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Network centrality, knowledge searching and creativity: The role of domain

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This study aims to determine the role of knowledge searching on creativity in the fields of science research and technology development. Creativity is a process of knowledge combination, thus internal and external knowledge searching is important for creativity in both fields, particularly in the open innovation age. However, the nature of the work across these fields is different. While science research aims to solve theoretical problems and generate new knowledge, technology development aims to apply new knowledge to solve practical problems. Compared to science research, technology development has clear task goals, which make it easier to identify the related external knowledge and integrate this knowledge and in turn improve employee creativity. Thus, employees' attention to external knowledge as well as the influence of external knowledge on creativity might be different in the two fields. Results based on an empirical study of 211 employees from science research and 257 employees from technology development showed that external knowledge searching increased employee creativity in the field of technology development but not in science research. Furthermore, employees' centrality in the intra-team problem-solving network moderated the relationship between external knowledge searching and creativity in the science research field. Suggestions about employee creativity management in science and technology fields are discussed.

1|INTRODUCTION

Research on employee creativity has gained attention in the last two decades, especially from the perspective of motivational mechanisms (Liu, Jiang, Shalley, Keem, & Zhou, 2016). Meanwhile, the importance of knowledge in relation to cognitive aspects of employees' creativity has also been investigated (e.g., Dong, Bartol, Zhang, & Li, 2016; Huang, Hsieh, & He, 2014; Ma, Cheng, Ribbens, & Zhou, 2013). How-ever, we believe that additional research on the cognitive aspects of employee creativity is still needed due to the complexity of this relationship (Ward & Kolomyts, 2010). More specifically, one of the important questions regarding cognition and creativity in psychological research that is still unanswered is whether creativity is domain general or domain specific. Prior research and theory have not pro-vided a conclusive answer to this issue, but suggested that creativity among individuals likely has aspects that are specific to a certain field (Baer & Kaufman, 2005; Hornberg & Reiter-Palmon, 2017; Kaufman & Beghetto, 2009). Specifically, creativity relies on knowledge, which is inherently domain specific (Hu & Adey, 2002). In order to further address the issue of cognition, knowledge and creativity, we must have a better understanding of tasks and domains (Lubart & Guignard,2004). While work in creativity and education or the psychology of creativity has indeed focused on creativity as domain specific or domain general (Baer, 2012, 2015; Baer & Kaufman, 2005), research in applied settings on this issue has lagged. Empirical studies suggest that creativity requires expertise which is domain specific. For example, Reiter-Palmon, Illies, Kobe Cross, Buboltz, and Nimps (2009) found that creativity in response to everyday problems was different based on the problem presented. Kaufman (2012) identified five broad domains for creativity and creative expression that are not always related. Similarly, Barbot, Besancon, and Lubart (2016) found that domain-specific skills significantly influenced creative performance. Additionally, research has suggested that domain expertise is important for creativity (e.g., Mumford, Marks, Connelly, Zaccaro, & Johnson, 1998). In this study, we focus on one cognitive mechanism of employee creativity, knowledge searching, and evaluate whether there are domain differences in the relationship between knowledge search and creativity.

This study investigates two work fields or sub-domains of scientific creativity: science research and technology development. Science and technology are increasingly regarded as distinct but intertwined domains. However, the nature of the work in these domains can be different, and understanding these differences in tasks and work will help shed light on how to improve creativity in both fields. The purpose of this study was to evaluate the role of knowledge searching—specifically, work team knowledge searching (knowledge network centrality) and external knowledge searching—in employee creativity for these two different work fields or domains.

2|LITERATURE REVIEW

2.1|Creativity in science research and technology development

Previous studies pointed out that research and development (R&D) employees need to define and construct a problem, search and retrieve problem-relevant information, generate and evaluate a diverse set of alternative solutions (Hemlin, Olsson, & Denti, 2013;Mumford, Reiter-Palmon, & Redmond, 1994; Reiter-Palmon & Illies,2004). The work of R&D consists of two kinds: science research and technology development. Fundamentally, the nature of work in science research and technology development fields is to find creative solutions to problems, or to explore and exploit those solutions. Science research is characterized by ill-defined problems where it is often not clear if a problem even exists (Dillon, 1982). Further, science research problems typically have ambiguous goals and multiple different paths to solve those problems (Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991; Schraw, Dunkle, & Bendixen, 1995). Thus, the important work of science researchers is to find, invent or discover the problem (Dillon, 1982; Poincaré, 1913), and define the problem in such a way that it can be solved. From a methodological viewpoint, investigation is a core process in science, which means employees in this field need to explore diversified knowledge to find the right question and the best solution (Giere, 2002). Meanwhile, there are no or limited cognitive constraints in this exploration process. The focus for the science researcher is to identify novel but appropriate problems and solutions to these problems (Brooks, 1994; Kuhn, 1996).

Conversely, technology development focuses on more structured and closed problems, which typically have known methods for solution and its main methodology is to design, that is, exploitation (NRC,1996). Kuhn (1996) points out that technology is a result of knowledge systems and the knowledge is the experience accumulated through trial-and-error. Technology developers have clear task goals and schedules during the exploitation process. They need to identify the related knowledge and integrate it into their hands-on work. Competitive and usefulness are the two main criteria of technology development work.

The discussion above suggests that the nature of the work per-formed by these two fields is different. The focus for research is on exploration whereas the focus of technology development is that of exploitation (March, 1991). As the nature of the work performed in the fields is different, it is likely that different cognitive processes will be important and emphasized in the work required for each domain. While creativity may be needed in both domains, the domain and work requirements may indicate that different processes are emphasized. There are multiple models of creative cognition; however, some of the most important and common processes across these multiple models are problem identification and construction, information search, combining or reorganizing ideas, and evaluation of those ideas based on specific standards (Baughman & Mumford, 1995; Mumfordet al., 1991; Nijstad & Stroebe, 2006; Reiter-Palmon, Herman, &Yammarino, 2008).

One important distinction between the two fields is their knowledge searching scope. In the science research field, the first step of the work is to find out the questions and then use evidence to pro-pose explanations for observations about the natural world (Bybee,1998), while work in technology often originates in problems of human adaptation to the environment (Bybee, 1998), and has more clarified work goals. Goal clarity of technology development is likely to provide more specific and narrow direction, resulting in more focused search for information, which is directly relevant to the task.

This narrowed attention will lead to increased cognitive concentration, or the degree of sustained and focused task-directed cognitive effort (Nijstad, De Dreu, Rietzschel, & Baas, 2010). In comparison, when the task goal is more ambiguous (such as in the science research field), individuals will also attend to information that is less directly relevant to the goal and that the search for information will be broader and more diverse (Harms & Reiter-Palmon, in press). More ambiguous goals also suggest that it will be harder to maintain high cognitive con-centration, which indicates that cognitive effort will be more diverse. This will directly influence information search. Research shows that routine tasks are related to information search that is more con-strained whereas less routine tasks relate to flexible knowledge search (Guo & Li, 2007; Li & Belkin, 2008; Xie, 2009).

