CITATION: Blank, T. H., & Naveh, E. (2018). Competition and Complementation of Exploration and Exploitation and the Achievement of Radical Innovation: The Moderating Effect of Learning Behavior and Promotion Focus. *IEEE Transactions on Engineering Management*, *99*, .

COMPETITION AND COMPLEMENTATION OF EXPLORATION AND EXPLOITATION AND THE ACHIEVEMENT OF RADICAL INNOVATION: THE MODERATING EFFECT OF LEARNING BEHAVIOR AND PROMOTION FOCUS

Tali Hadasa Blank
The Jerusalem School of Business Administration
Hebrew University
Jerusalem, Israel
E-mail: talihadasablank@gmail.com

&

Eitan Naveh
Faculty of Industrial Engineering and Management
Technion – Israel Institute of Technology
Technion City, Haifa 32000, Israel
E-mail: naveh@ie.technion.ac.il

ABSTRACT

We aim to address inconsistencies in the research literature regarding whether exploration and exploitation compete with or complement each other in their effect on radically innovative team outcomes. This study takes into consideration the moderating effect of team learning behavior, which includes seeking or providing feedback, sharing information, and elaborating task-relevant information, and team promotion focus, which refers to the motivation for innovation. Using results obtained from 108 R&D teams from 6 high-tech organizations, our findings show two ways to achieve radical innovation performance. Both are characterized by a high level of exploration; however, the level of exploitation and of learning behavior in each of them is either high or low. Against our expectations, promotion focus does not modify the effect of exploration and exploitation on radical innovation performance. While promotion focus is usually assumed to be positively associated with team innovation, we counterintuitively show that when the level of exploration is high, a low (compared to high) level of promotion focus leads to increased radical innovation.

Managerial relevance statement

The paper's expected contributions to practice are three-fold. First, managers can improve their organization's radically innovative performance by encouraging both exploration and exploitation while promoting learning behavior at the same time. Thus, managers should not be concerned with implementing the exploitation-oriented approaches prevalent in concurrent engineering in their R&D units. R&D projects may benefit from activities stemming from quality engineering approaches, including exploitation-oriented practices, without concerns about a possible deterioration of radical innovation. The paper's second contribution to practice is that high levels of radical innovation can be achieved through a combination of high levels of exploration together with low levels of exploitation and of learning behavior. The results of such a setup are not much different than those achieved by having high levels in all three factors simultaneously. Thus, managers can choose the combination that best fits their needs. Lastly, while a motivation to achieve accomplishments and aspirations (i.e.,

promotion focus) is usually assumed to be positively associated with team innovation, our counterintuitive findings are that when the level of exploration is high, a low rather than a high level of promotion focus may be associated with higher levels of radical innovation. Therefore, managers may consider the use of such a combination of levels of exploration and promotion focus instead of maintaining high levels of both, since this may actually impede the achievement of radical innovation.

Key words: radical innovation; exploration; exploitation; learning behavior; promotion focus; prevention focus; R&D teams

INTRODUCTION

In today's fiercely competitive marketplace, organizations striving to succeed need to develop and provide their customers with radically innovative new products and services. Innovation refers to "the successful implementation of creative ideas by an organization" [1, p. 332], [2]. Radically innovative performance refers to a significant deviation from existing products and processes; and it involves high degrees of risk, uncertainty, and, potentially, extreme success [2]. However, the research literature on innovation is not clear on how research and development (R&D) teams reach radical innovation: should R&D teams engage in exploration regardless of their current capabilities, or simultaneously promote exploration and exploitation?

The opposing nature of exploration and exploitation has led scholars and practitioners to argue that exploitation inhibits radical innovation. March [3] asserts that although exploration and exploitation are both essential for organizations, they compete for the same scarce resources. He claims that exploration and exploitation represent a distinction between the refinement of an existing technology and the invention of a new one. Benner and Tushman [4], who studied the implementation of process management practices (specifically, the implementation of the ISO 9001 quality standard), claim that it is impossible to concentrate efforts on exploiting by mapping, improving, and adhering to organizational processes and, at

the same time, achieve radical innovation. This line of argument posits that investing in one activity drives out the other and thus suggests that the two activities should be carried out separately in terms of time and place [5], [6].

Other scholars and practitioners contrast the strict separation of conflicting activities and argue that both exploration and exploitation are needed in order to achieve radical innovation. Farjoun [7] suggests that stable mechanisms can enable radical innovation and specifies that "when used effectively, bureaucracy, control systems, and formalization can be enabling and can facilitate non-routine work, including radical innovation" (p. 213). Katila and Ahuja [8] argue that a positive relationship exists between relatively high levels of exploitation (e.g., search depth), exploration (e.g., search scope), and product innovation. Gibson and Birkinshaw [9] assert that it is possible to simultaneously achieve conflicting demands (such as alignment and adaptability) not by relying on structural or temporal separation, but by building a supportive business unit context. A system may have sufficient levels of internal complexity so that tensions can be kept within it and managed, rather than organized "out" of the system [10]. Furthermore, other studies present a positive relationship between placing a focus on reliable, efficient procedures and the innovative outcomes of such activities (i.e., [11], [12]). They provide empirical support for the coexistence of the values of exploration and exploitation represented by innovative and attention-to-detail behaviors [13], [2].

These mixed results generate confusion regarding the practices that are suggested for R&D teams hoping to achieve radical innovation performance. On the one hand, due to the contrasting nature of exploration and exploitation, the literature points to two main mechanisms for separating and balancing these activities: structural ambidexterity and punctuated equilibrium. The first mechanism implies a composition of highly differentiated but weakly integrated teams and subunits, while the second mechanism refers to a temporal cycling between long periods of exploitation and short bursts of exploration [5], [14]. On the other hand, following the view that exploration and exploitation complement each other, systems engineering approaches suggest that organizations should implement practices that ensure the joint and simultaneous implementation of both types of activities within R&D teams. Examples

of this perspective are concurrent engineering and a lean enterprise philosophy that emphasizes a holistic and integrative approach to all organizational activities [15].

In this paper we aim to address the research literature's inconsistencies regarding whether exploration and exploitation compete with or complement each other in their effect on radically innovative team outcomes. Specifically, this contribution is based on our counterintuitive findings about two factors, learning behavior and motivation. Previous studies have already suggested that learning behavior serves as a catalyst to achieve a balance between exploration and exploitation [6]. However, we advance these results a step forward. While learning behavior is usually assumed to be positively associated with team outcomes, particularly with innovation [6], [2], we counterintuitively show that under certain levels of exploration and exploitation there is a negative side to learning, and that the latter may not necessarily help synergize exploration with exploitation. In addition, we advance from the prior assumption of either separation or integration of exploration and exploitation, as discussed in the literature (see above), to a situation where both separation and integration may lead to radical innovation under given combinations of certain levels of exploration, exploitation, and learning behavior. Thus, the contribution and the difference between this and previous studies regarding possible catalysts for balancing exploration and exploitation is that, in the current study, we discover the complex mechanism of learning behavior. When acting as a catalyst for balancing exploration and exploitation, learning behavior operates differently depending on the level of exploration and exploitation. To the best of our knowledge, this approach has never been suggested before. Moreover, we do not refer only to learning behavior as a catalyst for balancing exploration and exploitation, but also to motivation. While motivation, and specifically promotion focus (motivation oriented toward achieving accomplishments and aspirations), is usually assumed to be positively associated with team outcomes, we show counterintuitively that when the level of exploration is high, a low rather than a high level of promotion focus leads to increased radical innovation.

EXPLORATION, EXPLOITATION, AND RADICAL INNOVATION

In line with previous research, we focus on the team level since organizations increasingly rely on teams in order to successfully innovate and deal with the complexity of new technologies and information [2], [5], [9], [14], [15].

Learning behavior moderates the interaction of exploration and exploitation

In this section we first relate to the definition of exploration, exploitation, and learning behavior, and then elaborate on their influence of radical innovation performance.

Definition of exploration, exploitation, and learning behavior. One reason for the inconsistent nature of the relationship between exploration and exploitation and radical innovation lies in the inadequate differentiation made between type of learning, meaning exploration or exploitation, and learning behavior. Learning behavior refers to the processes of seeking or providing feedback, sharing information, and elaborating task-relevant information. Previous literature studies exploration and exploitation as two independent factors ([5], [8]) using two different definitional approaches. One approach "embrace[s] the idea that both exploration and exploitation are associated with learning and innovation, albeit of different types" ([5], p. 694); the other approach "treat[s] all activities associated with learning and innovation as instances of exploration and reserve[s] the term 'exploitation' for activities in which the central goal is using past knowledge rather than moving down any kind of a learning trajectory". A similar argument was also suggested by Lavie et al. [6]. Indeed, an overview of earlier studies suggests that the definition of exploration and exploitation combines both type of learning and learning behavior (see Table 1).

