resources, the rate of evolution in production technologies is much slower. Accordingly, a high degree of ongoing exploration is far more essential for the pure R&D companies, whereas a high degree of ongoing exploitation is far more essential for the pure production companies.

It is worth noting that both March (1991) and Benner and Tushman (2003) signaled the possibility that, under well-specified conditions, specialization rather than duality might be entirely viable. As March noted, "Finding an appropriate balance is made particularly difficult by the fact that the same issues occur at levels of a nested system—at the individual level, the organizational level, and the social system level" (1991: 72). In keeping with this observation, we have argued above that, under certain conditions, individual organizations may justifiably focus solely on exploration or exploitation while delegating the task of achieving a balance between the two to the social system. Along

¹ According to field interviews with executives in two different fabless semiconductor companies headquartered in California, semiconductor manufacturers share *design rules* and *SPICE models* ("SPICE" is "Simulation Package for Integrated Circuit Emulation") with the fabless companies. As long as the product design of a new chip conforms to these rules and models, the need for coordination between a fabless company and a contract manufacturer is relatively modest. The same facility can manufacture multiple generations of semiconductor chips, even when different generations have radically different product designs.

similar lines, in concluding their arguments regarding the desirability of ambidextrous organizations, Benner and Tushman noted: "While our ideas may be relevant for all types and sizes of firms, they apply most readily to firms whose strategies include both exploitative and exploratory innovation. . . . Our propositions are therefore less relevant for firms whose strategies focus solely on either exploitation or exploratory innovation" (2003: 252). Although Benner and Tushman (2003) clearly accepted the possibility of specialized organizations, they did not articulate the conditions under which such specialization might be not only viable but also effective for fostering long-term survival. We have attempted to do so above.

THE WORK IN THIS SPECIAL RESEARCH FORUM

In this section, we summarize the papers selected for this special research forum and connect them, where appropriate, to the four issues discussed above. Overall, we received 83 submissions. Of these, the authors of 15 manuscripts were asked to revise and resubmit, and 7 manuscripts were ultimately accepted for publication. The 7 articles in the special forum span all levels of analysis: the individual operating in a team or an organizational context (Miller, Zhao, & Calantone, 2006; Taylor & Greve, 2006), the team (Beckman, 2006; Perretti & Negro, 2006), the single organization (Siggelkow & Rivkin, 2006), and the interorganizational context (Lavie & Rosenkopf, 2006; Wadhwa & Kotha, 2006). The papers thus range from micro to macro, and we have arranged them in the issue along this spectrum. Table 1 summarizes the key features of each paper. As is obvious, the papers vary in their treatment of the various issues discussed earlier: continuity versus orthogonality, ambidexterity versus punctuated equilibrium, and duality versus specialization. These variations are entirely consistent with and reinforce the logic reflected in the above discussion and conclusions.

Miller, Zhao, and Calantone's article, "Adding Interpersonal Learning and Tacit Knowledge to March's Exploration-Exploitation Model," replicates and extends March's (1991) model simulating learning within an organization, using an agent-based simulation. First, these authors extend his model by considering the role of direct interpersonal learning, in addition to learning from an organizational code. Second, they place individuals in a location or space. Doing this allows them to distinguish between distant and local search. Finally, Miller and colleagues recognize the importance of tacit knowledge. Tacit knowledge cannot

be transmitted through an organizational code, but only by individuals sharing their knowledge directly with others. The first key contribution of Miller and colleagues' extension of March's model is their recognition of the value of individual learning and how interpersonal interactions in organizations are critical for knowledge transfer. The second important contribution these authors make is their offering the first simulation model distinguishing tacit and explicit knowledge. A third contribution is that their model captures the spatial bias that exists in organizations, whereby individuals tend to interact more often with proximate others. Finally, their model is able to differentiate between local and distant search as two distinct aspects of learning. Miller and colleagues' model points to the importance of decentralized interpersonal learning to overcoming the potential rigidity of organizations emphasizing exploitation rather than exploration. Therefore, Miller, Zhao, and Calantone highlight the fact that some degree of specialization in exploration or exploitation can exist at different levels in a system, while the overall system exhibits duality.