In addition, the role of knowledge integration and combination of different concepts likely differs between these two fields. As more diverse information is elicited, the importance of combining and integrating this diverse information becomes more critical (Reiter-Palmon, Wigert, & de Vreede, 2011). This also requires cognitive flexibility as a result of the frequent changes in perspective or categories of relevant ideas (Nijstad, Stroebe, & Lodewijkx, 2003). The notion of conceptual combination or combining different ideas has received some attention in the study of creative problem solving at the individual level (Baughman & Mumford, 1995; Mumford et al., 1991), and researchers suggest that it is indeed important for creative problem solving and especially for more original as opposed to incremental ideas (Gilson & Madjar, 2011). Compared with science research, technology development work is constrained to materials and cost–risk–benefit analysis in the process of finding the best solution (Bybee, 1998). Thus, it utilizes conceptual combinations that are less remote.

2.2|Centrality in team knowledge network and employee creativity

Prior studies demonstrated that accessing information or knowledge helps R&D employees' creativity or performance (Sparrowe, Liden,Wayne, & Kraimer, 2001). R&D teams become the most important source of knowledge that is accessible internally or within the organization (Chuang, Jackson, & Jiang, 2016). Employees' team knowledge searching can be analysed through social network analysis (Phelps, Heidl, & Wadhwa, 2012). One important team knowledge network index is the degree centrality, or the number of ties that an actor in asocial network has with other actors (Freeman, 1979). High degree centrality represents more direct ties, and therefore increases the number of knowledge sources the person has access to. Moreover, direct ties can facilitate knowledge sharing (Berg, Duncan, &Friedman, 1982; Brennecke & Stoemmer, 2018). Thus, centrality is recognized as a major channel for acquiring necessary information (Battke, Schmidt, Stollenwerk, & Hoffmann, 2016; Guan, Zuo, Chen, &Yam, 2016). Employees who are central to the network have more opportunities to synthesize and combine diversified knowledge into novel ideas (Phelps et al., 2012). Considering the requirement of accessing diversified knowledge in order to be creative in the science research field, degree centrality will improve employee creativity in the field. There is evidence to support this hypothesis. For example, centrality of co-authorship network is positively related to performance of scientists (Bordons, Aparicio, González-Albo, & Díaz-Faes,2015). Further, researchers' central position of their co-authorship network positively predicts their productivity (h-index) in the Information Science and Library Science fields (Abbasi, Jalili, &Sadeghi-Niaraki, 2018). Centrality of the other nodes to which the academic scientist is connected improved the weighted citation index of academic scientists (Rotolo & Messeni Petruzzelli, 2013). Finally, centrality of R&D employees' advice network in Taiwan's defense-oriented R&D institutes positively influences their creativity (Jen, 2014). As a result, we hypothesize the following:

> ***Hypothesis 1a****. Employees' centrality in the team problem-solving network will be positively related to creativity in the science research field.*

Supporting evidence also come from the technology development field. In technology development-oriented system integration companies, employees' degree centrality in their co-worker network positively influences their creativity (Hahn, Lee, & Lee, 2015). Intra-team knowledge is important for employees in the technology development field, as their work in the field is knowledge-intensive. It was found that diversified expertise and knowledge sharing in the teams improve engineer creativity in R&D teams of a large telecommunication firm (Huang et al., 2014). A study on 100 R&D teams in 19 Korean companies involved in the telecommunication, electronics, chemical, aerospace, information technology, and pharmaceutical technology field found that team knowledge sharing improved employee creativity (Gong, Kim, Lee, & Zhu, 2013); centrality of Mexican engineers' co-authorship network had a positive effect on publications and citations (Miramontes & González-Brambila, 2016). Hence, it is likely that diversified knowledge coming from a central position in the team knowledge network will benefit employee creativity in the field. Assuch, we hypothesize the following:

> ***Hypothesis 1b****. Employees' centrality in the team problem-solving network will be positively related to creativity in the technology development field.*

2.3|External knowledge searching and employee creativity

We are currently experiencing the “radical, irreversible, worldwide transformation in the way that science is organized and performed” (Ziman, 1994, p. 7). Trans-disciplinarily and collaboration is increasingly important for R&D creativity (Turpin, Garrett-Jones, & Rankin,1996). Organizations are increasingly willing to obtain and share information across organizational boundaries in order to facilitate innovation (e.g., Camelo, García, Sousa, & Valle, 2011; Ferreras-Méndez, Newell, Fernández-Mesa, & Alegre, 2015). External knowledge has been suggested to be especially important for exploration (Schultz, Schreyoegg, & von Reitzenstein, 2013; Tang & Ye, 2015), because communicating with diverse individuals brings diversified knowledge (Mannix & Neale, 2005). Exploration requires the development of new knowledge and not just learning how to use existing knowledge, and acquiring knowledge from external sources results in changes to schemas and the team's cognitive architecture (Perry-Smith & Shalley,2014).

Evaluation of the relationship between employees' external knowledge searching and creativity in the science research field is lac-king. However, there is related evidence from research on collaboration between scientists and their creativity. For example, Bikard, Vakili, and Teodoridis (2019) found that academic scientists who worked with industry collaborators produced more follow-on publications. Zhou and Lv (2015) studied physicists in China and Germany and found they benefit from collaboration by raising publication productivity. Finally, a study evaluating 5300 Italian academics in the sciences over the period 2004–2008 demonstrated that collaborating with multidisciplinary teams improved outputs (Abramo, D'Angelo, &Di Costa, 2018). Based on these studies, we hypothesize the following:

> ***Hypothesis 2a.*** *Employees' external knowledge searching will be positively related to creativity in the scientific research field.*

The benefit of external knowledge searching can also be found in the technology development field. For example, in pharmaceutical firms, R&D employees' access to diversified external knowledge increased creativity (Tang, 2015) and knowledge sourcing behaviours foster R&D employee creativity (Khedhaouria, Montani, & Thurik,2017). Similar results come from studies at the firm level. A study on184 Taiwanese electronic product manufacturers revealed that external knowledge searching improved firm innovation (Chiang & Hung,2010), and technological knowledge from other organizations enhanced firms' performance on radical innovation (Wuyts, Dutta, & Stremersch, 2004). Finally, knowledge from customers, suppliers, partner firms and universities increases firm innovation (Santoro, Bierly, &Gopalakrishnan, 2007; Spaeth, Stuermer, & Von Krogh, 2010). Hence, we hypothesize the following:

> ***Hypothesis 2b***. *Employees' external knowledge searching will be positively related to creativity in the technology developmentfield*.

2.4|The interactive effect of external knowledge searching and centrality in the team knowledge network

However, research on the effect of external knowledge searching on exploration is not consistent. Contradicting research on the positive effects, external knowledge searching was found to have no influence on firm innovation (Ferreras-Méndez et al., 2015), and broad collabo-ration was found to add no value to firm innovation (e.g., Chen, Chen, & Vanhaverbeke, 2011; Laursen & Salter, 2006). The mixed results regarding the relationship between external knowledge search and innovation indicates that there may be boundary conditions that influence this relationship. It was suggested that simple access to a pool of external knowledge was not sufficient for innovation. Absorptive capacity is necessary for effective use of external knowledge (Soo, Devinney, & Midgley, 2007). That is, simple acquisition of external knowledge does not imply successful application (Lane, Koka, &Pathak, 2006). It is necessary to recognize and understand the potential value of the knowledge through exploratory learning, combine the new knowledge with existing knowledge through transformative learning, and finally use the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning (Lane et al., 2006).