INSERT TABLE 1 ABOUT HERE

Therefore, in this study we distinguish between type of learning and learning behavior. *Exploration* refers to activities such as search, increasing variation, experimentation, play, flexibility, discovery, and risk-taking [3]. It emphasizes the breaking of existing paradigms, openness to different ways of thinking, and experimenting. These exploration activities enrich the knowledge pool by increasing the potential for using new or previously unavailable

variations of knowledge. Having a wide spectrum of variation ensures a sufficient extent of choices to solve problems in a divergent way — a way that supports radical innovation [3]. Researchers agree that increased exploration positively affects radically innovative performance (e.g., [2], [15]).

Exploitation refers to activities such as refinement, production, efficiency, selection, implementation, and execution [3]. It emphasizes routinization, coordination, and process repetition, and relates to current capabilities, thus preventing usage of and exposure to new knowledge and market trends [15]. These activities contribute to resistance to change, competency traps, and inadequate or inappropriate responses, and thus may hinder the achievement of radical innovation [16]-[20].

L*earning behavior* [21] refers to a learning process that includes activities such as seeking or providing feedback, sharing information, and elaborating task-relevant information.[1] It is important because team members need to engage in intensive information elaboration processes that enable them to take advantage of unique information, knowledge, and ideas that reside in distinct exploration and/or exploitation activities. This refers to the extent to which team members exchange, discuss, and integrate advice, suggestions, recommendations, ideas, knowledge, and insights from exploration and exploitation activities [24].

Accordingly, if exploration and exploitation are considered to be activities related to learning types only, learning behavior may support and accelerate both of them. This claim is also espoused by Farjoun [7], who asserts that some learning mechanisms can support both exploration and exploitation. Likewise, Smith and Lewis [25] recognize that "exploration and exploitation reinforce one another through their interwoven support of organizational learning" (p. 388). In summary, we suggest that exploitation, exploration, and learning behavior are independent, though correlated, factors that exist simultaneously at various levels.

[1] Other studies used alternative terms such as extensive communication [22] and learning organization [23].

The influence of the relationship between exploration, exploitation, and learning behavior on team radical innovation performance. The previous explanation about the independence of the three factors (exploration, exploitation, and learning behavior) allows us to refer now to the influence of different combinations of these three independent factors on radical innovation performance. We suggest that it is the three-way interaction between exploration, exploitation, and learning behavior that has an impact on radical innovation. We now explain this three-way interaction and specifically refer to four possible combinations of its elements. All these combinations include a high level of exploration because, according to Benner and Tushman [4], it is necessary to have a high level of exploration in order to achieve radical innovation performance (see Table 2).

INSERT TABLE 2 ABOUT HERE

When the level of learning behavior in the team is high, higher levels of exploration are positively associated with radical innovation when the level of exploitation is high rather than low. This is because high levels of learning behavior serve as a mechanism that stimulates the linkage and connects the exploration of new knowledge with the exploitation of existing capabilities. A high level of learning behavior supports synergic, enabling, and mutually-permitting relationships between exploration and exploitation when the levels of these two are high [7]. In addition, Farjoun [7] and Levinthal and Rerup [26] propose that stable mechanisms and limits enable change and adaptability. In this respect, it is worth taking notice of Katila and Ahuja's [8] claim that "exploitation is important not just for fine-tuning and economizing the efficiency of an existing technology but also for creating new knowledge" (p. 1191). Their study further suggests that exploitation also has a role in "combining existing solutions to generate new combinations". A high level of learning behavior enables employees to use their accumulated knowledge to recognize and facilitate the absorption and further development of new knowledge [27]. It creates opportunities for team members to communicate, interact, exchange knowledge and ideas, and better understand and work together on aspects relating to both exploration and exploitation [28], [29]. It promotes willingness to embrace and appreciate

different knowledge bases, and to better integrate the information. Under high levels of learning behavior, the different types of knowledge related either to exploration or to exploitation are appreciated by team members, who become more aware of the existing diversity of perspectives. Both exploration and exploitation receive attention, and their interdependency is recognized and shared [30], [31]. This allows members to take advantage of the unique information, knowledge, and ideas associated with both exploration and exploitation. In addition, high levels of learning behavior increase the amount of available resources because both information and knowledge are expandable resources. March [3] claims that exploration and exploitation compete less with each other when resources are readily available. In this way, "exploitation is a more comprehensive concept than it is usually considered to be" ([8], p. 1191). Therefore, with a high level of learning behavior, exploitation constraints may accelerate the positive relationship between exploration and radical innovation. Thus, the linkage between high levels of exploration and of exploitation, stimulated by high levels of learning behavior, increases the level of radical innovation performance (Table 2, combination 1).

In contrast, when the level of learning behavior in the team is low, such mutual fertilization between high levels of exploration and exploitation is prevented, and exploration and exploitation compete against each other. This situation occurs because learning behavior, which serves as a mechanism connecting contradictory activities, is not emphasized and, as a result, information sharing and knowledge transfer activities are reduced or eliminated. A low level of learning behavior prevents the creation of connections, information channels, and potential combined efforts between old ways of thinking, the reuse of existing knowledge, and the use of new information [32]. In such cases, resources do not expand, and in a limited-resource situation, high levels of exploitation and exploration compete further against each other because of the tension, elimination, and hindrance relationships between them [3], [7]. Thus, when the level of both exploration and exploitation is high and, in addition, the level of learning behavior is low, exploitation's intention to control processes and "attack" variation conflicts with prescriptions for variation-increasing activities [4], and thus radical innovation performance is harmed (Table 2, combination 2).

When the level of exploration is high and that of exploitation is low, a high level of learning behavior that intensifies and magnifies dominant activities [33] results in an extended focus on exploration. Learning behavior is a mechanism by which the aspects that are already dominant become stronger. The argument that high levels of learning behavior intensify and magnify dominant activities is in accordance with activation theory. This theory suggests that a team context brings out, i.e., activates, dominant characteristics. Such characteristics become more dominant when the environment, that is, the level of learning behavior, encourages this to happen. Thus, a high level of learning behavior is a team environment that encourages the domination of exploration and exploitation if they are already at a high level [34], [35]. When the level of exploration is high and that of exploitation is low, exploration is the team's dominant characteristic and high levels of learning behavior in the team intensify it [24]. Intensifying exploration when the level of exploitation is low leads to an unbalanced situation that does not allow a mutually-permitting relationship between exploration and exploitation [7], and as a result, radical innovation performance is harmed. Thus, we suggest that the combination of high levels of learning behavior with low levels of exploitation, and high levels of exploration leads to low radical innovation (Table 2, combination 3). In this combination, the low level of radical innovation performance is the price paid for the lack of equilibrium between exploration and exploitation. The claim that more learning does not inevitably lead to better performance is not new and has already been suggested in organizational literature [33].

Finally, a situation in which the level of exploration is high and that of both exploitation and learning is low influences radical innovation in different way. When the team's level of learning behavior is low, it does not promote further and intensify either exploration or exploitation. In this case, the team can benefit from the influence of exploration on radical innovation, but it does not enjoy the benefit of the synergy of exploration with exploitation (because the team's levels of learning behavior and exploitation are low). However, it also does not suffer any hindrance due to the tension between exploration and exploitation. Given that exploration is a satisfied condition to achieve radical

innovation [4], in this combination the level of radical innovation performance is high (Table 2, combination 4). Indeed, in this scenario radical innovation performance does not pay the price of ignoring exploitation (as in Table 2, combination 3), and it benefits from the low tension between exploration and exploitation.

Given the above, we hypothesize that:

Hypothesis 1. A three-way interaction between learning behavior, exploration, and exploitation predicts radically innovative performance so that, when the level of learning behavior is high, exploration and exploitation complement each other in their relationship with radical innovation, i.e., exploration is positively associated with radically innovative performance when the level of exploitation is high rather than low. When the level of learning behavior is low, exploration and exploitation compete against each other in their relationship with radical innovation, i.e., exploration is positively associated with radically innovative performance when the level of exploitation is low rather than high.

Promotion focus moderates the interaction of exploration and exploitation

Another reason for the inconsistent relationship of exploration and exploitation with radical innovation may be due to the fact that the literature does not pay enough attention to the motivational aspect involved in attaining radical innovation. None of the leading papers in the field listed in Table 1 mention motivational aspects. A critical feature of radical innovation is that, in order to achieve it, team members must be able to cope with failure and be determined and highly motivated [36]. Exploration has less certain outcomes, longer time horizons, and a more diffuse influence [3]. It has also been claimed that "exploration often leads to failure, which in turn promotes the search for even newer ideas and thus more exploration, thereby creating a failure trap" ([5], p. 695). Therefore, team members' motivational aspects play a critical role in attaining radical innovation.

Considering the motivation for innovating, Higgins [37] described two different ways in which people regulate their actions: either through a *promotion focus* or through a *prevention focus*. Individuals and teams that operate primarily within a *promotion focus* are more concerned with accomplishments and aspirations, whereas a *prevention focus* emphasizes duties and obligations. We suggest that the team's specific motivation focus influences the relationship between exploration, exploitation, and attainment of radical innovation.

The promotion focus is more relevant to radical innovation than the prevention focus, so our theory refers mainly to promotion motivation [38], [39]. Nevertheless, because many motivational focus studies refer to both promotion and prevention, we control for the prevention focus effect (see the Control Variables section). We refer to the collective character of team regulation, based on the suggestion by recent studies that individual team members' regulatory focus is shaped by team contextual cues, and that a team provides unique conditions that shape its members' regulatory focus [40].

