Leadership in research and development organizations: A literature review and conceptual framework

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Abstract

We present a conceptual framework and review the empirical literature on leadership in research and development (R&D) organizations. Findings of studies reviewed suggest that transformational project leaders who communicate an inspirational vision and provide intellectual stimulation and leaders who develop a high-quality leader–member exchange (LMX) relationship with project members are associated with project success. Boundary-spanning activity and championing by the leader are also found to be important factors for project success. The review also suggests that a number of moderators and contextual variables such as project group membership and rate of technological change may make leadership in R&D organizations different from that in operating organizations. Propositions for future research are suggested.

1. Introduction

Literature reviews of leadership research typically cover a vast number of studies and experiments as evidenced by such compendiums as Bass (1990) and Yukl (2002). As we will show in this review, however, only a small percentage of this literature has been conducted in research and development (R&D) organizations or contexts. The question then arises whether we can use the findings from the general leadership literature and apply them to R&D, or is the context of R&D different such that this particular literature should be analyzed for findings separately? If leadership in R&D organizations is different, moreover, what have we learned from the extant research about effective leadership in this context? These are the
questions we will be considering as we review, synthesize, and try to draw inferences from
the literature on leadership in R&D settings.

2. The nature of R&D and the technological innovation process

We know that technology itself has been advancing and changing at dizzying rates in the past
decades with no letup in sight. In contrast, the process by which technological innovation via
R&D occurs has been fairly stable over the years. For example, earlier work by Allen (1977)
and Pelz and Andrews (1966) as well as more recent efforts by Burgelman, Maidique, and
Wheelwright (2001) and Tornatzky and Fleischer (1990) describe an interpersonal process
involving scientists and engineers who generally work in project groups or teams with a project
leader. Project groups can be categorized as research groups that tend to focus on radical
innovation and development groups that are generally concerned with modifications and
incremental innovations (Keller, 1995). The R&D organization in general, and the project
group in particular, imports scientific and technological information (STI), transforms it into
technological innovations in the form of ideas, products, or processes, and then exports these
innovations to other units of the organization. Much has to happen in the rest of the firm or
organization for these innovations to reach the market, but our focus is on the R&D
organization.

By focusing on the R&D organization, we are most often interested in what happens in
the project group, which is where R&D is actually conducted. The project group is the
vehicle of choice because such groups, often cross functional in membership, can bring the
right mix of scientists, engineers, and other specialists together to bring in and process STI
into technological innovations (Denison, Hart, & Kahn, 1996). Responsibility for managing
the process and the people in R&D groups usually falls on the shoulders of the project
leader, and it is this person whom we usually focus on when we study leadership in R&D
organizations.

There are two other important points to consider in understanding the R&D context. First,
the outputs and performance measures are usually quite different than those used in other
areas of the firm. Instead of timely and market-sensitive measures that the CEO is accustomed
to such as profitability and return on investment, R&D has a time-lagged, sporadic, and
nonmarket nature to its outputs (Narayanan, 2001). For example, new products, patents, or
innovations can take years before they are transformed from STI into outputs. An additional
period of time and other activities from marketing and manufacturing are then needed before
a revenue stream can be derived from these R&D outputs. Hence, performance measurement
and evaluation of R&D is usually done under uncertainty with the use of proxies such as
management evaluation of project progress. Additionally, project leaders are usually selected
as much for their technical expertise as for their leadership skills (Narayanan, 2001). Generally,
skill in handling interpersonal problems among members of a cross-functional
project group is not something for which a leader in R&D has been formally trained. As noted
by Mumford, Scott, Gaddis, and Strange (2002), leading creative and innovative individuals
requires managers to possess certain skills in addition to technical expertise. Studies reviewed
in this paper provide some insight into the leadership skills necessary for innovation to occur in R&D organizations.

To help the reader to visualize leader behaviors in R&D organizations and the relevant contextual variables that make R&D a different environment, we have developed a conceptual framework that is presented in Fig. 1. The framework presents an overview of the topics that have been researched along with particular variables that have been found to have direct and indirect effects on R&D leader effectiveness.