Taylor and Greve's article, "Superman or the Fantastic Four? Knowledge Combination and Experience in Innovative Teams," examines whether the team compositional factors—diversity of knowledge and experience working together—that lead to variance-enhancing behaviors (i.e., exploration) differ from those that lead to higher mean performance (i.e., exploitation). They examine these issues by studying teams involved in the creation and publishing of comic books (e.g., artists and writers). Taylor and Greve argue and find that having multiple knowledge domains leads to the combining of knowledge in ways that yield innovations. Somewhat surprisingly, they find that similar factors affect both innovations that lead to extreme success or failure (as measured by a comic's commercial value) and those that lead to high average performance. Also, individuals were found to be able to combine diverse knowledge more effectively than teams, which makes sense, given the potential process losses inherent in team work. A key contribution of this paper is that the researchers look at the full range of innovations, rather than only successful innovations. Therefore, they are able to model factors that can lead to high mean performance over time, radical innovations, and commercial failures. This is important, since much of the prior research has not looked at the effect of risk and what factors lead to failures rather than successes.

TABLE 1
Summary of the Articles in the Special Research Forum on Managing Exploration and Exploitation

Article	Level of Analysis	Sample/Method	Role of Exploration/ Exploitation	Definitions and Connotations of Exploration/Exploitation	Continuity vs. Orthogonality	Ambidexterity vs. Punctuated Equilibrium	Duality vs. Specialization	Conclusions
Miller, Zhao, & Calatone	Individual and organization	Agent-based simulation	Dependent variable	Differences in rate of learning (i.e., rapid vs. slow)	Continuous	Ambidexterity	Specialization at different levels of system, duality for overall system	Direct interpersonal learning and tacit knowledge transmission exist.
Taylor & Greve	Individual and team	Comic books published 1972–96 (archival and survey data)	Dependent variable	Differences in how teams use knowledge for either radical or incremental innovation (i.e., local and distant search vs. local search only)	Initially viewed as continuous, but results indicate can be orthogonal	Ambidexterity	Duality possible	Similar factors affect both innovations with extreme results and innovations with high average performance.
Beckman	Team and organization	Young high-technology firms (interview, survey, and archival data)	Dependent variable	Differences in level of learning (i.e., more intense, distant search vs. local search only)	Orthogonal	Ambidexterity	Duality best	Founding team prior company affiliations affect pursuit of exploratory and exploitative strategies.
Perretti & Negro	Team	Hollywood films produced 1929–58 (archival)	Dependent variable	Exploration vs. exploitation in team design (proportion of newcomers and proportion of new member combinations)	Continuous	Punctuated equilibrium (implicit assumption)	Specialization: Exploration only	Decision maker status and organizational hierarchy have a U-shaped relationship with exploration in team design.
Siggelkow & Rivkin	Organization	Agent-based simulation	Independent variables (local or distant search and tight coupling)	Differences in interdependencies between organizational levels can reverse the effects of decentralized exploration	Orthogonal: Focus on exploration only	Punctuated equilibrium: Focus on exploration only	Specialization: Exploration only	Exploration can be decentralized only when cross-level interdependencies are low.
Lavie & Rosenkopf	Organization	U.S. software firms, 1990–2001 (archival: COMPUSTAT and Securities Data Corporation)	Dependent variable	Differences in alliance function, structure, and attribute across time and between domains	Continuous	Ambidexterity through alliance type; punctuated equilibrium within domain	Duality between alliance type; specialization within domain	Firms can deploy both ambidextrous alliance strategies and punctuated equilibrium alliance strategies.
Wadhwa & Kotha	Interorganizational	U.S. telecommunication equipment manufacturers, during 1989–99 (archival)	Independent variable (impact of exploratory moves on knowledge creation)	Corporate venture capital investments treated as exploratory moves	Continuous	Punctuated equilibrium (implicit assumption)	Specialization: Exploration	High involvement significantly boosts the knowledge creation gains from corporate venture capital investments.

Second, Taylor and Greve's findings point to the value of measuring the career experiences and knowledge of team members, since they found that the right team composition (for instance, diverse members as well as depth of experience) can enable an ambidextrous approach. Third, their finding that common factors predict both exploration and exploitation points to the orthogonality of these approaches for teams. Finally, they discuss how the dichotomy of exploration versus exploitation may actually be driven by differences in goals and expectations for a task rather than by different team knowledge assets. Thus, Taylor and Greve's work highlights the learning and knowledge exchanges between heterogeneous team members that can enhance ambidexterity.