We claim that looking into promotion motivation is critical when investigating exploration and exploitation and their effects on radical innovation. Promotion motivation involves a "risky" processing style in which novel alternatives are eagerly and actively sought, and creative thought is enhanced while concentrating on positive outcomes [37], [41].

We argue that exploration and exploitation complement each other when operating under a high level of promotion motivation. In other words, under such circumstances, a higher level of exploration is positively associated with radical innovation when the level of exploitation is high rather than low. Team members following a high level of promotion focus are motivated to work and act toward the fulfillment of their wishes and aspirations, and are attentive to positive outcomes in spite of exploitation constraints and restricted processes. Working under a promotion focus encourages employees to persist in carrying out challenging, complex, unfamiliar tasks [42], thus overcoming exploitation constraints or using them in a beneficial way. A promotion focus bolsters creative insights and creative generation [41], which enable both the exploration of new knowledge and the exploitation of existing capabilities. Motivated team members enhance their cognitive flexibility, willingness to take risks, and openness to

complexity, which in turn expands their access to ideas and potentially creative solutions [43]. High reliability organization theory [44] also supports such claims, suggesting that vigilance resulting from exploitation activities requires creative thought that is enhanced by a promotion focus in order to respond to constraints.

However, when the level of promotion motivation is low, we expect exploration and exploitation to compete with each other. In this case, a higher level of exploration is positively associated with radical innovation when the level of exploitation is low rather than high. Working under a low promotion focus preserves the tension between exploration and exploitation. The team members' motivation is not attentive to positive outcomes but to restrictions and obstacles; thus, exploitation constraints inhibit exploration. Therefore, we hypothesize that:

Hypothesis 2. There will be a three-way interaction between promotion, exploration, and exploitation in predicting radical innovation performance so that, when the level of promotion is high, exploration is positively associated with radically innovative performance when the level of exploitation is high rather than low. When the level of promotion is low, a high level of exploration is positively associated with radically innovative performance when the level of exploitation is low rather than high.

METHODS

Sample

We tested our theoretical model in Israel, which is the second most innovative nation in the world according to The World Economic Forum's Global Competitiveness Report [45]. The sample consisted of 108 teams from 6 mature high-tech organizations. These organizations develop, operate, and produce cutting-edge innovations at the semiconductors, communications, and information technology segments. They act as major pioneers in their fields, advancing new ideas and technologies. Our study sample included R&D teams focused on targeted innovation outcomes in these segments. For example, one R&D team's goal was to develop a unique unit that would be able to connect, transfer, and receive information from

multiple other systems, recognize different input formats, process the information received, and send independent responses simultaneously to multiple systems that use different communication formats. The team developed a unit that works fast, produces accurate calculations, is lightweight, and does not overheat.

The number of teams in each organization was 35, 21, 21, 19, 7, and 5, respectively. Altogether, the sample included 443 employees working in R&D teams who assessed the independent and control variables, and 212 team leaders/managers who assessed the dependent variable. Thus, the total sample size comprised 655 participants. The response rate was 90% in each participating team. The average number of respondents per team was 4.1; the number of respondents in each team ranged from 3 to 11. Out of the entire population participating in the study, 23% were female and 77% were male. Team members' age was distributed so that 45% were 25-34 years old, 39% were 35-44 years old, 12% were older than 45 years old, and 4% were younger than 25. The average number of years in the organization was 4.8 years (SD = 1.28), and the average number of years in the team was 4.12 years (SD = 1.39). Education level was distributed so that 3.4% had high school education, 21% had technical education, 59% had a B.Sc. or B.A. degree, 14.5% had M.Sc. or M.A. degrees, and 2.1% had a Ph.D. degree. Team members filled out the independent-variable questionnaires.

For each team, 2 managers filled out the dependent-variable questionnaire indicating team performance. Out of a total of 212 leaders/managers, 85% were male and 15% were female. Their age was distributed so that 66% were 35-44 years old, 13% were aged 25-34, and 21% were older than 45 years old. The managers' response rate was also 90% in all participating teams.

Measures

All questions were answered on a seven-point Likert scale from 1 ("To a very slight extent") to 7 ("To a very large extent"). See the Appendix for all scale items.

Independent variables. Team members were asked to rate the extent to which each statement presented to them characterizes their team's work. *Exploitation* was measured using

5 items drawn from Miron, Erez, and Naveh [46]. *Exploration* was measured using 6 items drawn from Miron et al. [46].

Moderator variables. *Learning behavior* was assessed using 6 items drawn from Edmondson [21]. Although Edmondson's original scale was published in a paper on psychological safety, it has been extensively used for assessing learning in general [32], and innovation-related learning in particular [47] - [50]. Team members were asked to state the extent to which the statements presented to them characterize their team's work.

Promotion focus was measured using 5 items drawn from Lockwood, Jordan, and Kunda [51]. Employees were asked to rate the level of promotion focus characterizing their team's work.

Control variable. We controlled for *prevention focus*, because regulatory focus theory posits that people are guided by both promotion and prevention as two distinct motivational approaches. Prevention motivation involves a relatively risk-averse and vigilant processing style in which repetition is favored over novelty and alternatives are carefully eliminated [37]. Prevention focus was measured using 5 items drawn from Lockwood et al. [51]. Employees were asked to rate the level of prevention focus in their team.

Dependent variable. *Radically innovative performance* was measured using a 5-item questionnaire adapted from Gatignon, Tushman, Smith, and Anderson [52] that includes characterizations of team products. The two managers who filled out the dependent-variable questionnaire for each team were highly familiar with the team's innovation activities and knowledgeable about the team's fields of activities in general, and thus were capable of replying to questionnaire items that refer to the team's activities. In answering the questionnaire items referring, for example, to the communications unit described above (in the Sample section), these questionnaire items become concrete and tangible.

Procedure

The study included 2 data collection phases and lasted about 7 months. First, to learn about team innovation processes and practices in the high-tech industry and the factors influencing them, we conducted interviews in 3 of the participating organizations. Interviewees included

the top management team manager, division manager, senior and junior managers, and 7 team members. Each interview lasted from 30 minutes to 1 hour. The interviews included short visits and explanations about innovation in the different teams. These visits and interviews enabled us to gain a deeper understanding of how the organization's employees and managers perceived radical innovation. Following the interviews, we designed and administered the study questionnaire.

In each participating organization we had a representative employee who cooperated and helped us manage the collection of the data. We created an on-line survey (using www.gizmo.com), and each participant received a direct link via email and filled it online. In 2 organizations, hard-copy surveys were used at their request.

RESULTS

Construct Validation

To test the structure of the independent, control, and dependent variables we conducted a confirmatory factor analysis (CFA) using the SAS 9.3 CALIS procedure at the individual level of analysis. The analysis was performed on variance–covariance matrices with pairwise deletion of missing values. We employed a maximum-likelihood estimation method with robust standard errors together with the Satorra–Bentler rescaled chi-square statistic [53].

The exploration, exploitation, learning behavior, promotion focus, and prevention focus variables' CFA yielded an acceptable fit level [54]: $\chi^2(125, N = 443) = 318.06$, $p < .01$, NNFI = .95, CFI = .96, and RMSEA = .06. All the standardized factor loadings in the model were above .60 (see the Appendix for the specific CFA loadings). To further support the distinction between learning type and amount, and since some scholars treat exploration and learning behavior as one factor, we tried another CFA. In this analysis, we tested a 4-factor structure that included, in addition to exploitation, promotion, and prevention, the dimensions of exploration and learning behavior as one single factor. This CFA yielded an unacceptable fit. The results showed a clear preference for the 5-factor construct; NNFI=.85, CFI=.79, RMSEA = .10, $\Delta\chi^2(4,$

$N = 443) = 420.94$, $p < .01$). Thus, these results supported separating exploration from learning behavior; see Cronbach's Alpha in brackets in Table 3.

Level of Analysis

The independent variables of exploration, exploitation, learning behavior, and promotion focus, and the control variable (prevention focus), as well as the dependent variable of radical innovation, are considered group-level variables. That is, they reflect events occurring in a team that are shared or experienced by all the individuals in the specific unit [55]. In order to justify the aggregation of the individual responses to the average team level, we calculated the within-team agreement (i.e., rwg agreement index; [56]). In addition, intraclass correlations (ICCs) indicate whether the measures are sufficiently reliable to model effects at the team level [57]. The exploration, exploitation, learning behavior, promotion focus, and prevention focus scales exhibited a sufficiently high average agreement (median r_{wg}=.81, .82, .91, .88, .86, respectively). Between-department effects based on the results of the one-way analyses of variance (ANOVA) were significant at p<.05 for the 4 independent variables and the control (prevention focus) variable, demonstrating that a significant proportion of the variance in individual responses can be accounted for by team membership [58]. Intraclass correlations were adequate, ICC(1) = .12*, .18**, .15**, .17**, and .07**, and ICC(2) = .35*, .46**, .42**, .44**, and .23**, respectively (**p<0.01, *p<0.05). These statistics justified the aggregation of the independent and control variables to the team level [57]. Therefore, we calculated the mean score of each scale for each team by averaging the corresponding employees' ratings, and then assigned each team its mean score.