3. Leadership research in the R&D context

Farris (1988) identified three categories of research examining leadership in an R&D context: (1) direct studies of leadership theories/behaviors, (2) characteristics of the organizational climate that may be attributable to the leader, and (3) informal organization consisting of roles performed by leaders. Our plan for this paper is to review the empirical literature on leadership in R&D organizations within these three categories and then discuss potentially useful directions for future research with some suggested propositions and research strategies. As a convenience for the reader, we have chronologically tabled the studies we have reviewed. In Table 1, we have summarized the variables studied, sample, and findings for each study.
Table 1
Studies of leadership in R&D organizations

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Dependent variables</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Andrews and Farris (1967)</td>
<td>94 scientists from 21 teams at a NASA research center</td>
<td>Individual and group innovation</td>
<td>When supervisors were perceived as less technically skilled, higher performance was associated with providing subordinates with more freedom to explore, discuss, and challenge ideas. Critical evaluation of subordinates’ work was associated with innovation for technically skilled supervisors. Suggestion stage: supervisors in high innovation groups were not viewed as a source of original ideas by group members. Proposal stage: supervisors in high innovation groups were viewed as helpful with technical problems and critical evaluation. Solution stage: supervisors in high innovation groups were viewed as helpful with administrative assistance.</td>
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<tr>
<td>Farris (1972)</td>
<td>117 professional employees representing 154 R&amp;D projects at 13 sites</td>
<td>Roles associated with group innovation across problem-solving stages</td>
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<tr>
<td>Thamhain and Gemmill (1974)</td>
<td>88 project managers and personnel in an electronics company</td>
<td>Degree of employee support and project involvement, willingness to disagree, and project managers’ effectiveness ratings</td>
<td>Influence methods focusing on work challenge and expertise rather than authority were associated with higher project manager performance ratings as well as a climate of involvement and willingness to disagree.</td>
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<tr>
<td>Barnowe (1975)</td>
<td>Questionnaires completed by 859 scientists and interviews conducted with 39 administrators of a large research organization</td>
<td>Scientific and applied research outcomes</td>
<td>Leader assistance behaviors were positively related to contributions to scientific knowledge and applied practices. This relationship was moderated by group isolation and subordinate experience.</td>
</tr>
<tr>
<td>Katz and Tushman (1981)</td>
<td>345 R&amp;D professionals in 61 project groups of a large corporation</td>
<td>Technical performance of projects as rated by managers. Five-year later promotions of project leaders</td>
<td>Gatekeeping (boundary-spanning) project leaders had a much greater incidence of promotion to managerial positions compared with non-gatekeeping leaders.</td>
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<tr>
<td>Cooper and Kleinschmidt (1987)</td>
<td>203 new product projects in 125 industrial product firms</td>
<td>New product success</td>
<td>Top management support for new product projects was related to indicators of product success, including payback period, domestic market share, relative profits, meeting sales, and profits objectives.</td>
</tr>
<tr>
<td>Allen et al. (1988)</td>
<td>181 project team from nine R&amp;D organizations</td>
<td>Project performance as rated by managers</td>
<td>Project performance is higher when functional leaders keep researchers updated with their relevant science or technology.</td>
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<tr>
<td>Barczak and Wilemon (1989)</td>
<td>10 leaders of successful R&amp;D teams in the electrical and electronics industries</td>
<td>Content analysis of interviews to identify roles</td>
<td>Leaders of both operating and innovating teams perform the roles of communicator, climate-setter, planner, and interfacers. Differences exists in the implementation of roles in the two types of teams.</td>
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<tr>
<td>Ancona and Caldwell (1988)</td>
<td>38 new product team managers from seven high-tech corporations</td>
<td>Type of boundary-spanning activity and team performance</td>
<td>Team performance is a function of the fit between amount of boundary-spanning activity and resource dependence of the project.</td>
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<tr>
<td>Keller (1989)</td>
<td>477 professional employees from four R&amp;D organizations</td>
<td>Job satisfaction and employee performance</td>
<td>Need for clarity moderated the relationship between initiating structure and job satisfaction in all four organizations and between initiating structure and performance in one organization.</td>
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<tr>
<td>Howell and Higgins (1990a, 1990b)</td>
<td>25 matched pairs of project champions and nonchampions from a variety of Canadian firms</td>
<td>Leader behaviors and influence tactics used by leaders</td>
<td>Champions used more transformational leader behaviors and a wider variety of influence tactics than nonchampions.</td>
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<td>Markham et al. (1991)</td>
<td>213 R&amp;D projects from 21 industrial firms across four industries</td>
<td>Emergence of project champions</td>
<td>Championed projects are better supported with resources and less likely to be terminated.</td>
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<tr>
<td>Keller (1992)</td>
<td><strong>Time 1:</strong> 462 professional employees from 66 project groups from three industrial R&amp;D organizations. <strong>Time 2:</strong> 440 professional employees from 61 project groups from three industrial R&amp;D organizations</td>
<td>Project group performance (ratings of project quality and budget/schedule performance by project members and managers)</td>
<td>Transformational leadership of project leaders is positively related to project quality and budget/schedule performance. The relationship between transformational leadership and project quality is stronger for research projects than for development projects. The relationship between initiating structure and project quality is stronger for development projects than for research projects. Project quality at Time 1 is positively related to higher transformational leadership at Time 2. Managers high in need for power focused on growth-related activities, empowering subordinates and providing a sense of responsibility. Their subordinates perceived an innovative climate.</td>
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<tr>
<td>Frischer (1993)</td>
<td>38 managers and subordinates in new product development units from four companies</td>
<td>Innovative climate</td>
<td>Positive relationship between high-quality LMX and innovative behavior as well as climate for innovation. Positive relationship between supervisors’ expectations and innovative behavior of technicians.</td>
</tr>
<tr>
<td>Scott and Bruce (1994)</td>
<td>172 engineers, scientists, and technicians and 26 managers at an R&amp;D facility of a U.S. industrial corporation</td>
<td>Innovative behavior (ratings by managers) Climate for innovation (ratings of subordinates)</td>
<td>Positive relationship between high-quality LMX and innovative behavior as well as climate for innovation. Positive relationship between supervisors’ expectations and innovative behavior of technicians.</td>
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Table 1 (continued)