In the context of team work, the absorptive capability not only rests on employees' own capability, but also comes from the team members. Knowledge sharing between team members will help employees access more intra-team knowledge and help integrate the accessed external knowledge (Alavi & Tiwana, 2002). Prior studies demonstrated that both intra-team and extra-team knowledge are important for knowledge-intensive employees, R&D employees and for knowledge exploitation (Chung & Jackson, 2013; Cuevas, Cabello, & Carmona, 2014; Vera, Nemanich, Vélez-Castrillón, &Werner, 2014). Moreover, in a study that surveyed technology-based companies (precision mechanics, electronics, chemicals, IT, communications, biotechnology), it was found that external knowledge acquisition positively affected organizational innovation when internal knowledge transfer was high (Segarra-Ciprés, Roca-Puig, & Bou-Llusar, 2014). Thus, it is expected that centrality of knowledge network will moderate the relationship between external knowledge searching and creativity.

Further, we argue that this moderation will only occur for the domain of science research because the problems and questions facing research scientists are more ambiguous and the accessed external knowledge should be more diversified. In this case, the intra-team knowledge is necessary in order to absorb the accessed external knowledge. On the other hand, for the technology development domain, employees have more specific goals when searching external information. Further, the trade or industrial technology standards are more widely accepted and therefore it is less difficult to absorb the external knowledge and integrate it with existing information. Hence, we suggest the following hypothesis:

Hypothesis 5. *A three-way interaction between domain, centrality and external knowledge searching is expected. Employees' degree centrality of team problem-solving network will moderate the relationship between external knowledge searching and creativity in the science research field, such that when degree centrality is high the positive effect of external knowledge searching on creativity will be high. No such interaction is expected for technology development.*

The model and hypotheses are presented in Figure 1.

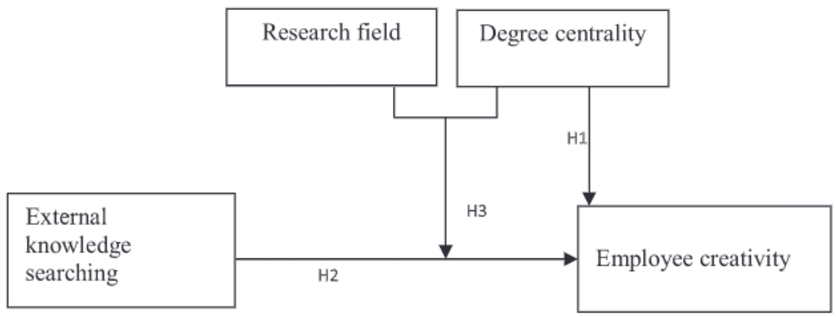

FIGURE 1 Research analysis model

3|METHOD

3.1|Samples

Science research participants were employees of research projects from 10 research institutes in China, performing research in the areas of semiconductor, nanoscience, biotechnology, chemical, physics, acoustics, space science and earth science, computer science. Technology development participants were employees of technical projects from 16 biopharmaceutical companies and three software companies in China, working in technology development and design. Through convenient sampling, R&D managers or human resources managers in the above organizations were contacted, and questionnaires were sent to the entire project team. Participants filled in the questionnaire during break time with the help of R&D project team leaders. Project team leaders provided a list of the project team members and encouraged all team members to complete the questionnaires. In order to make participants feel safe in answering the questions, researchers emphasized that the survey was only for research purposes and none of the individual information in the survey would be disclosed to anyone. Research assistants collected the questionnaires immediately after questionnaires were completed and participants got small gifts of50–100 RMB.

The final sample consisted of 468 individuals from 98 teams (team size ranged from 3 to 10 persons). Of those, 211 worked on scientific research projects (45.09%) and 257 worked on technology development projects (54.91%). Demographic information of the samples in the projects are presented in Table 1.

3.2|Measures

The introduction included information on the purpose of the study with a focus on behaviours and outcomes of a specific research or development project.

3.2.1|Creativity

Employee creativity was measured by a five-item scale adopted from Madjar, Greenberg and Chen (2011) and Farmer, Tierney, and Kung-McIntyre (2003). Employee creativity in the project was evaluated by the supervisor. Items included: ‘This employee [name] is a good source of creative ideas', and ‘This employee [name] generates novel, but operable work-related ideas'. The Cronbach's alpha for this measure was .92.

TABLE 1 Descriptive statistics on demographic variables

	Science research field (N = 211)			Technology development field (N = 257)	
Variable	**Characteristic**	***N***	**%**	***N***	**%**
Gender	Male	144	68.2%	177	68.9%
	Female	67	31.8%	80	31.1%
Age	≤30 years	35	16.6%	167	65.0%
	31–40 years	86	40.8%	79	30.7%
	≥41 years	90	42.7%	10	3.9%
	Missing	–	–	1	0.4%
Education	Bachelor	3	1.4%	108	42.0%
	Master	26	12.3%	86	33.5%
	Ph.D.	176	83.4%	62	24.1%
	Missing	6	2.8%	1	0.4%
Professional title	Junior	54	25.6%	188	73.2%
	Middle level	110	52.1%	41	16.0%
	Senior	32	15.2%	1	0.4%
	Missing	15	7.1%	27	10.5%
Work experience	≤1 year	14	6.6%	43	16.7%
	1–5 years	30	14.2%	131	51.0%
	5–10 years	62	29.4%	57	22.2%
	≥10 years	105	49.8%	25	9.7%
Team size	3–4 people	12	5.7%	21	8.2%
	5–7	146	69.2%	122	47.5%
	>7 people	53	25.1%	114	44.4%

3.2.2|Centrality of intra-team knowledge network

We used the roster method to collect data about intra-team knowledge network. Participants were presented with a list of all of their project team members. They were asked to rate the extent to which each individual team member provided them with work-related information when they met with a task-related problem on this project. Specifically, the question was 'Do you request information or knowledge from [alternating names of all the team members], when you have difficulties at work?' (Hansen, 1999). The question was rated using a 5-point Likert scale ranging from 0 (never) to 4 (very often). When the answer was 2 and above, a tie is recognized. The results were then coded into a matrix where each cell contained a team member's rating of another team member's input. The degree of centrality represents the total amount of knowledge the actor directly received. The higher a team member's degree of centrality, the more knowledge sources the member has (Brass, Galaskiewicz, Greve, & Tsai, 2004; Freeman, 1979). The standard degree of centrality score for each employee was computed by UCNET (Ahuja, Galletta, & Carley, 2003) to allow for comparisons across teams of different sizes. The degree of centrality is indicated by C_D.X_{ij}, which stands for whether actor *j* acquires information from actori,is0or1.gis the number of actors in the network. C_{Di} signifies the degree of centrality of actor *i* and C_{Di} signifies the standardized individual degree of centrality of actor *i*.

$$C_D = \frac{\sum_{i=1}^{g}(C_{D\max} - C_{Di})}{\max\left[\sum_{i=1}^{n}(C_{D\max} - C_{Di})\right],} \quad (1)$$

$$C_{Di} = \sum_{j}^{g} X_{ij}, \quad (2)$$

$$C'_{Di} = \frac{C_{Di}}{g-1} \quad (3)$$

3.2.3|External knowledge searching

Participants were asked to respond to the following question: “Rate your frequency of external knowledge searching in the following knowledge sources”. The 19 knowledge sources came from the OECD's Oslo Manual (2005) (Laursen & Salter, 2004), and were grouped into three categories: external market (user, supplier, competitor, business collaborators, other organization in the field, commercial R&D organization, start-up), public organization (university, government department, public research institute, public innovation service organization), and integrative knowledge sources (patents, professional conference or workshop/book/journal, exhibition, industrial association, other industrial associations, club and friends, technology standard making organization, public policy and norm of environment and safety). Participants responded using a five-point Likert scale (0 = never, 1 = very seldom, 2 = seldom, 3 = frequently,4 = very frequently). The external knowledge searching was calculated as the sum of the responses to all 19 items.