The scales of the dependent variable, radically innovative performance, exhibited a sufficiently high agreement (median r_{wg}=.96). Intraclass correlations (ICCs) indicated that the dependent variable measure was sufficiently reliable to model effects at the team level (ICC(1) = .63**, ICC(2) = .78**, **p<0.01). In order to demonstrate the measurement's reliability, we also calculated the correlation between the managers' scores, which was relatively high (r = .68). Therefore, we calculated the mean score of radically innovative performance for each

team by averaging the 2 managers' means scores, and then assigned each team its mean performance score.

Hypotheses Testing

Table 3 summarizes the means, standard deviations, and correlations among the variables.

INSERT TABLE 3 ABOUT HERE

The averages presented in Table 3 suggest that, on average, exploitation was higher than exploration, and that learning behavior was higher than both exploration and exploitation. The correlations presented in Table 3 suggest some initial evidence for our hypotheses, specifically, both learning behavior and promotion focus were significantly and positively associated with both exploration and exploitation. Thus, a higher level of learning behavior is associated with higher levels of exploration and exploitation. However, except of the control variables of organization seniority, team seniority and role seniority, all correlations are not at the .7 level and actually far from it, suggesting that the variables are independent [59]. Together with the CFA results presented above, these results support our theory that exploitation, exploration, and learning behavior are three separate factors whose levels vary (as suggested in hypotheses 1 and 2).

Because of the data's multilevel nested structure (a team within an organization), we used a mixed model method of data analysis. Mixed models take into account the fact that teams within one organization may be more similar to one another than to teams in other organizations [60]. In order to test our hypotheses, we used the SAS MIXED procedure [61] suitable for statistical models with non-independence of observations.

The analysis begins with the fitting of an unconditional null model in order to estimate the total systematic variance in the dependent variable [60]. This analysis clarifies how much variance resides within and between teams and organizations, and also serves as a foundation for later analyses. To effectively partial out these teams' and organizations' variances, thereby eliminating the potential lack of residuals' independence, we coded for organizations (from 1 to 6) and teams (from 1 to 108). Using MIXED models, we regressed radical innovation on

teams within organizations. The results of this null model indicated that the proportion of between-organizations variance to total variance (that is, the ICC(1) value for the dependent variable) was .38, $\chi^2(102, N = 108) = 145.08$, $p < .01$. These results justify modeling teams within organizations as cross-level effects.

Table 4 presents 5 stepwise models we ran to test our hypotheses. Model 1 includes the control variables. In Model 2 we added the two independent variables of exploration and exploitation. In Model 3 we added the two moderators of learning behavior and promotion focus and the 5 two-way interactions of: exploration and exploitation, exploration and learning behavior, exploitation and learning behavior, exploration and promotion focus, and exploitation and promotion focus. In Models 4 and 5 we added the three-way interactions between exploration, exploitation, and learning behavior, and exploration, exploitation, and promotion focus, respectively, while including the relevant two-way interactions.

INSERT TABLE 4 ABOUT HERE

The results of Model 1 (Table 4) showed no significant effects for the control variables of prevention focus, team size, gender, employee's number of years in the organization, on the team, and in the current position, and employee's educational level. The control variables also showed no significant effects in Models 2-5. In our sample, the age of the majority (84%) of team members was in the range of 25-44 years old. More than 70% of the sample holds a B.A. or M.A. degree. Also, the variables of team size, gender, employee's number of years in the organization, on the team, and in the current position showed little variance between teams. We assume that it is due to these similarities that we did not find a significant influence of such traits on the teams' radical performance. Our sample is not unique, because these characteristics are common in most high-tech firms.

The results of Model 2 (Table 4) did not show a significant main effect for exploitation and exploration. The only two-way interaction that was significant in Model 3 ($p < .1$) is that between exploitation and learning behavior. Model 4 showed a significant three-way interaction between exploration, exploitation, and learning behavior on radical innovation, and also

significant two-way interactions between exploitation and learning behavior and exploration and promotion focus. To understand the nature of the significant interactions we followed the graphing method outlined by Aiken and West ([62]; high and low are ±1 *SD*).

INSERT FIGURES 1a & 1b ABOUT HERE

Figure 1a shows that when the level of learning behavior was high, higher levels of exploration were associated with higher levels of radical innovation when the level of exploitation was high rather than low. Figure 1b shows that when the level of learning behavior was low, higher levels of exploration were associated with higher levels of radical innovation when the level of exploitation was low rather than high. Thus, Figure 1a and 1b fit with the four combinations presented between exploration, exploitation and learning behavior on radical innovation (Table 2) and we confirmed Hypothesis 1.

Hypothesis 2 was not confirmed. The three-way interaction between exploration, exploitation, and promotion focus was not significant (coefficient estimate = .14, SE = .23, $p > .1$, Table 4, Model 5). The two-way interaction of exploration and promotion focus was significant at a p-value of .08 (Table 4, Model 5). We followed Aiken and West's [62] graphing method.

INSERT FIGURE 2 ABOUT HERE

Figure 2 shows that a high level of exploration was associated with higher levels of radical innovation when the degree of promotion focus was low rather than high. Inversely, a low level of exploration was associated with higher levels of radical innovation when the degree of promotion focus was high rather than low.

DISCUSSION

This study investigates ways for teams to achieve radical innovation. In doing so, it addresses the challenge of settling the previous inconsistent results on the separation and integration of exploration and exploitation by referring to learning behavior and motivational factors.

With respect to learning, our analysis started by supporting the two definitional components of type of learning, which relates to exploration and exploitation, and of learning behavior. Confirmatory factor analysis showed that a model that distinguishes type of learning from learning behavior has a better fit to the data. These results are in accordance with our claim that the inconsistent nature of the relationship between exploration and exploitation and radical innovation lies in the mixture of type of learning and learning behavior. We take the relationship between learning behavior and exploration and exploitation a step forward by referring to its simultaneous nature.

Our results support Hypothesis 1, and the crossover (X- shaped) interaction pattern (in Figures 1a and 1b) supports the influence of the combinations of exploration, exploitation, and learning behavior on radical innovation performance, as suggested and summarized by us in Table 2. Our findings show that when the level of learning behavior is high, exploration and exploitation complement each other (as suggested earlier by [2], [8], [13]). However, when the level of learning behavior is low, exploration and exploitation compete with each other and thus reduce the chances of reaching radical innovation (in accordance with earlier research by [3], [4], [6]).

To date, studies tend to concentrate on one way to achieve radical innovation, either by separating the type from the amount of learning or by integrating them. However, this paper's contribution suggests that high levels of radical innovation can be achieved using different combinations of exploration, exploitation, and learning behavior. A review of the literature suggests that this idea has not received much attention yet. Achieving radical innovation through high levels of exploration, exploitation, and learning behavior may offer more benefits for mature organizations because of the spillover of these activities into other organizational performances. For example, exploitation is related to incremental innovative and quality performances [13]; thus, high levels of both exploration and exploitation may support not only a radically innovative performance but also incremental innovative and quality performances. Future research may identify conditions under which each combination better fits specific organizational conditions. Adopting a research approach that argues that radical innovation is

not the result of a single combination of factors but rather of different such combinations raises questions that can lead to new lines of study on radical innovation. For instance, what is the combination that better fits a specific organization's potential to generate radical innovation?

Another interesting question in regard to the results is whether the configuration of high levels of exploration, exploitation, and learning behavior is costly compared to high levels of exploration and low levels of exploitation and learning behavior, given that the two configurations result in a similarly high level of radical innovation. Testing this question empirically is beyond the scope of this study, but it provides an interesting direction for future research. We suggest that the cost associated with each configuration is context–dependent; therefore, no clear-cut answer can be provided to this question. The later-mentioned configuration may be cheaper under some conditions and more expensive under others. Low levels of exploitation are associated with a decreased emphasis on quality, so any combination that includes low levels of exploitation may overall be costlier if quality suffers (for example, the cost of quality discussed in [13]).

Regarding motivation (operationalized by promotion focus and prevention focus), earlier studies treated promotion motivation as enabling a culture of creativity and innovation (e.g., [41], [63]), and the current study contributes the perspective of radically innovative performance. In a similar fashion to the influence of learning behavior on exploration and exploitation affecting radical innovation outcomes, we assumed that we would find motivational aspects of promotion that are also positively correlated with such outcomes. Our results did not support this hypothesis, i.e., the effect of the three-way interaction between exploration, exploitation, and promotion focus on radical innovation was not significant. Thus, the relationship between exploration and exploitation is not dependent on the level of promotion motivation. Prevention focus, to which we related as a control variable, was also not significant in its association with radical innovation. Although we did not expect a high correlation between prevention focus and radical innovation, the zero-correlation obtained here is indeed on the extreme side. One possible explanation may be that there was not enough variance in the sample to identify differences in the correlation between prevention

focus and radical innovation. These results may suggest that the relationship between exploration and exploitation and radical innovation is less motivationally related and more learning-dependent. In this respect, the findings support a line of study that relates to exploration and exploitation as learning-oriented (e.g., [3], [8]).