<table>
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<tr>
<td>Waldman and Atwater</td>
<td><em>Interviews:</em> 40 project members, leaders, and higher-level managers in R&amp;D units of two organizations. <em>Surveys:</em> 147 project members, leaders, and higher-level managers in R&amp;D units of three organizations.</td>
<td>R&amp;D project effectiveness (ratings by higher-level managers)</td>
<td>Transformational leadership and championing behavior is positively related to project effectiveness.</td>
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<td>(1992)</td>
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<tr>
<td>Green (1995)</td>
<td>214 R&amp;D projects in 21 large industrial firms</td>
<td>Top management support, project success, and project termination</td>
<td>Perceived top management support was related to expected contribution, size of investment, innovativeness, and business advocacy and influenced whether a project was terminated.</td>
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<tr>
<td>Hitt et al. (1996)</td>
<td>250 firms that reported R&amp;D expenditures each year between 1985 and 1991</td>
<td>Financial controls, strategic controls, internal innovation, and external innovation</td>
<td>Intense use of acquisitions and divestitures resulted in the implementation of financial controls and less internal innovation.</td>
</tr>
<tr>
<td>Judge et al. (1997)</td>
<td>Interviews with R&amp;D managers, research scientists, and laboratory technicians from eight new biotechnology firms</td>
<td>Innovation in R&amp;D units</td>
<td>Managers can create an innovative culture by giving employees operational autonomy, providing personalized recognition, emphasizing group cohesiveness, and maintaining a continuity of slack resources.</td>
</tr>
<tr>
<td>Kim et al. (1999)</td>
<td>503 professional employees from 87 project teams from three government-sponsored and three private R&amp;D organizations in Korea</td>
<td>Team performance</td>
<td>Roles of technical expert, team builder, gatekeeper, and strategic planner were related to team performance. The relationships between roles of technical expert, gatekeeper, and strategic planner and team performance became stronger as the leader’s tenure increases. The team builder role had a positive relationship when the task uncertainty was low. When uncertainty was high, the strategic planner role was the most important factor in team performance. Roles of technical expert and gatekeeper were important regardless of uncertainty.</td>
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3.1. Leadership roles

Theorists have suggested that a number of leadership roles are essential for innovation in an R&D context (Farris, 1988), including idea generating, entrepreneuring/championing, project leading, gatekeeping, and sponsoring/coaching (Roberts & Fusfield, 1981). The idea-generating role involves developing and testing new ideas and creative problem-solving. Motivating team members, organizing projects, and coordinating team members are key activities associated with the project-leading role. Sponsoring/coaching focuses on providing guidance and developing team members’ abilities. Each of these roles focuses primarily on leadership behaviors within a project group. Gatekeeping involves activities both inside and outside of the project team, including information dissemination, personnel coordination, and obtaining knowledge regarding professional development outside of the organization. Finally, entrepreneuring/championing focuses on obtaining resources and selling ideas to those outside of the project group. Research examining these roles performed by R&D leaders will be reviewed in the next two sections of our paper.

3.1.1. Roles within the project group

Overall, research indicates that R&D leaders perform important roles within project groups that contribute significantly to performance. Through interviews with leaders of successful R&D teams, Barczak and Wilemon (1989) identified four roles performed by leaders of operating teams focusing on incremental product improvement and innovating teams focusing on new product development: communicator, climate-setter, planner, and interfacер. As addressed in the following studies, research has also identified factors that

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<tr>
<td>Tierney et al. (1999)</td>
<td>191 research managers, research scientists, section leaders, project leaders, work group professionals, and work group technicians in the R&amp;D sector of a chemical corporation</td>
<td>Creativity (ratings by managers, invention disclosure forms, and research reports)</td>
<td>Positive relationship between high-quality LMX and creativity for adaptors.</td>
</tr>
<tr>
<td>Cardinal (2001)</td>
<td>57 pharmaceutical drug units with R&amp;D programs</td>
<td>Innovation (new drugs and drug enhancements) as measured by data from FDC reports</td>
<td>Innovation is related to input, output, and behavior control mechanisms.</td>
</tr>
<tr>
<td>Shim and Lee (2001)</td>
<td>83 projects from 22 Korean R&amp;D institutes</td>
<td>Project performance as rated by members and leaders</td>
<td>Project performance is related to the fit between the style of leader influence and the organizational context.</td>
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moderate the role–performance relationship including stages of innovation as well as characteristics of the project, group, leader, and subordinates.