3.2.4|Control variables

Control variables included gender, age, education background and team size. Age and education background might relate with employees' expertise, which in turn may influence their creativity. Gender might influence external communication behaviour (Hyde &Linn, 1988). Team size has been found to affect creativity negatively (Kratzer, Leenders, & Van Engelen, 2006). Thus, they were controlled in this study.

4|RESULTS

We used t-tests to analyse the differences between the two samples. Differences were found for employee creativity (t=−9.12,p< 0.01,with $M_{\text{technology development}}$ = 3.354, $SD_{\text{technology development}}$= 0.826, $M_{\text{science research}}$=4.045, $SD_{\text{science research}}$= 0.802) and external knowledge searching (t=−7.381,p< 0.01, with $M_{\text{technology development}}$= 10.004, $SD_{\text{technology development}}$= 4.159,$M_{\text{science research}}$= 12.853, $SD_{\text{science research}}$= 4.150). These differences indicate that supervisors rated employees of science research as more creative and that science researchers searched more external sources. There was no significant difference in centrality.

The mean, standard deviation and Spearman's correlations are presented in Table 2 by field. Results indicated that degree of centrality in the team problem-solving network was negatively correlated with external knowledge searching (r=−0.22, p< 0.01) in the science research field. On the contrary, their correlation was positive in the technology development field (r= 0.38, p< 0.01). External knowledge searching had no significant correlation with employee creativity in basic scientific research (r= 0.02, *ns*), but was positively correlated with employee creativity in technology development research *(*r= 0.37, p< 0.01). Degree centrality of team problem-solving net-work was positively correlated with employee creativity in both the science research field and the technology development field (r= 0.33, p< 0.01; r= 0.53, p< 0.01, respectively).

Hypotheses H1.and H2 were tested for each domain (science research and technology development) separately. In step 1, control variables were entered (see Models 1 and 4 in Table 3). In step2 (Models 2 and 5), degree of centrality and external knowledge searching were entered.

TABLE 2 Means, standard deviations and correlations

	M	*SD*	1 2		3
Science research (*N* = 211)					
Employees' external knowledge searching	12.85	4.15	1		
Employees' degree centrality in team knowledge network	.44	.30	−.22**	1	
Employee creativity	4.04	.80	.02	.33**	1
Technology development (*N* = 257)					
Employees' external knowledge searching	10.00	4.16	1		
Employees' degree centrality in team knowledge network	.40	.33	.38**	1	
Employee creativity	3.35.	83	.37**	.53**	1

Note:
**p < .01, two-tailed test.

The results indicated that degree of centrality in team problem solving network positively related to employees' creativity (ß= 0.36, p< 0.01) for the science research domain, thus supporting 1a. However, contrary to H2a external knowledge searching was not significantly related to employee creativity (ß= 0.06, *ns*). For the technology development domain, results indicated that that degree of centrality in team problem solving network (ß= 0.4*,* p< 0.01) and external knowledge searching (ß= 0.12, p< 0.05) were positively related to employee creativity, thus supporting H1b and H2b.

TABLE 3 Regressions

	Creativity in science research field				Creativity in technology development field			
Variable	Model 1	Model 2	Model 3	VIF	Model 4	Model 5	Model 6	VIF
Gender[e]	−.08	−.04	−.04	1.05	−.08	−.01	−.01	1.06
Age[f]	.06	.04	.05	1.19	.06	−.02	−.02	1.18
Education[g]	.15[a]	.17[a]	.14[a]	1.16	.42[c]	.28[c]	.28[c]	1.21
Group size[g]	.03	.07	.08	1.04	−.08	−.05	−.04	1.07
DC		.36[c]	.28[c]	1.35		.40[c]	.39[c]	1.35
EKS		.06	−.02	1.38		.12[a]	.14[a]	1.40
DC * EKS			.20[b]	1.42			−.04	1.15
R^f	.02	.14	.16		.19	.37	.37	
$\triangle R^f$	.04	.12	.03		.20	.18	.00	
F	2.15	14.94[c]	6.92[b]		16.03[c]	35.72[c]	.45	
Df	4, 206	2, 204	1, 203		4, 250	2, 248	1, 247	

Notes:
[a]$p < .05$,
[b]$p < .01$,
[c]$p < .001$
[d]0 = male, 1 = female;
[e]0 = 30 years old or less, 1 = more than 30 years old;
[f]0 = bachelor or master degree, 1 = PhD degree;
[g]0 = with 8 or less than 8 team members, 1 = with more than 8 team members;
DC = Degree of centrality in team problem solving network
EKS = External knowledge searching

Hypothesis 6.was tested with a three-way interaction, using all participants (see Table 4). Domain was dummy coded, and the variables of centrality and external knowledge searching were centred (Aiken & West, 1991). Results indicated that the three-way inter-action was significant (ß=−0.1,p< 0.05), supporting H3.

To determine the nature of the interaction, the two-way interaction between centrality and external knowledge search were tested and graphed separately for each domain (research science and technology development), following the procedure outlined by Aiken and West (1991), see Models 3 and 6 in Table 3. Figure 2 depicts the relationship for the research science domain and indicates that when employee's degree of centrality is high, employee's external knowledge searching is positively related to creativity (ß= 0.51*, p*< 0.001). When employee's degree centrality is low the relationship between employee's external knowledge searching and creativity is not significant (ß=−0.05, *p*> 0.05). For the technology development domain, the two-way interaction between degree of centrality and external knowledge searching was not significant. Thus, hypothesisH3 was supported.