Nevertheless, our results do suggest a significant interaction between exploration and promotion focus: the highest level of radically innovative performance is achieved when the level of exploration is high and the degree of promotion focus is low (Figure 2). This is theoretically counterintuitive and interesting, because increased levels of both promotion focus and exploration should lead to a higher degree of radical innovation. These results suggests that when a team emphasizes exploration, a higher level of promotion motivation is not a contributing factor; however, when the level of exploration is low, a high degree of promotion focus can further support radical innovation. When the level of exploration is low, a high rather than low level of promotion focus leads to higher levels of radical innovation, but this relationship is not maintained when exploration is at a high level. High promotion levels may lead to excessively high levels of risk-taking that eventually do not lead or contribute to radically innovative outcomes. This result makes sense when we imagine how an innovation journey develops [64]. At the beginning, movement is slow and every little push helps it advance forward (when the level of exploration is low), but once the journey gets going (when the level of exploration is high), additional pushes are barely noticeable. These results also suggest some extent of substitution between exploration and promotion focus, because similar levels of radical innovation were achieved with a combination of low levels of exploration and high levels of promotion focus and a combination of high levels of exploration and low levels of promotion focus.

A possible explanation for high levels of exploration and promotion focus resulting in low radical innovation (Figure 2) may relate to the employees' perception of promotion motivation. In our study, promotion focus may be associated with negative feelings if viewed as extrinsic motivation. Employees may express negative feelings toward extrinsic rewards, because they view these rewards as tools to regulate their activities [65]. Reaching radical innovation requires

tremendous efforts that carry with them a high level of risk. Thus, motivation is important. However, if employees view the promotion mechanism as a tool to regulate their activities, their motivation could find itself hindered instead of bolstered [65]. Future studies may look into differences in the influence of exploration activities with various extrinsic and intrinsic types of motivation. Another explanation may be that, since personality plays an important role in achieving radically innovative performance [2], the emphasis on team-level promotion is less affected when the individual level is highly dominant. It would be interesting to investigate this line of thought in future research.

This result joins other studies' inconsistent results regarding motivational aspects and radical innovation. For example, Miron-Spektor and colleagues' [2] insignificant results concerning team potency, i.e., the team members' generalized belief about their team's capabilities to address tasks, call for further investigation of motivational effects on the achievement of radical innovation. Future research in this direction may also enhance our understanding of the effects of promotion motivation, and specifically, the conditions under which a promotion-oriented focus exerts a limited effect on performance improvement. This angle is also interesting from the point of view of research on promotion motivation, since the latter has been theorized to be a powerful explanatory factor but there are relatively few empirical studies that support this line of thought.

Limitations and Future Research

The present study benefited from a relatively high number of teams from several organizations, a high response rate, and a research design that made it possible to establish a linkage between data on the independent variables and data on radical innovation performance collected from separate independent sources. The dependent variable — radical innovation — was based on independent assessments made by 2 managers for each team. Our measurement is based on leading studies on innovation (such as [2], [9]). However, radical innovation may be subject to reporting bias. Therefore, future research should also use hard data on radically innovative performance, such as information on registration of new patents and sales growth ([4], [8], [66]), although this kind of data has its own limitations. To examine learning behavior,

we used Edmondson's scale [21]. Though widely acceptable and used (e.g., [47] - [50]), it is more common in the context of psychological safety. Thus, future research may develop a better-oriented scale (for example, in accordance with Argote & Miron-Spektor [32]) that corresponds to the intent and content of learning scales geared towards innovation-based learning.

This study was performed in the high-tech industry, which emphasizes the importance of radical innovation. Future investigation in traditional industries, e.g., food, textiles, or banking, may lead to a deeper understanding of the conditions under which radical innovation can be accelerated.

It would also be interesting to apply the team-level theoretical construct we developed in this study to the organizational level of analysis and to multilevel analyses, taking into consideration both team and organization levels.

In addition, while this study focuses on radical innovation, many organizations encourage both radical and incremental innovation. Future studies should perhaps use multidimensional measurements that include, in addition to innovation, quality and efficiency performances [67]. Examining the effects of exploration and exploitation on a variety of performance dimensions may lead to a better understanding of organizational phenomena in general and of radical innovation in particular.

Finally, both moderating variables, learning behavior and promotion focus, may be cast as aspects of organizational culture and norms that emphasize discovery, learning, and risk-taking. Future research may identify other cultural values and additional variables that may affect the impact of the interaction of exploration and exploitation on radical innovation.

Practical Implications

Our study suggests to managers that exploration and exploitation complement each other when the level of learning behavior is high, and therefore, it is not necessary for them to be separated in time or place. Regarding the simultaneous positive effect of exploration and exploitation on radical innovation, managers should be more concerned with applying learning behaviors than with motivational activities such as promotion focus. We provide a clear and

integrated message for team managers: they can improve their organization's radically innovative performance by encouraging both exploration and exploitation while promoting learning behavior at the same time. This message has important applications for many organizations and many settings. Following our results, managers should have no concerns about implementing the exploitation-oriented approaches of concurrent engineering in their R&D units. R&D projects may benefit from the activities proposed by quality engineering approaches, including exploitation-oriented practices, without being concerned about hindering radical innovation. The application of exploitation-oriented approaches such as concurrent engineering and quality engineering will improve the radically innovative performance.

The finding that high levels of radical innovation can be achieved through different levels of exploration, exploitation, and learning behaviors is also useful to managers. The combination of high levels of exploration and low levels of exploitation and of learning is not much different (on the radically innovative performance score) than being high in all three factors, and for some organizations this situation may be simpler to achieve. Depending on the specific organization's conditions, managers can choose the combination that best fits their needs and culture.

Our findings support approaches and activities already adopted by leading organizations, although so far the academic literature has provided only partial support for them. Michael Dell said that "At Dell, innovation is about taking risks and learning from failure" [68]. Apple has claimed that, in order to achieve radical innovation, they adopted a high-quality approach. Toyota is another successful example of an organization that for many years combined exploration with exploitation [69].

The study's findings make an important contribution because they may enable teams and organizations to accelerate radical innovation. Specifically, in order to enhance radical innovation, organizations should design systems that target both exploration and exploitation simultaneously while maintaining a high level of learning behavior. Nevertheless, there is more than one way to achieve radical innovation: if the level of learning behavior is low, maintaining a low level of exploitation and a high level of exploration should lead to the desired result.

Finally, while motivation to achieve accomplishments and aspirations (i.e., promotion focus) is usually assumed to be positively associated with team innovation, managers should take into consideration that this study's findings counterintuitively suggest that a low, rather than a high, level of promotion focus may be associated with higher levels of radical innovation.

REFERENCES

[1] Amabile, T. M. *"Stimulate creativity by fueling passion*," MA: Blackwell, 2000.

[2] Miron-Spektor, E., Erez, M., & Naveh, E. "The effect of conformist and attentive-to-detail members on team innovation: Reconciling the innovation paradox," *Academy of Manage. J.*, vol, 54, pp. 740-760, 2011.

[3] March, J. G. "Exploration and Exploitation in Organizational Learning," *Org. Sci.*, vol. 2, pp. 71-87, 1991.

[4] Benner, M. J. & Tushman, M. "Process management and technological innovation: A longitudinal study of the photography and paint industries," *Administrative Sci. Quarterly*, vol. 47, pp. 676-706, 2002.

[5] Gupta, A. K., Smith, K., & Shalley, C. E. "The interplay between exploration and exploitation."*Academy of Manage. J.*, vol. 49, pp. 693-706. 2006.

[6] Lavie, D., Stettner, U., & Tushman, M. "Exploration and exploitation within and across organizations," *The Academy of Manage. Annals*, vol. 4, pp. 109-155, 2010.

[7] Farjoun, M. "Beyond dualism: stability and change as a duality," *Academy of Manage. Review*, vol. 35, pp. 202-225, 2010.

[8] Katila, R. & Ahuja, G. "Something old, something new: A longitudinal study of search behavior and new product introduction," *Academy of Manage. J.*, vol. 45, pp. 1183-1194. 2002.

[9] Gibson, C. B. & Birkinshaw, J. "The antecedents, consequences, and mediating role of organizational Ambidexterity," *Academy of Manage. J.*, vol. 47, pp. 209-226, 2004.

[10] Bledow, R., Frese, M., Anderson, N., Erez, M., & Farr, J. "A dialectic perspective on innovation: Conflicting demands, multiple pathways, and ambidexterity." *Industrial and Organizational Psychology: Perspectives on Sci. and Practice*, vol. 2, pp. 305-337, 2009.

[11] Kim, D. Y., Kumar, V., & Kumar, U. "Relationship between quality management practices and innovation," *J. of Operations Manage.*, vol. 30, pp. 295-315, 2012.

[12] Azadegan, A. & Dooley, K. J. "Supplier innovativeness, organizational learning styles and manufacturer performance: An empirical assessment," *J. of Operations Manage.*, vol. 28, pp. 488-505, 2010.

[13] Naveh, E. & Erez, M. "Innovation and attention to tetail in the quality improvement paradigm," *Manage. Sci.*, vol. 50, pp. 1576-1586, 2004.