In one of the earlier studies of R&D leadership, Andrews and Farris (1967) examined teams of scientists at a NASA research center to determine whether supervisors can influence the innovation of subordinates. Results indicated that the effectiveness of leadership behavior was dependent on leaders’ skills. When supervisors were perceived as possessing less technical skill, higher performance was associated with giving subordinates more freedom to explore, discuss, and challenge ideas. Critical evaluation of subordinates’ work was associated with innovation for technically skilled supervisors. Research has also indicated that the leader’s position can influence the effectiveness of roles. In examining long-term project teams, Allen, Katz, Grady, and Slavin (1988) found differences in roles associated with high performance for project and functional managers. Team performance was higher when functional managers performed roles related to technology, including disseminating information regarding technical advances and being knowledgeable regarding current professional activities. In newly formed teams, information dissemination was not associated with high performance for either project or functional managers; however, being informed about current professional activities was associated with high performance for project managers but not for functional managers.

Other research has identified team tenure as well as leader tenure as moderators to the role–performance relationship. In a study of R&D team leaders in Korea, Kim, Min, and Cha (1999) found that the roles of technical expert, team builder, gatekeeper, and strategic planner were related to team performance. With the exception of team builder, the relationships became stronger as the leader’s tenure increased. The team builder’s role had a negative effect on performance as team tenure increased and a positive effect when the task uncertainty was low. When uncertainty was high, the strategic planner role was the most important factor in team performance. The roles of technical expert and gatekeeper were important regardless of uncertainty.

Barnowe (1975) examined leadership behaviors similar to those described by Roberts and Fusfield (1981) and found that leader assistance behaviors including supportiveness, task emphasis, technological skill, and participation were positively related to contributions to scientific knowledge and applied practices. This relationship, however, was moderated by group isolation and subordinate experience. When groups were isolated from the scientific community, leadership was significantly related to performance; this relationship was not significant for nonisolated groups. Leadership behaviors were also more important when scientists had less experience. Thus, leader roles were more important when subordinates were disadvantaged in some way.

Farris (1972) tested a model of organizational decision making, which proposed that “colleague roles” differed in importance across three stages of a complex problem-solving process. In examining roles associated with group innovation, results indicated that supervisors in high innovation groups were not cited by group members as sources of original ideas in the “suggestion” stage of the model. In later stages, however, group members in high innovation groups indicated that supervisors were helpful with critical evaluation and provided technical and administrative assistance.
3.1.2. Boundary-spanning and championing roles of leaders

In addition to their internal leadership activities with project group members, project leaders have important roles to play in spanning across the boundaries of the group and the R&D organization to other constituencies both inside and outside the firm. For example, inside the firm, the support of higher-level management, marketing, manufacturing, and operating divisions is usually required for technological innovations to be successfully transformed into new products and processes that reach the market. Outside the firm, relations with customers, suppliers, governmental agencies, trade associations, and sometimes even competitors are needed for new product success. To reach these several constituencies, the project leader must exert upward and outward influences across boundaries and often must act as a project champion (Howell & Higgins, 1990b; Shim & Lee, 2001). Research has indicated that project champions are higher in risk-taking and innovativeness and tend to be more transformational in their leadership behaviors (Howell & Higgins, 1990a, 1990b).

How important is the boundary-spanning activity of the leader for project success? Markham, Green, and Basu (1991) studied 213 R&D projects from 21 firms and found that projects with an active championing effort from the leader were better supported across the organization and less likely to get cancelled than projects without championing. Champions were also more active for projects related to their home-function interests. A study of 40 R&D projects by Waldman and Atwater (1992) using interviews reported that championing activity and transformational leadership result in better project success, especially when leaders exert influence at higher levels of the organization. Ancona and Caldwell (1988), moreover, studied 38 project leaders and found that team performance was related to the fit between the level of boundary-spanning activity and how dependent the project was on resources outside the project. Similarly, Shim and Lee (2001) studied 83 R&D projects in 22 Korean research institutes and found that project leaders who exert upward influence tend to be more achievement and self-monitoring oriented and that the best influence style should fit the organizational context at hand. Even functional managers need to boundary span, as a study of 181 project teams from nine R&D organizations by Allen et al. (1988) found that functional managers contributed to project performance by keeping researchers updated with their area of science or technology. While leaders who boundary span can help their projects’ performance, research has indicated that they can also enhance their own career success. For example, Katz and Tushman (1981) conducted a 5-year follow-up study of boundary-spanning project leaders and found that they were promoted to higher management positions at a much greater rate than those who did not boundary span.