TABLE 4 Three-way interactions

Variable	Creativity (N = 468) Model 1	Model 2	Model 3	Model 4	VIF
Gender[e]	−.02	.00	.01	.01	1.05
Age[f]	.09[a]	.01	.01	.01	1.54
Education[g]	.44[c]	.28[c]	.27[c]	.27[c]	1.89
Group size[h]	−.06	−.01	−.01	−.01	1.04
DC		.37[c]	.35[c]	.32[c]	1.33
EKS		.10[a]	.08	.08	1.53
Research field[23]		−.15[b]	−.18[c]	−.19[c]	2.37
DC * Research field			.05	.06	1.30
EKS* Research field			.03	.07	1.31
DC * EKS			.03	.05	1.47
DC * EKS * Research field				−.10[a]	1.28
R^f	.24	.388	.390	.398	
$\triangle R^f$	.240	.148	.003	.008	
F	36.393[c]	36.887[c]	.642	5.915[a]	
Df	4, 461	3, 458	3, 455	1,454	

Notes:
[a]$p < .05$,
[b]$p < .01$,
[c]$p < .001$
[d]0 = male, 1 = female;
[e]0 = 30 years old or less, 1 = more than 30 years old;
[f]0 = bachelor or master degree, 1 = PhD degree;
[g]0 = with 8 or less than 8 team members, 1 = with more than 8 team members;
[h]1 = science research field, 2 = technology development field;
DC = degree of centrality in team problem solving network
EKS = external knowledge searching

5|DISCUSSION

The results from this study suggest that the degree of centrality in the problem-solving team was an important predictor of creativity regardless of the domain. However, external knowledge searching was shown to be predictive only for the technology domain. It is important to note that an interaction was found between domain, external knowledge searching, and degree of centrality, which supersedes these main effect findings. Specifically, for the science domain, a two-way interaction was found between external knowledge searching and degree of centrality, such that when both external knowledge searching and degree of centrality are high, the highest level of employee creativity is observed. However, no such interaction was found for the technology development domain, indicating that the predictive effects were additive.

These finding suggest important domain differences in knowledge searching. The purpose for external knowledge searching by scientists is less focused on a specific goal, and may be focused on learning and curiosity. As such, scientists engage in broad external knowledge searching. However, technology development employees may tend to have more focused and goal-related external searches. Because of the broad nature of their external knowledge search, it is more difficult for scientists to combine their external knowledge with their existing knowledge directly. As such, external knowledge does not contribute to scientific creativity directly in this study.

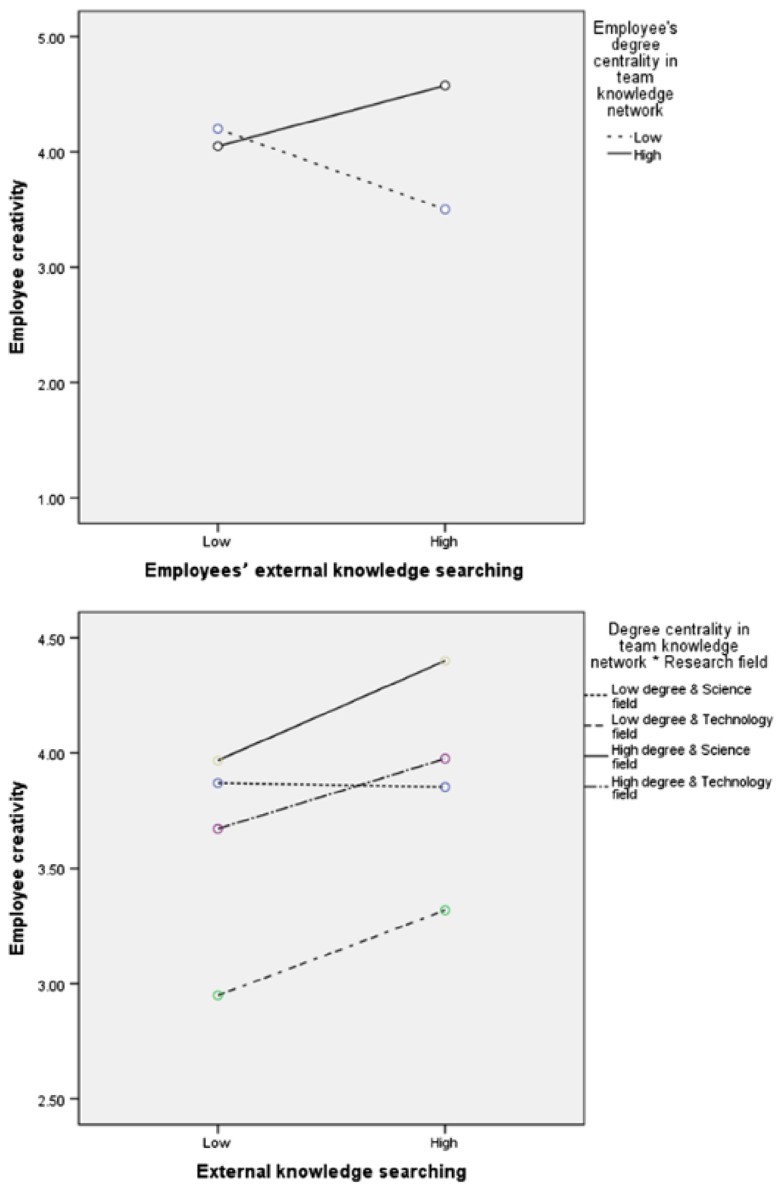

FIGURE 2 The moderating effect in scientific research field [Colour figure can be viewed at wileyonlinelibrary.com]

We contend that due to the broad external searching, the absorption of the information gleaned relies on the team as opposed to a single individual. Hence, scientists rely on the team members' diversified perspectives and accumulated knowledge and those play a more important role in absorbing external knowledge in the science research field. Taken together, the finding supports our argument that the creative process from the perspective of knowledge handling is domain specific, and that to understand such processes we must include the domain in our research.

5.1|Theoretical implications

This study provides an important contribution to understanding creativity across domains. Domain differences have been argued to be important in creativity (Baer, 1998, 2012). There is the body of research suggesting that while some aspects of cognition and problem solving may be more universal, some of these aspects maybe more domain specific (Baer, 2012; Mumford, Antes, Caughron, Connelly, & Beeler, 2010). This study is a first field study exploring domain-specific and domain-general issues in scientific creativity from the perspective of the creative process. Decades ago, Tushman (1977) pointed out that the work of R&D is relatively complex, difficult and unpredictable. Domain differences between scientific creativity and technical creativity has already been identified (Ziman, 2003). However, empirical research has not evaluated the characteristics that may distinguish the creative process of science research work and that of technology development work. This study ties cognitive and problem-solving behaviours to the concept of exploration or exploitation and suggests that different domains may have a different emphasis. Specifically, we found that the relationship of external knowledge searching and employee creativity was not the same in the scientific research and technology development fields.

