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A systematic investigation of absorptive capacity and external information search in groups

Implications for group cognition

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Abstract

Purpose – This paper aims to test the influence of external information search (EIS) on knowledge elaboration and group cognitive complexity (GCC) under the moderating effect of absorptive capacity (AC is indicated by prior knowledge base and gender diversity).

Design/methodology/approach – The results of three studies (one field study and two experimental studies) are reported. The first study tests the interaction between EIS and the two dimensions of AC on group knowledge elaboration in a sample of 65 organizational groups. In the second study, EIS was directly manipulated and the interaction with AC in a sample of 65 groups was tested. In the last experimental study, the AC of the boundary spanner (highest level of expertise versus lowest level of expertise) was manipulated and the effects of EIS in a sample of 37 groups were tested.

Findings – The first study reveals a significant interaction between EIS and prior knowledge base on knowledge elaboration and points toward a compensatory interplay of EIS and AC on GCC. The results of the second study indicate that EIS increases the time spent on task, as well as the efficiency of knowledge integration (GCC per unit of time). Furthermore, EIS has the strongest positive effect on GCC in groups in which at least one of the AC dimensions is average or high. The results of the last study show that the AC of the boundary spanner compensates for the lack of absorptive capacity of the group and also show that the cognitive distance between the boundary spanner and the rest of the group has a negative influence on the efficiency of knowledge integration in groups.

Research limitations/implications – The limitations of Study 1, common to non-experimental research (related to causality), are dealt with in the second and third studies that establish causality between EIS and GCC.

Practical implications – The paper has important implications for the management of information search effort in organizational groups, in particular the groups are advised to: engage in EIS to increase their cognitive repertoire and cognitive complexity, delegate, when possible, their most competent members to engage in boundary spanning activities as they will maximize the cognitive benefits of EIS and finally

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minimize the cognitive dissimilarity between the boundary spanner and the rest of the group to facilitate the effective integration of novel insights into the group cognition.

Originality/value – This study is among the first empirical attempts to uncover the causal effect of EIS on knowledge elaboration and GCC in groups and to uncover the role of the boundary spanner in the EIS efforts.

Keywords Absorptive capacity, Experiments, Knowledge, External information search, Group cognition, Group cognitive complexity

Paper type Research paper

In organizations, knowledge-intensive work that requires substantial information processing capabilities is often carried out by groups (Hinsz, 2015). Groups are versatile organizational forms that learn and adapt by blending internal and external knowledge resources (Chuang *et al.*, 2016). Illustrative examples are top management teams that come up with new strategies by integrating the expertise and insights of their members and reach out to seek inputs from other groups, consultants or strategy advisors. Research and development teams often engage in boundary spanning activities, both outside their own organization and outside their technological domain to preserve and foster their innovativeness and competitiveness (Rosenkopf and Nerkar, 2001). Even sport teams send their scouts to acquire intelligence about the training systems used by their competitors to further improve their own, whereas for military teams, espionage is key for their adaptive performance.

Team learning as an outcome is defined as "a relatively permanent change in the team's collective level of knowledge and skill produced by the shared experience of the team members" (Ellis *et al.*, 2003, p. 822). In our study, we build on this cognitive perspective on team learning and argue that the interplay between external and internal knowledge is essential for team learning and adaptation (Ellis *et al.*, 2003; Kump *et al.*, 2015; Stahl, 2010). In particular, we argue that teams draw on internal (e.g. the knowledge and expertise of their members) and external (e.g. other groups, external stakeholders) knowledge resources to build collective knowledge structures. Team cognition, therefore, reflects team learning processes and emerges from the interplay and co-evolution of individual cognitions during social interactions (Curşeu *et al.*, 2010; Curşeu *et al.*, 2007; Kump *et al.*, 2015; Stahl, 2010).