3.2. Creating a climate for innovation

Research examining climate issues has focused primarily on two questions: What aspects of the organizational environment can influence innovation, and what is the role of leaders in this relationship? In addressing the first question, theorists have identified antecedents of innovation and creativity including vision, participative safety, climate for excellence, norms of support for innovation, operational autonomy/freedom, good project management, encouragement, organizational resources, recognition, time, challenge, and pressure (Ama-
bile, 1988; West, 1990). Research examining the second question indicates that leaders may influence innovation by creating an innovative climate (Ekvall & Ryhammar, 1999). It has been suggested that a climate of innovation can be created by the use of both structure and behaviors, such as providing subordinates with multiple tasks, time pressures, administrative as well as technical tasks, technical collaboration with colleagues, and clarity of fit between work and organizational goals (Farris, 1988).

Empirical studies across a number of organizational contexts have examined the direct relationship between organizational factors and innovation as well as perceptions of an innovative climate as a mediator of this relationship. Results of a metaanalysis indicated that significant positive relationships exist between innovation and organizational variables including specialization, functional differentiation, professionalism, managerial attitudes toward change, technical knowledge resources, administrative intensity, slack resources, and internal/external communication. Innovation, moreover, was negatively related to centralization. The relationship between organizational determinants and innovation was stronger for organizations that developed a large number of innovations (Damanpour, 1991).

3.2.1. Climate of innovation

Consistent with Damanpour's (1991) findings, literature examining climate issues in an R&D context has suggested that R&D leaders can control organizational factors, thus influencing innovation in project groups (Farris, 1988). One way that this can occur is by creating a culture or climate conducive to innovation. Judge, Fryxell, and Dooley (1997) interviewed R&D managers of biotechnology firms to examine the type of organizational culture necessary for innovation and the managerial practices that can create such cultures. The managers indicated that an innovative culture was created through building a sense of community consisting of a family feeling, socializing, trust, caring, information flow, learning approach, individual recognition/rewards, and teamwork. Managerial practices that can create this type of culture include giving employees operational autonomy, providing personalized recognition, emphasizing group cohesiveness, and maintaining a continuity of slack resources.

Other research has indicated that managerial practices such as those described by Judge et al. (1997) are associated with both high performance and perceptions of an innovative climate. In an examination of project groups in an electronics company, Thamhain and Gemmill (1974) found that influence methods focusing on work challenge and expertise rather than authority were associated with higher project manager performance ratings as well as a climate of project personnel involvement and willingness to disagree. Similarly, in a study of new product development units, Frischer (1993) found that subordinates whose managers expressed a high need for power perceived a more innovative climate than those whose managers reported a high need for affiliation. Managers with high need for power focused on growth-related activities, empowering subordinates and providing a sense of responsibility. Research has also examined the role of climate in the relationship between managerial behaviors and innovation. Scott and Bruce (1994) examined this issue and found that perceived support for innovation was positively related to innovative behavior but found only limited support for climate as a mediator.
3.2.2. Structures supportive of an innovative climate

In an examination of structure issues in an R&D context, Cardinal (2001) found positive relationships between organizational controls and innovation in the pharmaceutical industry. Input controls such as the diversity of specialists in the organization’s R&D programs and the employees’ contact with professional colleagues outside of the organization were positively related to both radical (new drug development) and incremental (drug enhancements) innovations. In terms of behavior controls, radical innovation was positively related to centralization, formalization, and performance appraisal frequency. Incremental innovation was positively related to centralization, negatively related to formalization, and not significantly related to performance appraisal frequency. Finally, the study examined output controls including goal specificity, emphasis on output, emphasis on professional output, and rewards/recognition. The author found a positive relationship between each output control and both types of innovation, with the exception of a nonsignificant relationship between emphasis on professional output and radical innovation.

3.3. Leadership theories

Despite calls for research on leadership in technological innovation (Farris, 1988), there is a relative lack of theory-based leadership studies in an R&D context (Scott & Bruce, 1998). Farris (1988) observed that most early research in this category focused on traits and behaviors of first-line supervisors and found that innovation was positively related to leaders’ technical skills, negatively related to administrative skills, and not related to human relations skills. More recent research has moved beyond simple examinations of leaders’ traits and behaviors. The following sections will review this research, which includes studies examining transformational leadership, path-goal theory, leader–member relations (LMX) theory, and strategic leadership.