In her article, "The Influence of Founding Team Company Affiliations on Firm Behavior," Beckman proposes that the firm and market experience of new ventures' founders (their prior company affiliations) shape the type of new firms created as well as the strategies and structures put into place. She argues that founding teams with members with common prior company affiliations are more likely to have shared beliefs and a common language, which will contribute to the adoption of routines for efficiency and incremental improvements in products and processes (i.e., exploitation). It should be noted that Beckman views prior common affiliations as important not because founding team members have had direct prior work experience with each other, but because cohesion results from shared experiences gained through the mere affiliation with the same company. On the other hand, Beckman argues that diverse prior company affiliations lead to a variety of perspectives, the discovery of new alternatives, and increased external social capital, which should lead to innovations (i.e., exploration). Finally, she expects founding teams composed of a mixture of members with both common and diverse prior company affiliations to promote organizational ambidexterity and ultimately greater firm performance. She finds support for these arguments. A key contribution of this paper is the message that new firms need to pay attention to the composite set of experiences that potential team members have had when constructing founding teams. This view is a nice complement to Taylor and Greve's (2006) focus on the role of career experiences and knowledge of team members. Also, Beckman is able to show that diverse founding teams can be ambidextrous in their use of strategies, an ability that improves firm performance.

Perretti and Negro's article, "Filling Empty Seats: How Status and Organizational Hierarchies Affect Exploration versus Exploitation in Team Design," focuses on the introduction of newcomers and the

formation of new member combinations in team design. Treating exploration and exploitation as two ends of a continuum, they take the position that team design can be viewed as more exploratory when the proportion of newcomers on a team is high and/or when the proportion of new member combinations is high. Perretti and Negro's empirical setting is the Hollywood film industry during the period 1929–58, and their teams are the five-person groups that contain the key players in the development of any film: the director, the two lead actors, the editor, and the director of photography. They regard team members as new when they are new to the industry as a whole. In keeping with Phillips and Zuckerman's (2001) notion of "middle-status conformity," Perretti and Negro find that team design is most exploratory when it is driven by either very high status or very low status individuals. Further, building on Siggelkow and Levinthal (2003), they also find that team design is most exploratory within organizational contexts with either three hierarchical layers or one layer. In summary, both decision maker status and the extent of organizational hierarchy have U-shaped relationships with exploration/exploitation choices in team design.

Siggelkow and Rivkin's article, "When Exploration Backfires: Unintended Consequences of Multilevel Organizational Search," questions the accepted proposition that decentralization of the exploration process by bringing it to lower organizational levels enhances exploration and performance for an entire organization. In an agent-based simulation, they find that decentralization can in fact backfire and diminish exploration as well as performance for the organization as a whole. However, they also find that when lower-level units are loosely connected to one another—for example, when the level of interdependency between departments is low—more extensive exploration at lower levels can increase performance for the organization. Siggelkow and Rivkin contribute to our understanding of how exploration can be achieved in multilevel organizations by focusing on the question of when exploration should be decentralized. They conclude that decentralization is appropriate when decisions and departments are modularized. This paper reinforces our discussion of the appropriateness of specialization and certain organizational design features, such as loosely coupled structures, for achieving exploration.

Lavie and Rosenkopf's article, "Balancing Exploration and Exploitation in Alliance Formation," explains how equilibrium between exploration and exploitation is achieved through three forms of alliances: function (marketing or R&D), structure (re-

current partner or new partner), and attribute (similar or dissimilar partner). Their focus on different types of alliances reflects the premise that organizations can pursue exploration and exploitation in different domains; for example, firms can trade off exploring in R&D functions versus exploiting in marketing functions; learning from new partners versus taking repeat partners; and working with similar partners versus working with dissimilar partners. Data from a sample of U.S. software firms suggested that although path dependencies reinforce existing patterns of exploration or exploitation within certain domains, software firms do balance alliance exploration and exploitation both over time and across domains. Lavie and Rosenkopf's results emphasize the importance of looking at different types of exploration and exploitation through a wide lens and using longitudinal data to study the balancing process. The firms they studied appeared to be able to deploy both ambidextrous strategies (exploration and exploitation at the same time) and punctuated equilibrium strategies (switching across time). However, if researchers were to examine a single type of alliance over a shorter period, specialization rather than balance might emerge as the more valid description.