Research to date has extensively explored the group processes through which group cognition and learning emerge. For example, Zoethout *et al.* (2017) showed that conversational transactivity (building on each other's arguments during debates) is an important antecedent for the emergence of team learning behaviors, and knowledge sharing seems to have a similar effect (Leicher and Mulder, 2016), whereas Curşeu *et al.* (2017a) showed that discussion quality positively predicts collaborative learning results. The emergence of complex group-level cognitive structures is fostered by teamwork quality (Curşeu *et al.*, 2007), diversity (Curşeu and Pluut, 2013) and dissent (Curşeu *et al.*, 2017b). However, little attention was devoted so far to understand how groups use external knowledge resources to generate collective cognitive structures. Therefore, in our paper, we aim to provide a systematic investigation of the cognitive benefits (for emergent team cognition and thus team learning) associated with external information search (EIS) as a boundary spanning activity in groups.

We build on the groups-as-information-processing-systems framework (Hinsz *et al.*, 1997; Hinsz, 2015) and argue that groups are socio-cognitive systems embedded in an environment that provides them with a rich cognitive resource pool (Kouchaki *et al.*, 2012). Through boundary spanning activities, groups acquire task-relevant external knowledge that increases their performance in knowledge-intensive tasks (Chuang *et al.*, 2016; West, 2002). Group performance in knowledge-intensive tasks requires both knowledge differentiation (use of knowledge from different fields or domains) and knowledge integration (synthesizing the available knowledge in a unitary mental model or collective cognitive structure) (Gruenfeld and Hollingshead, 1993; Mesmer-Magnus and DeChurch, 2009; West, 2002). In this paper, we present a multi-study examination of the effect of EIS on knowledge differentiation and integration in groups (or group integrative complexity (Driver and Streufert, 1969; Gruenfeld and Hollingshead, 1993).

In terms of group cognition, we focus on two constructs used previously to describe the richness of the collective cognitions that emerge from group interactions, namely knowledge elaboration (Homan *et al.*, 2007) and group cognitive complexity (GCC) (Curşeu *et al.*, 2007). Knowledge elaboration was defined as extensive exchange, discussion and integration of task-related insights (Homan *et al.*, 2007, p. 1206), whereas GCC was defined as the structural richness of the collective cognitive representations developed by groups (Curşeu *et al.*, 2007). Knowledge elaboration and GCC reflect both knowledge differentiation and integration processes in groups and as such are proxies for the integrative complexity of groups as information processing systems (Driver and Streufert, 1969; Gruenfeld and Hollingshead, 1993).

Although previous research explored the relationship between social networks and group cognition, to the best of our knowledge, no experimental study has tested the effects of EIS on knowledge differentiation and integration in groups. Therefore, an important contribution of our paper is that we test the association between EIS and group knowledge elaboration in a field study on organizational groups and then we establish causality by testing the effect of EIS on GCC (GCC) in two experimental studies.

By taking into account group absorptive capacity as a moderator, our studies answer the call for more research on contingencies of the EIS–performance relationship (Marrone, 2010). We also address the call for more research on how the individual absorptive capacity (IAC) of boundary spanners affects knowledge elaboration (Lane *et al.*, 2006). Finally, our paper contributes to the research debate on the EIS–efficiency dilemma (Gibson and Dibble, 2013). Given that EIS efforts are likely to be time consuming, in the Experimental Studies 2 and 3, we explore the potential trade-off between cognitive complexity and efficiency in a knowledge-intensive task.

Study 1: external information search and group integrative complexity

The relationship between groups and their environment is most often characterized as one in which the environment is a resource pool on which groups are dependent (Kouchaki *et al.*, 2012; Han, 2018). That is, groups are information processing systems (Hinsz *et al.*, 1997; Hinsz, 2015) embedded in a web of social ties through which they exchange resources with their environment (Curşeu *et al.*, 2012; Han, 2018; Reagans and Zuckerman, 2001; Reagans *et al.*, 2004). One of the core resources that groups can access in their environment is external information (Han, 2018). We therefore focus on information search as a group boundary spanning activity, which encompasses "team actions to parties that hold specific knowledge and for gaining access to [problem- or project-specific] information and expertise" (Marrone, 2010, p. 8). Additional external information entered into the group by the boundary spanners has the potential to increase the elaboration or complexity of the collective knowledge structures developed by the group.