[14] Lewis, M. W., Welsh, M. A., Dehler, G. E., & Green, S. G. "Product development tensions: Exploring contrasting styles of product management," *Academy of Manage. J.*, vol. 45, pp. 546-564, 2002.

[15] Naveh, E. "Formality and discretion in successful R&D projects," *J. of Operations Manage.*, vol. 25, pp. 110-125, 2007.

[16] Cohen, M. D. & Bacdayan, P. "Organizational routines are stored as procedural memory: Evidence from a laboratory study," *Org. Sci.*, vol. 5, pp. 554-568, 1994.

[17] Leonard-Barton, D. "Core capabilities and core rigidities: A paradox in managing new product development." *Strategic Manage. J.*, vol. 13, pp. 111-125, 1992.

[18] Levinthal, D. A. "Adaptation on rugged landscapes," *Manage. Sci.*, vol. 43, pp. 934-950, 1997.

[19] Levitt, B. & March, J. G. "Organizational learning," *Annual Review of Sociology*, vol. 14, pp. 319-340, 1988.

[20] Sull, D. R. T. & Rosenbloom, R. "Managerial commitments and technology change in the U.S. tire industry," *Industrial and Corporate Change*, vol. 6, pp. 461-500, 1997.

[21] Edmondson, A. "Psychological safety and learning behavior in work teams," *Administrative Sci. Quarterly*, vol. 44, pp. 350-383, 1999.

[22] Brown, L. S. & Eisenhardt, M. K. "The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations," *Administrative Sci. Quarterly*, vol. 42, pp. 1-34, 1997.

[23] Senge, M. P. *"The fifth discipline: The art and practice of the learning organization,"* New York: Doubleday/Currency, 1993.

[24] Van Knippenberg, D., De Dreu, C. K., & Homan, A. C. "Work group diversity and group performance: an integrative model and research agenda," *J. of Applied Psychology*, vol. *89*, pp. 1008-1022, 2004.

[25] Smith, W. K. & Lewis, M. W. "Toward a theory of paradox: A dynamic equilibrium model of organizing," *Academy of Manage. Review*, vol. 36, pp. 381-403, 2011.

[26] Levinthal, D. & Rerup, C. "Crossing an apparent chasm: Bridging mindful and less-mindful perspectives on organizational learning," *Org. Sci.*, vol. 17, pp. 502-513, 2006.

[27] Cohen, W. M. & Levinthal, D. A. "Absorptive capacity: A new perspective on learning and innovation," *Administrative Sci. Quarterly*, vol. 35, pp. 128-152, 1990.

[28] Carton, A. M., & Cummings, J. N. "The impact of subgroup type and subgroup configurational properties on work team performance," *J. of Applied Psychology*, vol. 98, pp. 732-758, 2013.

[29] Gibson, C., & Vermeulen, F. "A healthy divide: Subgroups as a stimulus for team learning behavior," *Administrative Sci. Quarterly*, vol. 48, pp. 202-239, 2003.

[30] Cronin, M. A., & Weingart, L. R. "Representational gaps, information processing, and conflict in functionally diverse teams," *Academy of Manage. Review*, vol. 32, pp. 761-773, 2007.

[31] Pearsall, M. J., & Venkataramani, V. "Overcoming asymmetric goals in teams: The interactive roles of team learning orientation and team identification," *J. of Applied Psychology*, vol. 100, pp. 735-745, 2015.

[32] Argote, L. & Miron-Spektor, E. "Organizational learning: From experience to knowledge," *Org. Sci.*, vol. 22, pp. 1123-1137, 2011.

[33] Bunderson, J. S., & Sutcliffe, K. M. "Management team learning orientation and business unit performance." *J. of Applied Psychology*, vol. 88, pp. 552-560, 2003.

[34] Hirst, G., Van Knippenberg, D., & Zhou, J. "A cross-level perspective on employee creativity: Goal orientation, team learning behavior, and individual creativity," *Academy of Manage. J.*, vol. 52, pp. 280-293, 2009.

[35] Tett, R. P., & Guterman, H. A. "Situation trait relevance, trait expression, and cross-situational consistency: Testing a principle of trait activation," *J. of Res. in Personality*, vol. 34, pp. 397–423, 2000.

[36] Baer, M. "Putting creativity to work: The implementation of creative ideas in organizations," *Academy of Manage. J.*, vol. 55, pp. 1102-1119, 2012.

[37] Higgins, E. T. "Promotion and prevention: Regulatory focus as a motivational principle," *Advances in Experimental Social Psychology*, vol. 30, pp. 1-46, 1998.

[38] Rietzschel, E. F. "Collective regulatory focus predicts specific aspects of team innovation." *Group Processes & Intergroup Relations*, vol. 14, pp. 337-345, 2011.

[39] Wallace, J. C., Butts, M. M., Johnson, P. D., Stevens, F. G., & Smith, M. B. "A multilevel model of employee innovation: Understanding the effects of regulatory focus, thriving, and employee involvement climate," *J. of Manage.*, vol. 42, pp. 982-1004, 2016.

[40] Park, G., Spitzmuller, M., & DeShon, R. P. "Advancing our understanding of team motivation: Integrating conceptual approaches and content areas," *J. of Manage*, vol. 39, pp. 1339-1379, 2013.

[41] Friedman, R. S. & Förster, J. "The effect of promotion and prevention cues on creativity," *J. of Personality and Social Psychology*, vol. 81, pp. 1001-1013, 2001.

[42] Gagné, M. & Deci, E. L. "Self-determination theory and work motivation," *J. of Org. Behavior*, vol. 26, pp. 331-362, 2005.

[43] Grant, A. M. & Berry, J. W. "The necessity of others is the mother of invention: intrinsic and prosocial motivations, perspective taking, and creativity," *Academy of Manage. J.*, vol. 54, pp. 73-96, 2011.

[44] Carroll, J. S., Rudolph, J. W., & Hatakenaka, S. "Learning from experience in high-hazard organizations," *Res. in Org. Behavior*, vol. 24, pp. 87-137, 2002.

[45] World Economic Forum. The World Economic Forum's Global Competitiveness Report 2016-2017. https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1

[46] Miron, E., Erez, M., & Naveh, E. "Do personal characteristics and cultural values that promote innovation, quality, and efficiency Compete or complement each other?" *J. of Org. Behavior*, vol. 25, pp. 175-199, 2004.

[47] Edmondson, A. C. *"Teaming: How organizations learn, innovate, and compete in the knowledge economy,"* John Wiley & Sons, 2012.

[48] Garvin, D. A., Edmondson, A. C., & Gino, F. "Is yours a learning organization?" *Harvard Business Review*, vol. 86, pp. 109-116, 2008.

[49] McGrath, R. G. "Exploratory learning, innovative capacity, and managerial oversight," *Academy of Manage. J*., vol. 44, pp. 118-131, 2001.

[50] Pisano, G. P., Bohmer, R. M., & Edmondson, A. C. "Organizational differences in rates of learning: Evidence from the adoption of minimally invasive cardiac surgery," *Manage. Sci*., vol. 47, pp. 752-768, 2001.

[51] Lockwood, P., Jordan, C. H., & Kunda, Z. "Motivation by positive or negative role models: Regulatory focus determines who will best inspire us," *J. of Personality and Social Psychology*, vol. 83, pp. 854-864, 2002.

[52] Gatignon, H., Tushman, M. L., Smith, W., & Anderson, P. "A structural approach to assessing innovation: Construct development of innovation locus, type, and characteristics," *Manage. Sci*., vol. 48, pp. 1103-1122, 2002.

[53] Satorra, A. & Bentler, P.M. "Corrections to test statistics and standard errors in covariance structure analysis," In Von Eye, A. & Clogg, C.C. Eds., *Latent variable analysis: Applications to Developmental Res*. Pp. 399-419. Newbury Park: Sage, 1994.

[54] Hu, L. T. & Bentler, P. "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives," *Structural Equation Modeling*, vol. 6, pp. 1-55, 1999.

[55] Kozlowski, S. W. J. & Klein, K. J. "*A multilevel approach to theory and research in organizations: Contextual, temporal, and emergent processes*," San Francisco: Jossey-Bass, 2000.

[56] James, L. R., Demaree, R. G., & Wolf, G. *"r wg* : An assessment of within-group interrater sgreement," *J. of Applied Psychology*, vol. 78, pp. 306-309, 1993.

[57] Beliese, P. D. *"Within group agreement, non-independence, and reliability*," San Francisco: Jossey-Bass, 2000.

[58] James, L. R. "Aggregation bias in estimates of perceptual agreement," *J. of Applied Psychology*, vol. 67, pp. 219-229, 1982.

[59] Cohen, J. *"Statistical power analysis for the behavioral sciences (2nd ed.),"* Hillsdale, NJ: Erlbaum, 1988.

[60] Raudenbush, S.W. & Bryk, A.S. *"Hierarchical linear models: Applications and data analysis methods,"* Thousand Oaks, CA: Sage, 2002.

[61] Littell, R. C., Milliken, G. A., Stroup, W. W., Wolfinger, R. D., & Schabenberger, O. *"SAS for mixed models"*, 2nd ed. SAS Institute, Cary, NC, 2006.