Finally, Wadhwa and Kotha's article, "Knowledge Creation through External Venturing: Evidence from the Telecommunications Equipment Manufacturing Industry," examines the factors that drive technological learning from corporate venture capital (CVC) investments. These authors treat exploration and exploitation as two ends of a continuum and view CVC investments as more exploratory when they lead to greater technological learning on the part of corporate investors. Focusing on the telecommunications equipment manufacturing industry, Wadhwa and Kotha find that the number of CVC investments has an inverted U-shaped relationship with the extent of technological learning, suggesting that greater involvement in CVC activity comes not just with benefits but also with rapidly rising costs. They also find that the impact of CVC activity on technological learning is influenced heavily by whether or not the parent corporation is actively involved in the investee firm. Involvement significantly boosts the extent of technological learning. Most interestingly, when involvement is high, the relationship between number of CVC investments and technological learning changes direction and, instead of an inverted U-shaped relationship, a U-shaped relationship emerges. In summary, according to Wadhwa and Kotha, technological learning from CVC investments depends far more on direct interpersonal interaction between personnel on both sides than it does on mere

financial investment by larger corporations into young ventures.

These seven articles significantly contribute to knowledge of what drives variations in exploration and exploitation, whether and how a balance between the two may be achieved, and how variations in exploration and exploitation impact performance. Collectively, these papers also reinforce our primary conclusions:

- (1) Both exploration and exploitation involve learning, albeit of different degrees and/or types.
- (2) Depending on whether one's focus is on a single or multiple domains, exploration and exploitation can be treated as two ends of a continuum or as orthogonal to each other.
- (3) Depending on the context, either ambidexterity or punctuated equilibrium may serve as the more appropriate balancing mechanism between exploration and exploitation.
- (4) When a multiplicity of subsystems interact with each other via modular/standardized interfaces, the task of balancing exploration and exploitation can be delegated to the higher-level system, and each subsystem can focus on just exploration or just exploitation without any major threats to long-run performance.

TOWARD FUTURE RESEARCH

Building on our review of the literature on exploration versus exploitation and the seven works included in this special research forum, the following emerge as some of the more promising directions for future research:

First, studies that examine exploration and exploitation at a micro level are relatively scarce. Even though our call for papers invited submissions across the full range from the micro (i.e., individual) to the macro (i.e., the interorganizational) levels, the bulk of the submissions focused on the more macro levels of analysis. We hope that the microlevel papers included in this research forum (Miller, Zhao, & Calantone, and Taylor & Greve) will add a fillip to research that addresses questions at the micro level of analysis. For example, at different stages of the creative or innovative process, are different types of people or skills required to be able to successfully explore or exploit? How can managers learn to recognize good ideas to exploit? What happens when others choose to exploit the ideas of an individual or team? How does politics come into play in groups in terms of when to share exploratory ideas and when they may be exploited by others?

Second, studies spanning multiple levels of analysis are also relatively scarce. Studies that address

questions such as the following have the potential to fill important gaps in scholars' knowledge base: What is the individual- and/or team-level origin of organizational capabilities for exploration and exploitation? What is the *joint* effect of intra- and interfirm networks on exploration and exploitation? How does exploration at one level interact with exploitation at a lower or higher level? What are the similarities, differences, and interactions between an individual's, a group's, and an organization's creative capacity, diffusive capacity, absorptive capacity, and risk-taking capacity? Also, are there parallel processes between levels of analysis in the manner in which individuals, groups, or organizations explore and exploit that could shed light on and inform how these processes should be managed across levels of analysis?

Third, studies that examine the challenges associated with achieving a balance between exploration and exploitation are scarce. In this introductory article, we highlighted ambidexterity and punctuated equilibrium as two alternative mechanisms for achieving such a balance. To date, very few studies have examined the dynamics of each of these mechanisms in isolation. Further, almost no attempt has so far been made to compare and contrast the feasibility and appropriateness of these two mechanisms in different contexts.

In conclusion, we began this introductory article by highlighting the importance of exploration and exploitation for successful organizational adaptation, technological innovation, organizational learning, and even organizational survival. We identified four key research questions related to exploration and exploitation, including matters of definition, continuity versus orthogonality, ambidexterity versus punctuated equilibrium, and duality versus specialization. As our discussion of these issues and summarization of the seven papers suggests, the twin concepts of exploration and exploitation involve a number of complex processes, variables, and contingencies. We are hopeful that this special research forum will advance understanding of these concepts. Such research is necessary and important if researchers are to learn how complex organizational systems can more effectively learn, adapt, and survive in the long term.

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