We propose that EIS fosters the integrative complexity of groups by allowing groups to get access to highly valued cognitive resources that include novel knowledge, timely information, the discovery of new opportunities, diverse ideas and performance feedback (Ancona and Caldwell, 1992; Marrone, 2010; Oh *et al.*, 2006). As such, EIS is a form of group social capital (Han, 2018; Oh *et al.*, 2006) because boundary spanners who tap into the external information domains of other groups enhance knowledge accumulation and ultimately facilitate the emergence of complex collective knowledge structures. We hypothesize the following:

H1. External information search is positively associated with group integrative complexity.

External information search and group absorptive capacity

Effective information processing in groups reflects the interplay between the group's external and internal environments. The external environment provides new knowledge resources that groups can access through horizontal intergroup relationships (Oh *et al.*, 2006; Han, 2018), whereas the internal group environment provides task-related knowledge, as well as the capabilities for integrating and working with knowledge from other groups. The advantages associated with boundary spanning activities (Mitchell and Nicholas, 2006) are dependent upon the ability to acquire and exploit external knowledge. That is, to fully benefit from externally available knowledge sources, groups (and organizations) should have enough absorptive capacity (Cohen and Levinthal, 1990).

In the general management literature, organizational absorptive capacity is defined as a set of dynamic capabilities to acquire, assimilate, generate, transform and use knowledge in order to achieve a competitive advantage (Zahra and George, 2002). Absorptive capacity has mainly been studied in the context of business unit innovation (Tsai, 2001) or organizational innovation (Liao *et al.*, 2007; Zahra and George, 2002), but it is similarly applicable to groups because small groups are socio-cognitive systems that acquire, store, transform and create knowledge (Curşeu *et al.*, 2007; Hinsz *et al.*, 1997). As such, groups' absorptive capacity refers to a set of cognitive capabilities to first recognize the potential of new knowledge, assimilate it and then exploit knowledge to achieve innovative performance (Fosfuri and Tribó, 2008; Lane *et al.*, 2006). These arguments suggest that absorptive capacity moderates the impact of EIS on group's knowledge elaboration.

Previous research shows that the depth and breadth of knowledge play a key role in building absorptive capacity (Fosfuri and Tribó, 2008; Volberda *et al.*, 2010) because "the ability to assimilate information is a function of the richness of the preexisting knowledge structure" (Cohen and Levinthal, 1990, p. 131). At the group level, the depth of knowledge is reflected by members' prior task-related knowledge base, whereas the breadth of knowledge is likely to be associated with group diversity. Therefore, in this research, we consider two dimensions or indicators of group absorptive capacity: prior knowledge base and gender diversity.

An important aspect of absorptive capacity is the system's knowledge stock acquired through previous experiences. Groups with richer preexisting knowledge structures are more likely to benefit from EIS efforts than groups with a poor knowledge base. We argue therefore that groups' absorptive capacity, as illustrated by group members' prior knowledge base, moderates the extent to which groups benefit from EIS.

We furthermore expect that gender diversity reflects the breadth of groups' knowledge repertoire and we use it as a proxy for the second dimension of absorptive capacity. Demographic diversity is associated with information processing competencies (Haas, 2010) and men and women are likely to have dissimilar life experiences which, in turn, lead to qualitatively different knowledge structures (Curşeu *et al.*, 2007). Moreover, we build on the assertions of social role theory (Eagly *et al.*, 2000) that in social settings, men and women adopt different role behaviors and as such contribute differently to the group. In other words, through their different life experiences and role socialization, men and women are likely to think and behave differently in the group and as such, gender diversity enriches the breadth of groups' knowledge repertoires. Knowledge diversity is argued to have assimilative potential (Cohen and Levinthal, 1990; Zahra and George, 2002) because, as Cohen and Levinthal (1990, p. 131) stated, "a diverse background provides a more robust basis for learning because it increases the prospect that incoming information will relate to what is already known." Thus, because diverse groups have broader knowledge repertoires and tend to perform better in making novel associations and conceptual linkages

(Harrison and Klein, 2007), we hypothesize that gender heterogeneous groups have higher absorptive capacity, which moderates the extent to which groups benefit from EIS. In sum, we argue that exposure to information leads to higher integrative complexity in groups with high rather than low absorptive capacity. We hypothesize the following:

H2a. Prior knowledge base moderates the effect of external information search on group integrative complexity in such a way that the benefits of external information search are stronger for groups with rich rather than with poor prior knowledge bases.