[62] Aiken, L. & West, S. *"Multiple regression: Testing and interpreting interactions,"* London: Sage, 1991.

[63] Kark, R. & Van Dijk, D. "Motivation to lead, motivation to follow: The role of the self-regulatory focus in leadership processes," *Academy of Manage. Review*, vol. 32, pp. 500-528, 2007.

[64] Van de Ven, A. H., Polley, E. D., Garud, R., & Venkataraman, S. *"The innovation journey*," New York: Oxford University Press, 1999.

[65] Ryan, R. M., & Deci, E. L. "Intrinsic and extrinsic motivations: Classic definitions and new directions," *Contemporary Educational Psychology*, vol. 25, pp. 54-67, 2000.

[66] He, Z.L. & Wong, P.K. "Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis," *Org. Sci*., vol. 15, pp. 481-494, 2004.

[67] Adler, P. S., Benner, M., Brunner, D. J., MacDuffie, J. P., Osono, E., Staats, B. R., ... & Winter, S. G. "Perspectives on the productivity dilemma," *J. of Operations Manage.*, vol. 27, pp. 99-113, 2009.

[68] Wynett, C., Fogarty, T., Kadish, R. T., Dell, M., et al. "Inspiring innovation. How do you boost an organization's creative potential? We asked some of today's most innovative leaders," *Harvard Business Review*, vol. 80, pp. 39-49. 2002.

[69] Spear, S. & Bowen, K. H. "Decoding the DNA of the Toyota production system," *Harvard Business Review*, vol. 77, pp. 96-106, 1999.

[70] Jansen, J. J. P., Van Den Bosch, F. A. J., & Volberda, H. W. "Exploratory innovation, exploitative innovation, and performance: Effect of organizational antecedents and environmental moderators," *Manage. Sci.*, vol. 52, pp. 1661-1674, 2006.

[71] Rosenkopf, L. & Nerkar, A. "Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry," *Strategic Manage. J*., vol. 22, pp. 287-306, 2001.

[72] Vermeulen, F. & Barkema, H. "Learning through acquisitions," *Academy of Manage. J*., vol. 44, pp. 457–476, 2001.

Tali Hadasa Blank received the B.A. degree in Mathematics and Computer Science and Education from the Haifa University, Israel, in 1996; and M.B.A. degree from Bar-Ilan University, Ramat-Gan, Israel, in 2009; and Ph.D. degree in Industrial Engineering and Management from the Technion-Israel Institute of Technology, Haifa, Israel.
She is a postdoctoral research associate at the Jerusalem School of Business Administration, Hebrew University, Jerusalem, Israel. Her research interests include radical innovation, entrepreneurship, and organizational and team learning. Her research has been published at *Quality Management Journal*, and *The Journal for Quality and Participation*.

Eitan Naveh received the D.Sc. degree in quality assurance and reliability from the Technion–Israel Institute of Technology, Haifa, Israel, in 1995. He is an Associate Professor with the Faculty of Industrial Engineering and Management, Technion–Israel Institute of Technology. His research interests include mainly two streams of organizational research, errors in organizations and linkage between innovation and quality. Applying an interdisciplinary approach that combines aspects of behavioral sciences and engineering, he has contributed to the understanding of errors, innovation, and quality by revealing the hidden tensions resulting from multiple priorities situations and exploring their consequences. He mainly studies research and development teams in hi-tech companies and medical teams in medical centers. His research has been published in the *Academy of Management Journal, the Journal of Applied Phycology, the Journal of Management, the Journal of Operations Management, Management Science,* and other leading academic journals.

TABLE 1
Definitions of exploration and exploitation in earlier studies

Article	Definition of Exploration and Exploitation	Compete vs. Complement
Benner & Tushman, 2002 [4]	Different search modes. Exploitation involves a local search that builds on a firm's existing technological capabilities; exploration involves a more distant search for new capabilities.	Compete
He & Wong, 2004 [66]	Two innovation strategies. Explorative activities are aimed at entering new product markets. Exploitative activities are aimed at improving existing product-market positions.	Complement
Jansen, Van Den Bosch, & Volborda, 2006 [68]	Two aspects. Exploitative innovations are built on existing knowledge, customers, or markets, and reinforce existing skills, processes, and structures. Exploratory innovations are based on new knowledge or the departure from existing knowledge, and are designed to meet the needs of emerging customers or markets.	Complement
Katila & Ahuga, 2002 [8]	Two search dimensions. Exploration is associated with search scope, i.e., local versus distant. Exploitation is associated with search depth, i.e., the degree to which existing knowledge is reused.	Complement
Rosenkopf & Nerkar, 2001 [69]	Exploration refers to all activities associated with the invention of new technology, including incremental technological advances, whereas exploitation refers to past knowledge.	Compete
Vermeulen & Barkema, 2001 [70]	Exploration is defined as the search for new knowledge, whereas exploitation is seen as promoting ossification, engendering myopia, and blocking learning and adaptation.	Complement

TABLE 2: Combinations of different levels of exploitation and learning behavior resulting in radical innovation when the level of exploration is high

Learning behavior	Exploitation	
	Low levels	**High levels**
Low levels	**[4][a] High levels of radical innovation** **Ambidexterity** When exploration is high, a low level of exploitation is sufficient to enable achieving radical innovation [4]. A balance between high levels of exploration and low levels of exploitation allows radical innovation. There is no synergy between exploration and exploitation (synergy is achieved when the level of learning behavior is high – see the combination entitled "Synergy that Enables"); however, the tension between them is minimal (it is a result of high levels of both exploration and exploitation while learning behavior is low – see the combination entitled "Tension that hinders").	**[2][a] Low levels of radical innovation** **Tension that hinders** The toll of the tension between high levels of exploration and of exploitation harms radical innovation performance [7]. When the level of learning behavior is low, there is no mechanism that reduces the tension between exploration and exploitation when both are at high levels [21].
High levels	**[3][a] Low levels of radical innovation** **Unbalanced exploration-exploitation relationships** Learning behavior intensifies exploration to the extent that it harms the sufficiently enabling relationship between exploration and exploitation (see the combination entitled "Ambidexterity") and thus harms radical innovation performance. The balance achieved between high levels of exploration and low levels of exploitation is lost as a result of intensifying exploration through high levels of learning behavior (in accordance with activation theory's claim that dominant characteristics are intensified and become dominant when the environment encourages it; [34], [35].	**[1][a] High levels of radical innovation** **Synergy that enables** High levels of learning behavior enable synergy while reducing the tension between exploration and exploitation when both are at a high level [7].

[a] The number refers to the explanations in the section on theoretical foundations.

TABLE 3

Means, Standard Deviations, and Correlations[a]

	Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1.	Exploration	4.20	0.75	**[0.87]**										
2.	Exploitation	4.96	0.72	0.30**	**[0.86]**									
3.	Learning Behavior	5.37	0.64	0.51**	0.48**	**[0.89]**								
4.	Promotion Focus	4.67	0.74	0.50**	0.43**	0.57**	**[0.91]**							
5.	Radically-Innovative Performance	5.15	0.97	0.16†	-0.10	-0.07	0.07	**[0.88]**						
Control variables														
6.	Prevention Focus	4.66	0.62	0.2*	0.39**	0.24*	0.40**	0.01	**[0.82]**					
7.	Team size	4.10	1.26	0.05	0.13	0.00	0.00	-0.06	0.08					
8.	Gender (male ratio)	77.0	0.28	0.06	-0.20*	-0.21*	-0.08	0.02	0.15	-0.08				
9.	Organization seniority	4.8	1.28	0.05	0.00	0.00	-0.13	0.00	-0.02	-0.15	0.38**			
10.	Team seniority	4.12	1.39	0.02	0.07	-0.13	-0.14	0.04	-0.03	-0.14	0.29**	0.68**		
11.	Role seniority	4.15	1.39	0.00	0.00	0.00	-0.12	0.08	0.00	-0.15	0.24**	0.82**	0.81**	
12.	Education level	3.00	0.60	-0.21*	-0.26**	-0.17*	-0.29**	-0.15	-0.09	-0.22*	0.14	0.22*	0.09	0.09

[a]Team-level analysis; n =108; Cronbach's alpha (α) coefficients appear in square brackets.