Prior studies on creative processes in the workplace find that knowledge searching is an important antecedence of employee creativity. External knowledge search (Ter Wal, Criscuolo, & Salter, 2017) and internal knowledge sharing (Kang & Lee, 2017; Tang, Shang, Naumann, & von Zedtwitz, 2014) have been shown to improve R&D employee creativity. In recent years, scholars have started to pay more attention to the issue that internal and external knowledge in isolation restricts the full understanding of knowledge and R&D employee creativity. For example, Tang (2016) demonstrated that external diversified knowledge increased R&D employees' creativity through their degree centrality of team knowledge network, and the characteristics of knowledge content moderated the contribution of external diversified knowledge and R&D employee creativity. Che, Wu, Wang, and Yang (2019) also find that knowledge sourcing significantly influences employees' innovation behaviour and the effect of knowledge sourcing depends on information transparency. However, no study has analysed the impact of the interaction of internal and external knowledge searching on employee creativity from the domain perspective or identified domain differences in the use of knowledge searching sources. Responding to the prior research which indicated that a domain-specific perspective should be considered in studying the relationship between knowledge and creativity (Baer, 2015; Lubart & Guignard, 2004), this study provides empirical support for this argument. We contribute to knowledge and creativity theory by pointing out that routineness of the task (for more detail of the concept, see Chung & Jackson, 2013) is a contextual factor that influences the dynamics of knowledge-searching and employee creativity. Science research work is less routine compared with technology development work and as such, scientists are more dependent on their R&D team to absorb external knowledge. The study of absorptive capacity at the employee level suggests that it contributes to employee creativity

(Schweisfurth & Raasch, 2018). According to the process model of employee absorptive capacity, employees' engagement of the absorption of new external knowledge includes recognizing, assimilating and applying external knowledge, and during the process individuals need to shared understanding (Sjödin, Frishammar, & Thorgren, 2019). This study implies that employees' knowledge absorptive capacity not only comes from personal ability, but is also the result of work with team members. Therefore, being in a central position in the team knowledge network will improve employee's knowledge absorptive capacity. Moreover, different fields have different requirements for relying on team members to absorb external knowledge. In less routine fields, team members' absorptive capacity should play a significant role in benefiting from external knowledge and improving creativity, such as the science research field in this study. However, these benefits from team position are not as critical for more routine or goal-directed tasks.

5.2|Practical implications

There are a number of practical implications resulting from this study. Research indicates that knowledge and expertise are critical drivers of and enhance creativity (Hu & Adey, 2002). One way in which knowledge has an effect is through access to knowledge, both within the organization and outside of it. The results presented here suggest that both external knowledge searching and centrality in the network are important for employee creativity in the technological development field, whereas for science research centrality in the network was critical. As such, these results suggest that the type of knowledge needed and how it is acquired is likely different. For scientific research, multiple sources of information, both internal to the organization and external to it, need to be available to employees. The ambiguous work nature in the science research field requires more diversified external knowledge in order to generate new ideas (Baughman & Mumford,1995). Meanwhile, intra-team communication during the problem-solving process will contribute to employees' creativity by increasing their ability to take benefit from external knowledge. Thus, in the science research field, being active in external knowledge searching and maintaining high communication within the team are needed at the same time. As such, to balance two kinds of knowledge searching behaviours seems more important in the science research field. On the other hand, internal and external knowledge searching both increase employee creativity independently in the technology development field. Taken together, this study sheds light on an important task for R&D employee management: optimally integrate internal and external knowledge for employee creativity.

5.3|Limitations

Some caveats should be taken into account in the interpretation of our study's results. Although this study established hypotheses based on the nature of two types of work and work environment and its impact on employees' attention, knowledge filtering and handling tendency, all these variables were not directly measured. Therefore, our reasoning for the mechanism by which domain may be related to the relationship between knowledge and creativity is based on theory, but has not been directly tested.

Previous studies identified the importance of relational variables on knowledge sharing and subsequently, on creativity, such as trust, psychological safety or communication (Carmeli, Gelbard, & Reiter-Palmon, 2013; Chung & Jackson, 2013; Cuevas et al., 2014). It will be a promising research area to integrate the interactional and cognitive approaches into the employee creativity study (Reiter-Palmon et al., 2011). Finally, the cross-sectional data of this study also makes it difficult to determine cause-and-effect relation-ships. In future work, use of longitudinal and objective data will verify the findings of this study.

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REFERENCES

Abbasi, A., Jalili, M., & Sadeghi-Niaraki, A. (2018). Influence of network-based structural and power diversity on research performance. Scientometrics,117, 579–590.

Abramo, G., D'Angelo, C. A., & Di Costa, F. (2018). The effect of multi-disciplinary collaborations on research diversification. Scientometrics,116, 423–433.

Carmeli, A., Gelbard, R., & Reiter-Palmon, R. (2013). Leadership, creative problem-solving capacity, and creative performance: The importance of knowledge sharing.Human Resource Management,52,95–121.

Ahuja, M. K., Galletta, D. F., & Carley, K. M. (2003). Individual centrality and performance in virtual R&D groups: An empirical study. Management Science,49,21–38.

Alavi, M., & Tiwana, A. (2002). Knowledge integration in virtual teams: The potential role of KMS. Journal of the American Society for Information Science and Technology,53, 1029–1037.

Baer, J. (1998). The case for domain specificity of creativity. Creativity Research Journal,11(2), 173–177.

Baer, J. (2012). Domain specificity and the limits of creativity theory. Journal of Creative Behavior,46,16–29.

Baer, J. (2015). The importance of domain-specific expertise in creativity. Roeper Review,37, 165–178.

Baer, J., & Kaufman, J. C. (2005). Bridging generality and specificity: The amusement park theoretical (APT) model of creativity. Roeper Review,27, 158–163.

Barbot, B., Besancon, M., & Lubart, T. (2016). The generality-specificity of creativity: Exploring the structure of creative potential with EPoC. Learning and Individual Differences,52, 178–187.

Battke, B., Schmidt, T. S., Stollenwerk, S., & Hoffmann, V. H. (2016). Internal or external spillovers: Which kind of knowledge is more likely to flow within or across technologies. Research Policy,45,27–41.

Baughman, W. A., & Mumford, M. D. (1995). Process-analytic models of creative capacities: Operations influencing the combination-and-reorganization process. Creativity Research Journal,8,37–62.

Berg, S., Duncan, J., & Friedman, P. (1982).Joint venture strategies and corporate innovation. Cambridge, MA: Oelgeschlager, Gunn & Hain.

Bikard, M., Vakili, K., & Teodoridis, F. (2019). When collaboration bridges institutions: The impact of university–industry collaboration on academic productivity. Organization Science,30, 426–445.

Bordons, M., Aparicio, J., González-Albo, B., & Díaz-Faes, A. A. (2015). The relationship between the research performance of scientists and their position in co-authorship networks in three fields. Journal ofInformetrics,9, 135–144.

Brass, D. J., Galaskiewicz, J., Greve, H. R., & Tsai, W. (2004). Taking stock of networks and organizations: A multilevel perspective. Academy of Management Journal,47, 795–817.

Brennecke, J., & Stoemmer, N. (2018). The network-performance relation-ship in knowledge-intensive contexts: A meta-analysis and cross-level comparison. Human Resource Management,57,11–36.

Brooks, H. (1994). The relationship between science and technology. Research Policy,23, 477–486.

Bybee, R. W. (1998). Bridging science & technology. The Science Teacher,65(6), 38–42.

Camelo, C., García, C. J., Sousa, G. E., & Valle, C. R. (2011). The influence of human resource management on knowledge sharing and innovation in pain: The mediating role of affective commitment. International Journal of Human Resource Management,22,1442–1463.

Che, T., Wu, Z., Wang, Y., & Yang, R. (2019). Impacts of knowledge sourcing on employee innovation: The moderating effect of information transparency. Journal of Knowledge Management,23, 221–239.

Chen, J., Chen, Y., & Vanhaverbeke, W. (2011). The influence of scope, depth, and orientation of external technology sources on the innovative performance of Chinese firms. Technovation,31, 362–373.