H2b. Gender diversity moderates the effect of external information search on group integrative complexity in such a way that the benefits of external information search are stronger for gender heterogeneous rather than for gender homogenous groups.

Method

To enhance generalizability across different organizational settings, the data for this study were collected in multiple organizations. A total of 379 team members (160 women, with an average age of 33.91 years old) in 65 organizational groups from 26 Dutch organizations participated in the study. Each group member was asked to fill out a survey containing demographic questions (age, gender and education) and several items evaluating EIS, knowledge elaboration and teams' prior knowledge base.

Gender diversity was computed using Teachman's (1980) index: $H = -\sum_{i=1}^{s} P_i(\ln Pi)$, where i represents a particular category, s is the total number of categories and P_i is the proportion of the members belonging to the ith category. Gender was coded dichotomously (male/female), therefore $s = 2$.

External information search was evaluated with three items adapted from a team learning scale (Edmondson, 1999). The three items were: "Team members go out and get all the information they possibly can from others - such as customers, or other parts of the organization," "We invite people from outside the team to present information or have discussions with us" and "This team frequently seeks new outside information that leads us to make important changes," and the answers were recorded on a seven-point Likert scale (1 = *fully disagree* to 7 = *fully agree*). Cronbach's alpha for this scale was 0.72. Because groups are the level of analysis, individual scores were aggregated at the group level and the results of the aggregation statistics supported this aggregation (the within group agreement index for EIS ranged from 0.73 to 1.00 with an average of 0.89).

Groups' *prior knowledge base* was evaluated by asking group members to judge on a 1- to 10-point scale, the extent to which their team had enough task-related knowledge. By using the 10-point grading system common in the Dutch educational system to evaluate knowledge, we attempted to attenuate the problems associated with the use of single item measures. The within-group agreement index ranged from 0.74 to 1.00 with an average of 0.91, showing a substantial amount of within group consensus.

Group integrative complexity was evaluated as self-reported knowledge elaboration using a four item-scale developed on the basis of the methodological suggestions reported in Huber and Lewis (2010). Team members were asked to evaluate the extent to which their team exhibited the following knowledge integration behaviors ("In this team: we inquire about specific knowledge we need to perform the task, we often ask for clarification on issues related to the task, we help each other to better understand the task and we prompt each other to discuss task related details") during the last four months. Answers were recorded on a five-point Likert scale (1 = *never* to 5 = *always*) and Cronbach's alpha for this scale was 0.76. Similar to EIS, individual scores were aggregated at the group level. The within-group agreement index supported this aggregation, as values ranged from 0.78 to 1.00 with an average of 0.93.

Results

Means, standard deviations and correlations are presented in Table I.

We tested the hypotheses using ordinary least squares (OLS) regression with knowledge elaboration as dependent variable, and gender diversity, previous knowledge base and external information as independent variables. Because we tested interactions, all independent variables were grand mean centered before computing the cross-product terms (Aiken and West, 1991). The results of the regression analyses are presented in Table II.

To further explore the interactions, we used a conditional process bootstrapping procedure described by Hayes (2008). The conditional effects of EIS depending on gender diversity and prior knowledge base are presented in Table V. *H1*, stating that EIS would be positively associated with knowledge elaboration, was fully supported by our data. Although the interaction between EIS and prior knowledge base was significant, the interaction pattern did not fit our expectations specified in *H2a*. The positive association between EIS and knowledge elaboration seemed to be stronger in groups with low and

Table I. Means, standard deviations and correlations for Study 1

Variables	M	SD	1	2	3	4	5	6
1. Group size	5.83	2.92	1					
2. Mean age	33.91	8.29	0.05	1				
3. GD	0.41	0.28	0.33**	−0.07	1			
4. PKB	7.88	0.65	−0.03	−0.12	−0.24*	1		
5. EIS	3.71	0.80	0.02	0.14	−0.10	0.11	1	
6. KE	3.82	0.40	−0.09	−0.09	−0.17	0.35**	0.41**	1