3.3.1. Transformational leadership

The concepts of transformational and transactional leadership were first articulated by Burns (1978) in a political science context and later formulated into a theory of leadership in organizations by Bass (1985). According to Bass’ theory, transformational leaders encourage followers to view problems from new perspectives (intellectual stimulation), provide support and encouragement (individualized consideration), communicate a vision (inspirational motivation), and engender emotion and identification (charisma) (Bass, 1985; Bass & Avolio, 1990). In contrast, transactional leaders motivate subordinates through the use of contingent rewards, corrective actions (passive management by exception), and rule enforcement (active management by exception) (Bass, 1985; Bass & Avolio, 1990). Although transformational leadership theory predicts that transformational leaders will be effective in all situations, the theory also indicates that contextual variables may increase the effectiveness of transformational behaviors (Bass, 1985). Consistent with transformational leadership theory, research has found that transformational behaviors are related to leadership effectiveness in many different types of organizations (Bass, 1997). Further, metaanalysis results have indicated that this relationship is stable across different levels of leadership (Lowe, Kroek, & Sivasubramaniam, 1996).
Studies examining transformational leadership in R&D organizations, however, suggest that leadership level as well as other contextual variables such as project type may moderate the relationship between transformational leadership and effectiveness. In a longitudinal study examining leadership behaviors exhibited by project leaders in three R&D organizations, Keller (1992) found that transformational behaviors were positively related to project quality and budget/schedule performance. This relationship, moreover, was stronger for research projects than for development projects. The relationship between transactional behaviors and project quality was more important in development projects than in research projects. Research focusing primarily on development activities has indicated that intellectual stimulation, charisma, and individualized consideration of higher-level R&D managers, but not project leaders, are related to project success (Waldman & Atwater, 1992).

In combination, the Keller (1992) and Waldman and Atwater (1992) studies suggest a complex relationship among transformational leadership behaviors, level of leadership, and R&D project type. Research projects, which typically occur during earlier stages of the innovation process, generally require project group members to engage in more original idea generation and to gather more information from outside the group than development projects that tend to focus on product/process modification (Keller, 1995). According to the Waldman and Bass (1991) model of leadership and the innovation process, transformational leadership behaviors are necessary in the early stages to create a vision and provide intellectual stimulation. Leaders who are most likely to provide intellectual stimulation to project groups are project leaders. During later stages of the innovation process where development projects occur, Waldman and Bass suggest that project effectiveness is related to charismatic leadership displayed by champions who are typically powerful organizational members. Thus, project effectiveness should be most related to transformational leadership behaviors displayed by project leaders in research projects and higher-level leaders in development projects.

3.3.2. Path goal

According to path-goal theory (House, 1971, 1996; House & Dessler, 1974), an effective leader is one who engages in behaviors that facilitate goal attainment and maximize the value of this achievement, thereby affecting subordinates’ expectancies, valence, performance, and satisfaction. Additionally, the relationship between leader’s behaviors and outcomes are theorized to be moderated by situational variables including characteristics of the task, environment, and subordinates. Studies examining situational moderators have focused more on job characteristics than other types of moderators and have not consistently supported path-goal theory predictions. In a metaanalysis, Wofford and Liska (1993) found support for only 6 of 19 moderator hypotheses. Task structure moderated the relationship between consideration and three outcomes (expectancies, role clarity, and satisfaction with supervisor) and between initiating structure and only one outcome (expectancies). Significant results were found for one other job characteristic, job scope, which moderated the relationship between consideration and performance. Only one subordinate characteristic, ability, had been researched sufficiently to perform a metaanalysis; ability moderated the relationship between initiating structure and performance.
Research examining path-goal theory in R&D organizations suggests that subordinates’ characteristics might explain some of the inconsistent path-goal findings. In a study examining 477 professional employees from four R&D organizations, Keller (1989) found that subordinates’ need for clarity moderated the relationship between initiating structure and job satisfaction in all four organizations and between initiating structure and performance in one organization. Supporting the notion that all employees may not respond the same way to role ambiguity (Schriesheim & Schriesheim, 1980; Stinson & Johnson, 1975; Yukl, 1981), Keller’s results indicated that the relationship between initiating structure and satisfaction was stronger for employees high in need for clarity. Thus, employee characteristics can influence the effectiveness of directive leadership behaviors.