† $p < .1$, * $p < .05$, ** $p < .01$

TABLE 4
Results of Hierarchical Linear Regression

	Radically Innovative Performance				
	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	5.08** (.33)	5.08** (.3)	5.09** (.32)	5.14** (.26)	5.14** (.29)
Exploitation		-.17 (.14)	-.07 (.16)	-.12 (.16)	-.09 (.16)
Exploration		.09 (.13)	.18 (.17)	.05 (.18)	.14 (.18)
Learning Behavior			-.2 (.23)	-.4† (.23)	-.18 (.22)
Promotion focus			-.04 (.17)	.02 (.17)	-.03 (.17)
Exploration X Exploitation			.24 (.25)	.12 (.25)	.14 (.22)
Exploration X Learning Behavior			-.40 (.29)	-.17 (.28)	
Exploitation X Learning Behavior			.56† (.30)	.47* (.23)	
Exploration X Exploitation X Learning Behavior				.56* (.27)	
Exploration X Promotion focus			-.1 (.21)	-.4† (.23)	-.35† (.19)
Exploitations X Promotion focus			-.32 (.26)		.05 (.21)
Exploration X Exploitation X Promotion focus					.12 (.24)
Control variables					
Prevention Focus	-.02 (.14)	.03 (.16)	.04 (.16)	.04 (.16)	.04 (.16)
Team size	-.08 (.08)	-.07 (.08)	-.06 (.08)	-.05 (.08)	-.07 (.08)
Gender	.57 (.35)	.45 (.37)	.57 (.41)	.58 (.4)	.44 (.38)
Organization seniority	-.07 (.13)	-.07 (.13)	-.14 (.13)	-.11 (.13)	-.1 (.14)
Team seniority	-.06 (.1)	-.08 (.1)	-.07 (.11)	-.09 (.1)	-.09 (.11)
Role seniority	.09 (.14)	.1 (.14)	.14 (.15)	.15 (.14)	.13 (.15)
Education	.11 (.16)	.08 (.17)	.11 (.17)	.03 (.17)	.04 (.17)
-2 log likelihood	300.1	302.9	304.4	307.7	302
Likelihood-ration chi-square	40.0**	41.5**	44.5**	46.7**	41.5**

Notes. Coefficient estimate with standard error in parentheses. † $p < .1$, * $p < .05$, ** $p < .01$

FIGURE 1a

Regression lines of radical innovation as a function of level of exploration and exploitation when the level of learning behavior is high

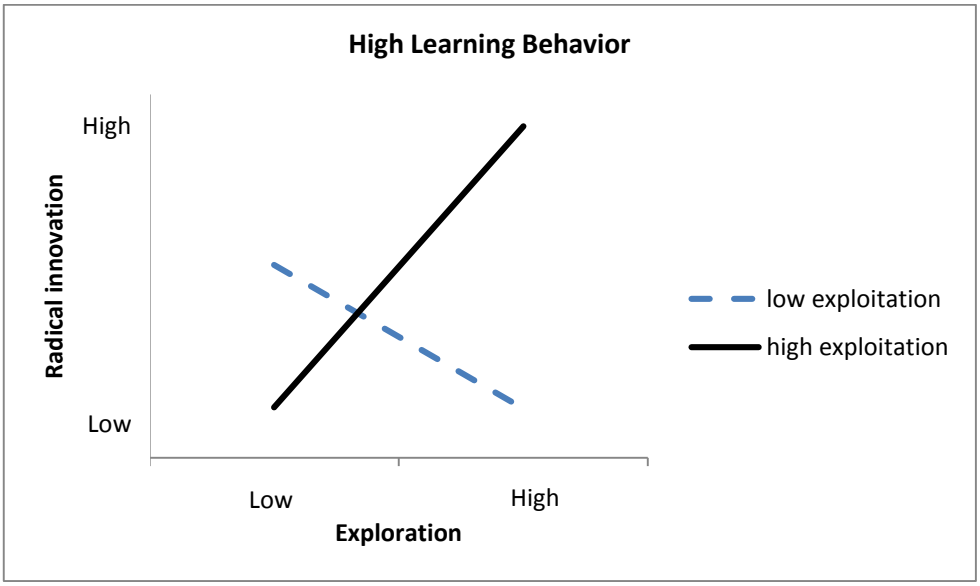


FIGURE 1b

Regression lines of radical innovation as a function of level of exploration and exploitation when the level of learning behavior is low

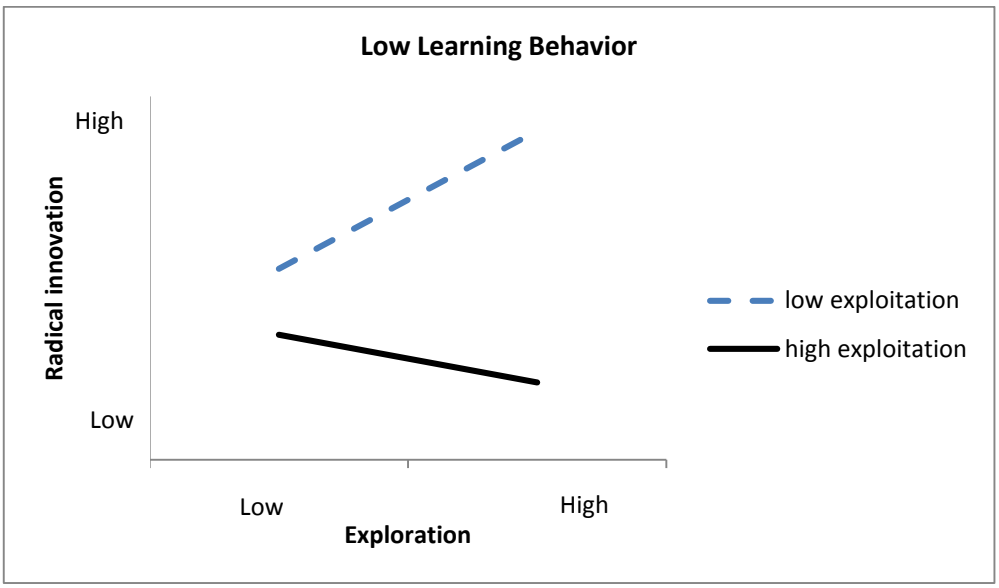
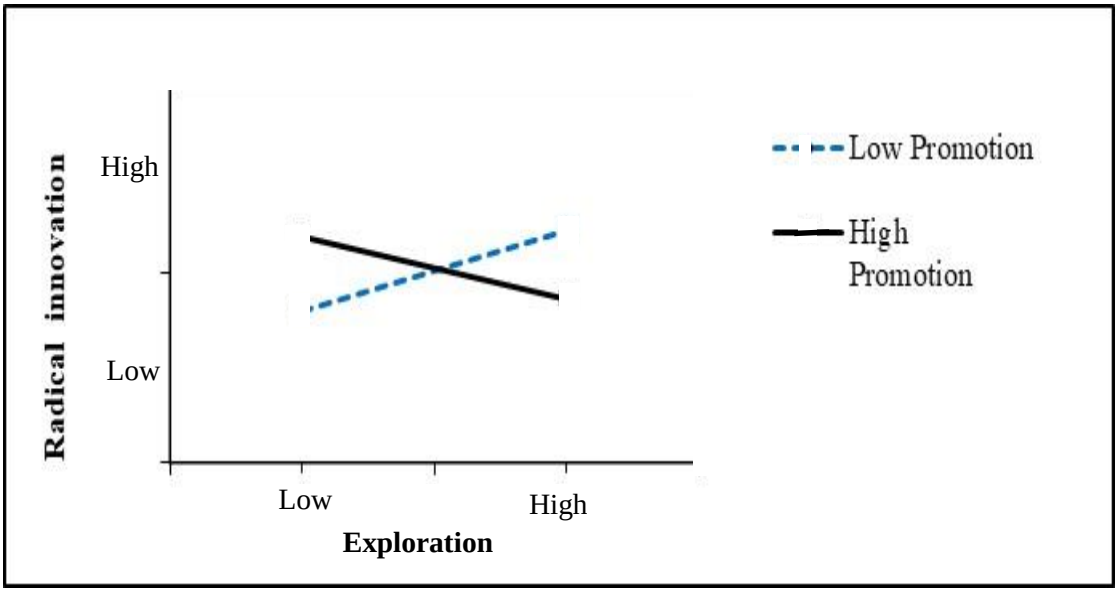


FIGURE 2

Regression lines of radical innovation as a function of level of exploration and promotion focus



Appendix

Measurement Scales

Variable	CFA standardized factor loadings
Exploitation	
1. We perform work process control	.90
2. We collect data for further process control	.84
3. We work according to rules and procedures	.61
4. We conduct review processes	.74
5. We examine the attainment of quality objectives	.61
Exploration	
1. Innovation goals are set and clear	.79
2. We have free time to innovate	.76
3. There is a budget for implementing innovative ideas	.76
4. We look for breakthroughs	.79
5. We take risks	.71
6. We perform experiments	.69
Learning behavior	
1. We get feedback on our work	.77
2. We search for information	.89
3. It is confirmed that we reflect on our work	.72
4. Advance in our performance is being noticed	.83
5. We are encouraged to learn	.76
6. We share and exchange information	.82
Promotion focus	
1. We focus on achieving success in our work	.83
2. We imagine good things that will happen to us in our work	.80
3. We think of how idealistic we want to be in our work	.91
4. We imagine ourselves fulfilling our hopes and wishes	.85
5. We focus on ways to reach success at work	.71
Prevention focus	
1. We try to avoid becoming professional failures	.60
2. We focus on avoiding failure	.60
3. We are concerned that we will not fulfill our obligations	.91
4. We are concerned that we will fail to reach our goals at work	.88
5. We think about how to avoid failure at work	.65
Radically innovative performance	
1. The products include new concepts and principles	.76
2. The products are fundamentally different from whatever exists in the market	.77
3. The products incorporate new technologies	.87
4. The products present unique solutions	.83
5. The products provide upscale performance	.78