Notes: GD = gender diversity, PKB = prior knowledge base, EIS = external information search, KE = knowledge elaboration; $**p < 0.01$; $*p < 0.05$

Table II. Results of the stepwise OLS regression for knowledge elaboration in Study 1

Step	Independent variables	Model 1	Model 2
1	Group size	−0.08 (0.02)	−0.11 (0.02)
	Gender diversity (GD)	−0.04 (0.17)	−0.09 (0.17)
	PKB	0.30** (0.07)	0.24* (0.07)
	EIS	0.38** (0.06)	0.43** (0.06)
2	EIS × PKB		−0.26* (0.12)
	EIS × GD		0.05 (0.20)
	R^2	0.28	0.34
	Adjusted R^2	0.23	0.28
	F	5.75**	5.08**
	F change	5.75**	2.97***

Notes: PKB = prior knowledge base, EIS = external information search, KE = knowledge elaboration, standardized regression coefficients are shown with standard errors between parentheses. All variables are grand mean centered; $**p < 0.01$; $*p < 0.05$; $***p < 0.10$

average rather than high absorptive capacity (Figure 1 and Table V). *H2b* was not supported, as we did not find an interaction effect between EIS and gender diversity on knowledge elaboration.

Discussion Study 1

The results reported in Study 1 fully supported *H1* and showed that engagement in EIS was beneficial for knowledge elaboration in groups. However, our results pointed to a compensatory rather than additive effect of the interplay between the external and internal factors driving group knowledge elaboration. That is, EIS compensated for a poor to average prior knowledge base in groups. This result was unexpected, as we argued in *H2a* that prior knowledge base would strengthen rather than weaken the positive influence of EIS on knowledge elaboration.

We believe that this finding may be attributed to groups' motivation to compensate for a lack of internal knowledge. The awareness that a group has insufficient task-related knowledge may have pushed some of the organizational groups in our sample to search for additional information and could have motivated these groups to use the external information optimally to promote knowledge elaboration. In other words, the argument preceding *H2a* was purely cognitive in nature (prior knowledge base fosters the integration of incoming information), whereas other motivational factors (e.g. the recognized need to engage in EIS when task-related knowledge is lacking) could have played a role in shaping the association between EIS and knowledge elaboration. These motivational factors at play in organizational groups and the self-report nature of our measure may also explain the lack of support for *H2b*.

Our first study has several limitations. First, it was a cross-sectional study and as such, no causal claims are warranted. Second, it was not possible to directly assess absorptive capacity or knowledge elaboration in a clear (information processing) task. To exclude the motivational factors associated with the task-related EIS requirements, one should control for the nature of the task (all groups involved in the study should perform the same or very similar information processing tasks). Third, there was no objective evaluation of time investment and it was therefore not possible to explore the trade-off between EIS and time efficiency in cognitive tasks. We designed an experimental study to address these three shortcomings. The first aim of this experimental study is to test the two hypotheses elaborated for Study 1 using a specific information processing task aimed at evaluating the cognitive complexity of groups and directly test the cognitive claims underlying *H2a* and

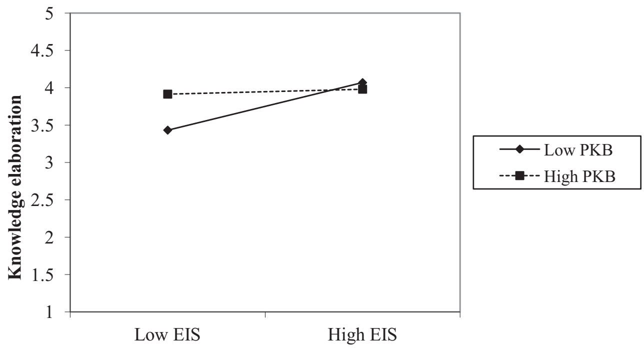

Figure 1.
The interaction effect between external information search and prior knowledge base on knowledge elaboration

H2b. The second aim of the study is to explore the trade-off between efficiency and GCC. We further address these two aims and their theoretical grounding in the following sections.