Chiang, Y. H., & Hung, K. P. (2010). Exploring open search strategies and perceived innovation performance from the perspective of inter-organizational knowledge flows. R&D Management,40,292–299.

Chuang, C. H., Jackson, S. E., & Jiang, Y. (2016). Can knowledge-intensive teamwork be managed? Examining the roles of HRM systems, leader-ship, and tacit knowledge. Journal of Management,42, 524–554.

Cuevas, R. G., Cabello, M. C., & Carmona, L. A. (2014). Internal and external social capital for radical product innovation: Do they always work well together? British Journal of Management,25, 266–284.

Dillon, J. T. (1982). Problem finding and solving. Journal of Creative Behav-ior,16,97–111.

Dong, Y., Bartol, K. M., Zhang, Z. X., & Li, C. (2016). Enhancing employee creativity via individual skill development and team knowledge sharing: Influences of dual-focused transformational leadership. Journal of Organizational Behavior,38, 439–458.

Farmer, S. M., Tierney, P., & Kung-McIntyre, K. (2003). Employee creativity in Taiwan: An application of role identity theory. Academy of Management Journal,46, 618–663.

Ferreras-Méndez, J. L., Newell, S., Fernández-Mesa, A., & Alegre, J. (2015).Depth and breadth of external knowledge search and performance: The mediating role of absorptive capacity. Industrial MarketingManagement,47,86–97.

Freeman, L. C. (1979). Centrality in social networks: Conceptual clarification. Social Networks,1, 215–239.

Giere, R. (2002). Scientific cognition as distributed cognition. In P. Carruthers, S. Stich, & M. Siegal (Eds.), The cognitive basis of science. New York, NY: Cambridge University Press.

Gilson, L. L., & Madjar, N. (2011). Radical and incremental creativity: Antecedents and processes. Psychology of Aesthetics, Creativity, and the Arts,5,21–28.

Gong, Y., Kim, T. Y., Lee, D. R., & Zhu, J. (2013). A multilevel model of team goal orientation, information exchange, and creativity. Academy of Management Journal,56, 827–851.

Guan, J., Zuo, K., Chen, K., & Yam, R. C. (2016). Does country-level R&D efficiency benefit from the collaboration network structure? ResearchPolicy,45, 770–784.

Guo, B., & Li, H. (2007). Information seeking behavior of R&D professionals in new product development. In2007 IEEE International Conference on Industrial Engineering and Engineering Management (pp. 1980–1984). Piscataway, NJ: IEEE.

Hahn, M. H., Lee, K. C., & Lee, D. S. (2015). Network structure, organizational learning culture, and employee creativity in system integration companies: The mediating effects of exploitation and exploration. Computers in Human Behavior,42, 167–175.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. Administrative Science Quarterly,44,82–111.

Harms, M., & Reiter-Palmon, R. (in press). The impact of problem construction and information search on creativity.The Psychology of Aesthetics, Creativity, and the Arts.

Hemlin, S., Olsson, L., & Denti, L. (2013). Creativity in R&D. InK. Thomas, & J. Chan (Eds.), Handbook of research on creativity (pp. 508–521). Cheltenham, UK: Edward Elgar Publishing.

Hornberg, J., & Reiter-Palmon, R. (2017). Creativity and the Big Five personality traits: Is the relationship dependent on the creativity measure? In G. Feist, R. Reiter-Palmon, & J. Kaufman (Eds.), The Cambridge handbook of personality and creativity. Cambridge, UK: Cambridge University Press.

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. International Journal of Science Education,24, 389–403.

Huang, X., Hsieh, J. J., & He, W. (2014). Expertise dissimilarity and creativity: The contingent roles of tacit and explicit knowledge sharing. Journal of Applied Psychology,99, 816–830.

Hyde, J. S., & Linn, M. C. (1988). Gender differences in verbal ability: A meta-analysis. Psychological Bulletin,104,53–69.

Jen, C. T. (2014). Social ties, knowledge diversity and individual creativity. Journal of Business Studies Quarterly,6, 110–124.

Kang, M., & Lee, M. J. (2017). Absorptive capacity, knowledge sharing, and innovative behaviour of R&D employees. Technology Analysis & Strategic Management,29, 219–232.

Kaufman, J. C. (2012). Counting the muses: Development of the Kaufman Domains of Creativity Scale (K-DOCS). Psychology of Aesthetics, Creativity, and the Arts,6, 298–308.

Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four Cmodel of creativity. Review of General Psychology,13,1–12.

Khedhaouria, A., Montani, F., & Thurik, R. (2017). Time pressure and team member creativity within R&D projects: The role of learning orientation and knowledge sourcing. International Journal of Project Manage-ment,35, 942–954.

Kratzer, J., Leenders, R. T. A., & Van Engelen, J. M. (2006). Managing creative team performance in virtual environments: An empirical study in 44 R&D teams. Technovation,26,42–49.

Kuhn, T. S. (1996).The structure of scientific revolution. Chicago, IL: University of Chicago Press.

Lane, P. J., Koka, B. R., & Pathak, S. (2006). The reification of absorptivecapacity: A critical review and rejuvenation of the construct.Academyof Management Review,31, 833–863.

Laursen, K., & Salter, A. (2004). Searching high and low: What types of firms use universities as a source of innovation? Research Policy,33,1201–1215.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. Strategic Management Journal,27, 131–150.

Li, Y., & Belkin, N. J. (2008). A faceted approach to conceptualizing tasks in information seeking. Information Processing & Management,44,1822–1837.

Liu, D., Jiang, K., Shalley, C. E., Keem, S., & Zhou, J. (2016). Motivational mechanisms of employee creativity: A meta-analytic examination and theoretical extension of the creativity literature. Organizational Behavior and Human Decision Processes,137, 236–263.

Lubart, T., & Guignard, J. (2004). The generality-specificity of creativity: Amultivariate approach. In R. J. Sternberg, & E. L. Grigorenko (Eds.),Cre-ativity: From potential to realization(pp. 43–56). Washington, DC: American Psychological Association.

Ma, Y., Cheng, W., Ribbens, B. A., & Zhou, J. (2013). Linking ethical leader-ship to employee creativity: Knowledge sharing and self-efficacy as mediators. Social Behavior and Personality: An International Journal,41,1409–1419.

Madjar, N., Greenberg, E. & Chen, Z. (2011) Factors for Radical Creativity, Incremental Creativity and Routine, Noncreative Performance. Journal of Applied Psychology,96, 730–743.

Mannix, E., & Neale, M. A. (2005). What differences make a difference? The promise and reality of diverse teams in organizations. Psychological Science in the Public Interest,6(2), 31–55.

March, J. G. (1991). Exploration and exploitation in organizational learning.Organization Science,2,71–87.

Miramontes, J. R., & González-Brambila, C. N. (2016). The effects of exter-nal collaboration on research output in engineering. Scientometrics,109, 661–675.

Mumford, M. D., Antes, A. L., Caughron, J. J., Connelly, S., & Beeler, C. (2010). Cross-field differences in creative problem-solving skills: A comparison of health, biological, and social sciences. Creativity Research Journal,22,14–26.