3.3.3. Leader–member relations

LMX was originally proposed by Graen and his colleagues (Dansereau, Cashman, & Graen, 1973; Dansereau, Graen, & Haga, 1975; Graen, 1976; Graen & Cashman, 1975) and focuses on the social exchange processes embedded in the leader–subordinate relationship. Recent revisions to the theory have further described these social exchanges in terms of three stages: (1) initial testing including evaluations of motive, attitudes, resources, role expectations; (2) development of mutual trust, loyalty, and respect; and (3) development of mutual commitment to organizational/unit goals (Graen & Uhl-Bien, 1991). It has been argued that one of the most important initial aspects of the exchange relationship is subordinates’ performance in a series of supervisors’ requests. Subordinates’ reactions to such requests can then influence perceptions of trustworthiness and loyalty (House & Aditya, 1997).

According to LMX theory, the quality of exchange relationships between leaders and subordinates influences a number of important organizational outcomes (Graen & Uhl-Bien, 1995). Although conceptual definitions of LMX have been questioned and measures of LMX and studies’ data analysis have been criticized (Schriesheim, Castro, & Cogliser, 1999), research has linked LMX to a number of important outcome variables. In a recent metaanalysis examining LMX across a variety of contexts, Gerstner and Day (1997) found that LMX is related to subordinate satisfaction with supervisor and overall satisfaction, performance (supervisors’ ratings and objective measures), commitment, role conflict, role clarity, member competence, and turnover intentions.

Overall, studies testing and applying LMX can be placed into three general categories: (1) research examining variables that predict the quality of exchange relationships, (2) research examining the relationship between LMX and behaviors of leaders and subordinates, and (3) relationship between LMX and outcomes (Yukl, 2002). Because LMX research in the R&D context has focused on the third category, only the relationship between LMX and outcomes will be discussed in this review.

The relationship between LMX and performance has been of particular interest in R&D studies that have operationalized performance as creativity and innovation. It has been suggested that the nature of high-quality exchange relationships that include providing subordinates with challenging tasks (Liden & Graen, 1980), leader support of risk-taking (Graen & Cashman, 1975), leaders who secure task-related resources (Graen & Scandura, 1987), provide recognition (Graen & Cashman, 1975), and supervisor advocacy (Duchon,
Green, & Taber, 1986) facilitate employee creativity and innovation (Amabile, 1988; Mumford & Gustafson, 1988). Consistent with predictions, research has found that high-quality exchange relationships are associated with innovation and creativity in R&D organizations. For example, in a study of engineers, scientists, technicians, and managers in the R&D facility of a large industrial corporation, Scott and Bruce (1994) found that high-quality exchange relationships were related to innovative behaviors and perceptions of an organizational climate supportive of innovation.

LMX research has suggested that the definition of what constitutes a high-quality exchange relationship may vary across employees, thus creating “boundary conditions” for the effects of LMX on outcomes (Graen, Scandura, & Graen, 1986; House & Aditya, 1997). Studies of LMX in an R&D context have examined problem-solving style as a possible boundary condition and have yielded mixed results (Scott & Bruce, 1998; Tierney, Farmer, & Graen, 1999). Problem-solving style, a domain of cognitive style, refers to the way that individuals gather, store, and process information (Jabri, 1991; Kirton, 1976). More innovative individuals, labeled by Kirton (1976) as innovators and by Jabri (1991) as bisociative thinkers, gather information from multiple domains and use novel problem-solving approaches. Less innovative individuals gather information from one domain of knowledge and process the information according to established methods; these individuals have been labeled adaptors (Kirton, 1976) and associative thinkers (Jabri, 1991).

In a study examining the interactive effects of LMX and problem-solving style on the innovative behaviors of engineers and scientists in an R&D setting, Scott and Bruce (1998) found that high LMX was related to managers’ ratings of innovative behavior for both associative and bisociative problem-solvers. In contrast, Tierney et al. (1999) found a significant interaction between LMX and employee cognitive style, such that high LMX was related to creativity for those with Kirton’s (1976) adaptive style but not for those with an innovative style. Innovators were creative regardless of LMX. Adaptors in high LMX relationships were more creative than those in low LMX relationships. The authors conclude that LMX has an “enabling” effect for those with an adaptive style. Creativity in this study was assessed with managers’ ratings, invention disclosure forms, and research reports. Differences in dependent variables and the measurement of problem-solving style could account for the conflicting findings in these studies.

3.3.4. Strategic leadership

Research examining leadership in R&D contexts has focused primarily on project leaders rather than those at the top management level. Our review uncovered a small number of studies that examined leadership from a strategic perspective and found links between top management actions and R&D project performance. Research examining acquisitions and divestitures by organizations found that the intense use of such activities was related to the implementation of financial controls by top managers, which had a negative effect on internal innovation (Hitt, Hoskisson, Johnson, & Moesel, 1996).

Other studies have indicated that top management support can have a positive impact on innovation. In an examination of 125 industrial product firms, Cooper and Kleinschmidt (1987) found that top management support for new product projects was related to various
aspects of product success including payback period, domestic market share, relative profits, meeting sales, and profits objectives. Similar results were found by Green (1995) in an investigation of R&D projects based on Hambrick’s (1989) strategic leadership framework. In this study, perceived top management support was related to expected contribution, size of investment, innovativeness, and business advocacy and influenced whether a project was terminated.