Study 2: external information search and group cognitive complexity

Representational views on groups as information processing systems (Hinsz *et al.*, 1997) or learning entities (Curşeu and Pluut, 2013) argue that group cognition emerges from the interplay of individual cognitions through social interactions within the group (Curşeu *et al.*, 2010). The emergence of complex collective cognitive structures requires both cognitive differentiation (divergent thinking) and cognitive integration processes (convergent thinking). Therefore, complex emergent collective knowledge structures (GCC) reflect groups' competence of combining knowledge stemming from within the group (as group members share, evaluate and analyze information) as well as from outside the group.

Although research to date did not directly test the effects of EIS on the emergence of group cognition, it documented both the role of prior knowledge base and gender diversity for the emergence of GCC. Curşeu *et al.* (2007) showed that groups composed of cognitively complex individuals (having rich knowledge structures in a particular knowledge domain) develop more complex collective knowledge structures than groups composed of less cognitively complex members. Also, recent evidence shows that gender heterogeneous groups are more effective information processing units than gender homogeneous groups (Curşeu *et al.*, 2013; Woolley *et al.*, 2010).

In this experimental study, we will test the effect of EIS on GCC (in line with *H1*) and examine the moderating role of prior knowledge base and gender diversity as dimensions of absorptive capacity (in line with *H2*). The results of Study 1 pointed toward a compensatory role of EIS for groups with poor prior knowledge base. This result was opposed to what we hypothesized and the first aim of the second study is to put this claim to test in a task in which we can actually:

- establish causal associations by manipulating EIS; and
- directly evaluate GCC and exclude the confounding effect of motivation to engage in EIS.

Trade-off between time efficiency and group cognitive complexity

Our second aim in this study is to explore the potential trade-off between time efficiency and GCC as a consequence of EIS. Organizations operating in competitive environments require both creative outputs and speedy processes for creating these outputs. Studies have therefore used efficiency (adherence to budget and schedule) as a team performance measure for innovative projects in addition to effectiveness (e.g. quality) (Hoegl and Gemünden, 2001; Hoegl and Parboteeah, 2007). A relevant but neglected issue is the potential trade-off between efficiency and creativity processes. Creativity as a group process involves searching for alternatives, modifying the generated alternatives and extending original ideas (Drazin *et al.*, 1999). Research findings provide some support for the notion that cost- and time-efficient end products are likely to not go hand in hand with such elaborate efforts. For instance, task achievement (as an indicator of need for efficiency) is one of the more significant barriers to creativity (Sadi and Al-Dubaisi, 2008), and a crisis in cost or schedule can favor a *shift* from creativity to efficiency (Drazin *et al.*, 1999). Moreover, a creative work environment interacts negatively with standardized work procedures (Gilson *et al.*, 2005), implying that a focus on efficiency interferes with (reaping the benefits of) creativity.

To further explore EIS in groups, we aim to explore whether EIS relates differently to time efficiency (operationalized as the time needed to perform a knowledge-intensive task) and GCC (as an indicator of both knowledge differentiation and knowledge integration). The effect of EIS on efficiency is complex, since it is contingent on the content of the boundary spanning activity and its duration (Ancona and Caldwell, 1992). While crossing boundaries with the goal of task coordination and finding support is likely to improve efficiency, and information seeking – the boundary spanning activity central to this paper – may undermine efficiency (Marrone, 2010). In fact, the concept of network efficiency (indicated by non-overlapping flows of information) suggests that it costs time and energy to maintain intergroup relationships and to engage in information search and knowledge transfer (Hansen, 1999). In addition, the boundary spanning activity is likely to result in extra ideas that need to be integrated with the previously discussed alternatives. In support of this, empirical data on multi-team R&D projects have shown that intergroup communication is associated with less time efficiency (Kratzer *et al.*, 2008). We therefore hypothesize the following:

H3. External information search is positively associated with time spent on a knowledge-intensive task.