Mumford, M. D., Marks, M. A., Connelly, M. S., Zaccaro, S. J., &Johnson, J. F. (1998). Domain-based scoring in divergent-thinking tests: Validation evidence in an occupational sample. Creativity Research,11, 151–163.

Mumford, M. D., Mobley, M. I., Uhlman, C. E., Reiter-Palmon, R., & Doares, L. M. (1991). Process analytic models of creative capacities. Creativity Research Journal,4,91–122.

Mumford, M. D., Reiter-Palmon, R., & Redmond, M. R. (1994). Problem construction and cognition: Applying problem representations in ill-defined domains. In M. A. Runco (Ed.), Problem finding, problem solving, and creativity(pp. 3–39). Westport, CT: Ablex Publishing.

Nijstad, B. A., De Dreu, C. K., Rietzschel, E. F., & Baas, M. (2010). Thedual pathway to creativity model: Creative ideation as a function of flexibility and persistence. European Review of Social Psychology,21,34–77.

Nijstad, B. A., & Stroebe, W. (2006). How the group affects the mind: A cognitive model of idea generation in groups. Personality and Social Psychology Review,10, 186–213.

Nijstad, B. A., Stroebe, W., & Lodewijkx, H. F. (2003). Production blockingand idea generation: Does blocking interfere with cognitive processes? Journal of Experimental Social Psychology,39, 531–548.

NRC (1996). National science education standards. Washington, DC: National Academy Press.

Perry-Smith, J. E., & Shalley, C. E. (2014). A social composition view of team creativity: The role of member nationality-heterogeneous ties outside of the team. Organization Science,25, 1434–1452.

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, networks, and knowledge networks: A review and research agenda. Journal of Man-agement,38, 1115–1166.

Poincaré, H. (1913).The foundations of science. Lancaster, PA: Science Press.

Reiter-Palmon, R., Herman, A. E., & Yammarino, F. J. (2008). Creativity and cognitive processes: Multi-level linkages between individual and team cognition. In M. D. Mumford, S. T. Hunter, & K. E. Bedell-Avers (Eds.), Multi-level issues in creativity and innovation(Vol. 7). Research in MultiLevel Issues. (pp. 203–267). Bingley, UK: Emerald Group Publishing.

Reiter-Palmon, R., & Illies, J. J. (2004). Leadership and creativity: Under-standing leadership from a creative problem-solving perspective. Leadership Quarterly,15,55–77.

Reiter-Palmon, R., Illies, M. Y., Kobe Cross, L., Buboltz, C., & Nimps, T.(2009). Creativity and domain specificity: The effect of task type on multiple indexes of creative problem-solving. Psychology of Aesthetics, Creativity, and the Arts,3,73–80.

Reiter-Palmon, R., Wigert, B., & de Vreede, T. (2011). Team creativity and innovation: The effect of team composition, social processes and cognition. In M. D. Mumford (Ed.), Handbook of organizational creativity (pp. 295–326). San Diego, CA: Academic Press.

Rotolo, D., & Messeni Petruzzelli, A. (2013). When does centrality matter? Scientific productivity and the moderating role of research specialization and cross-community ties. Journal of Organizational Behavior,34,648–670.

Santoro, M. D., Bierly, P. E., & Gopalakrishnan, S. (2007). Organisational learning from external sources: New issues and performance implications. International Journal of Technology Management,38,1–10.

Schraw, G., Dunkle, M. E., & Bendixen, L. D. (1995). Cognitive processes inwell-defined and ill-defined problem solving. Applied Cognitive Psychol-ogy,9, 523–538.

Schultz, C., Schreyoegg, J., & von Reitzenstein, C. (2013). The moderating role of internal and external resources on the performance effect of multitasking: Evidence from the R&D performance of surgeons. Research Policy,42, 1356–1365.

Schweisfurth, T. G., & Raasch, C. (2018). Absorptive capacity for need knowledge: Antecedents and effects for employee innovativeness. Research Policy,47, 687–699.

Segarra-Ciprés, M., Roca-Puig, V., & Bou-Llusar, J. C. (2014). External knowledge acquisition and innovation output: An analysis of the moderating effect of internal knowledge transfer. Knowledge Management Research & Practice,12, 203–214.

Sjödin, D., Frishammar, J., & Thorgren, S. (2019). How individuals engage in the absorption of new external knowledge: A process model of absorptive capacity. Journal of Product Innovation Management,36,356–380.

Soo, C. W., Devinney, T. M., & Midgley, D. F. (2007). External knowledge acquisition, creativity and learning in organisational problem solving. International Journal of Technology Management,38, 137–159.

Spaeth, S., Stuermer, M., & Von Krogh, G. (2010). Enabling knowledge creation through outsiders: Towards a push model of open innovation. International Journal of Technology Management,52, 411–431.

Sparrowe, R. T., Liden, R. C., Wayne, S. J., & Kraimer, M. L. (2001). Social networks and the performance of individuals and groups. Academy of Management Journal,44, 316–325.

Tang, C. (2016). Accessed external knowledge, centrality of intra-team knowledge networks, and R&D employee creativity. R&D Management,46(S3), 992–1005.

Tang, C., Shang, J., Naumann, S. E., & von Zedtwitz, M. (2014). How team identification and expertise identification affect R&D employees' creativity. Creativity and Innovation Management,23, 276–289.

Tang, C., & Ye, L. (2015). Diversified knowledge, R&D team centrality and radical creativity. Creativity and Innovation Management,24,123–135.

Ter Wal, A. L., Criscuolo, P., & Salter, A. (2017). Making a marriage of materials: The role of gatekeepers and shepherds in the absorption of external knowledge and innovation performance. Research Policy,46,1039–1054.

Turpin, T., Garrett-Jones, S., & Rankin, N. (1996). Bricoleurs and boundary-riders: Managing basic research and innovation knowledge networks. R&D Management,26, 267–282.

Tushman, M. L. (1977). Special boundary roles in the innovation process. Administrative Science Quarterly,22(4), 587–605.

Vera, D., Nemanich, L., Vélez-Castrillón, S., & Werner, S. (2014). Knowledge-based and contextual factors associated with R&D teams' improvisation capability. Journal of Management,42, 1874–1903.

Ward, T. B., & Kolomyts, Y. (2010). Cognition and creativity. InJ. C. Kaufman, & R. J. Sternberg (Eds.),The Cambridge handbook of creativity(pp. 93–112). Cambridge, UK: Cambridge University Press.

Wuyts, S., Dutta, S., & Stremersch, S. (2004). Portfolios of interfirm agreements in technology-intensive markets: Consequences for innovation and profitability. Journal of Marketing,68,88–100.

Xie, I. (2009). Dimensions of tasks: Influences on information-seeking and retrieving process. Journal of Documentation,65, 339–366.

Zhou, P., & Lv, X. (2015). Academic publishing and collaboration between China and Germany in physics. Scientometrics,105, 1875–1887.

Ziman, J. (1994).Prometheus bound science in a dynamic steady state. Cam-bridge, UK: Cambridge University Press.

Ziman, J. (2003). Non-instrumental roles of science. Science and Engineering Ethics,9,17–27.

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