4. Conclusions and propositions for future research

Our review of the literature suggests some important conclusions about leadership in the R&D context and some propositions for future research. The conceptual framework in Fig. 1 can help us to understand the importance of environmental and contextual factors that differentiate leadership in R&D organizations from that in operating divisions. In R&D, we are usually interested in the project group leader and in a number of moderators such as type of R&D, membership factors, and rate of technological change, among others. While the empirical research we have reviewed is ample, it is not abundant, so many unanswered questions and areas for future research exist to challenge the researcher interested in R&D leadership.

The first conclusion we have drawn is that the R&D project leader not only has to lead internally and inspire the team members but also he or she should engage in multiple roles including external ones. Namely, the leader should also boundary span with important constituents outside the project group, such as managers and personnel in marketing, manufacturing, and operating divisions, as well as with customers from outside the firm. This kind of activity to champion the project can be critical to the survival and success of the project. However, others in the project group can be project champions as well, and an open question with little existing research is who should do the project championing activity—the leader or someone else? Hence, our first proposition for future research is:

**Proposition 1:** Leaders who engage in multiple roles including internal team development and external boundary-spanning and project championing activities will be more effective than leaders who focus only on internal activities. Also, leaders will be more effective product champions than nonleaders.

Based on the literature we reviewed, transformational leadership appears to be an effective style for use in R&D contexts. The inspirational motivation of providing a common vision for the project enables team members from different disciplines to work together to bring a technological innovation to fruition. In addition, the leader’s use of intellectual stimulation encourages team members from disparate disciplines to look at problems from new vantage points that can enhance innovation. We think that project effectiveness will be highest when transformational leadership behaviors are displayed by project leaders in research rather than in development projects. In development projects, we see the role of the higher-level transformational leader as providing contextual support in the
form of a helpful organizational climate. Hence, our second proposition for future research suggests the following interaction:

**Proposition 2:** A three-way interaction will occur among type of project, type of leadership, and level of leader. Transformational leadership will interact with type of project such that transformational leadership in research projects will be positively related to project effectiveness. In development projects, transformational leadership and leadership level will interact such that transformational leadership of higher-level leaders will be positively related to project effectiveness.

The literature on LMX also is encouraging and has found that a high-quality exchange relationship between the project leader and the team members can lead to more creative and innovative outputs. We wonder, however, if the dyadic nature of LMX carries over to the project team as a whole or if the LMX relationship is more confined to particular dyads of leader–follower relationships. Hence, our third proposition:

**Proposition 3:** Significant variance across the leader–member dyads of a project team will exist such that some dyads will not have a high-quality relationship. These less-than-high-quality relationships will not contribute to project effectiveness.

Path-goal theory is severely underresearched with only one direct study in R&D organizations, which investigated the effectiveness of initiating structure for different types of subordinates and tasks (Keller, 1989). As indicated in a metaanalysis examining path-goal theory in a variety of contexts, consideration may also be an effective leadership style for more structured tasks and jobs with less task variety (Wofford & Liska, 1993). In an R&D context, projects differ in task structure and job scope; hence, development projects tend to have less task variety and tend to be more structured than research projects. Thus, the following proposition is suggested:

**Proposition 4:** Project type will moderate the relationships between consideration and subordinate satisfaction and performance such that the relationships will be positive and stronger for development projects than for research projects.

A research topic in which we did not find any studies conducted in an R&D context but that has much promise for application in R&D efforts is the use of virtual teams. At present, it is unclear how virtual teams, those dispersed across time and space, can be effectively used for the rich information processing needed for R&D work. We are at the early stages, however, of experience and information technology that can be used to take advantage of virtual teams for distance or global R&D projects (Montoya-Weiss, Massey, & Song, 2001). As the technology improves, one would expect a greater and more effective use of virtual teams.

Another void in the literature is a comparison of R&D leaders with other leaders to determine directly that a uniqueness exists in the R&D context. We have inferred that R&D is different based on the compelling nature of the moderator and context variables that exist in
R&D settings. We do not yet have, however, a study showing direct differences in effective leader behaviors between R&D and other contexts.

While our progress in learning about effective leadership is slow, it remains steady. As our review of R&D leadership suggests, we know more about what project leaders should do than we did 10 or 15 years ago. It is also likely that as the U.S. workforce becomes more composed of knowledge workers, effective leadership in R&D settings may become a model for several other contexts where knowledge creation and transfer are critical for success. The importance of the literature in the present review therefore may become greater and more applicable in the near future.

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