Method

A sample of 268 students (104 women) participated in the study. They were enrolled in a bachelor course at a large Dutch university (data were collected in two successive academic years). The course was based on collaborative learning principles and students were organized in 65 learning groups with a group size that ranged from 2 to 7 (average size 4.12) students. In one of the workshops devoted to teamwork, we used a quasi-experimental design involving control groups (but no pretest) to study the effect of boundary spanning on a group's cognitive complexity. During this workshop, student groups were asked to participate in a cognitive mapping exercise. Although the students were not randomly assigned to groups (as students were free to choose their group members and group composition was stable across the semester), the groups were randomly assigned to an experimental condition based on their enrollment in one of the eight workshops. All groups attending a particular workshop were placed in the same experimental condition, as the manipulation required groups in a particular lecture room to display similar patterns of EIS behavior.

The EIS manipulation applied in half of the student groups (n = 33) involved EIS during the execution of the cognitive mapping task. Only experimental groups received the following addition to the instruction:

> Please take the first 30 minutes to define the structure of your own cognitive map. Afterwards you are allowed to talk to the other groups in the room by appointing a representative (she/he will visit the chosen groups) in order to ask questions about the map or to explore the way (s) other groups constructed their maps. You are expected to visit at least once each group in the room. The representative may change and members of no more than 3 groups are allowed at the same time at one table.

Groups in the control condition were not allowed to visit other groups in the room, whereas manipulated groups were required to make use of the opportunity for EIS, and the workshop teacher closely supervised this process. The groups followed a sequential process (Gersick, 1988), as they dealt with internal information initially and engaged in EIS later. In these groups, we defined a boundary spanning role, allowing one individual at a time to carry information from the other groups in the classroom into the group (Kouchaki *et al.*, 2012). As a manipulation check, we made sure that at least one group member in each group from the experimental condition engaged in EIS. However, because concentrating external ties in the hands of only a limited number of group members can have detrimental consequences (Oh *et al.*, 2006), all members of the group were (in principle) allowed to act as boundary spanning individuals. In the experimental design, EIS was coded as a group-level dummy variable (engaged versus not engaged in EIS).

Absorptive capacity had two indicators: the comprehensiveness of groups' prior knowledge base and gender diversity. To have a more objective indicator of absorptive capacity than the self-report measure used in Study 1, we used a knowledge test to directly evaluate the comprehensiveness of group members' prior knowledge base. This test was a midterm exam consisting of 60 multiple choice questions (maximum score is therefore 60). The exam evaluated both breadth (it covered a variety of course-related topics) and depth (it asked students to define, compare, discriminate and contrast concepts and theories) of knowledge. The midterm scores were therefore indicative of students' absorptive capacity or ability to work with course-related concepts prior to the cognitive mapping session. The second indicator of absorptive capacity is gender diversity, operationalized as variety similar to Study 1 (Harrison and Klein, 2007).

Group integrative complexity was evaluated as GCC, an index computed using the cognitive maps developed by the groups during the cognitive mapping exercise. The cognitive mapping session used a card-sorting technique in which 41 relevant concepts for the leadership domain were written down on independent cards and had to be organized on an A3 blank sheet of paper in a way that made sense to the group as a whole. Although groups were given an indication of how long it will take to make a cognitive map, they were all allowed to finish and work at their own pace. In addition to a short introduction to and explanation about the cognitive mapping session, all the groups received the following instruction on paper at the start of the session:

> This is an exercise on group decision-making and it should not take longer than 45 minutes. In the provided envelops you have a number of concepts that you have to organize so as to get a coherent "picture" or cognitive map for LEADERSHIP. Your group is to employ the method of group consensus and each group member must agree upon the way in which the concepts you received will be organized. *First*, you have to select the concepts that in your view are related to leadership and organize them in a way that makes sense for you as a group – the final map should illustrate the way your group views leadership (the final map should represent the group as a whole). *Second*, after you decided on the way the concepts are to be organized, glue them on paper and draw the connections among the concepts. *Finally*, it is very important to label the connections among concepts, and specify the nature of the relationship they represent. Write a short statement illustrative for the type of connection that exists between the connected concepts.

Two coders (blind to the experimental condition for each group) independently coded the cognitive maps. Due to the subjective nature of the map diversity dimension (see below), the two coders jointly coded a number of five maps to mutually adjust their coding strategy for this particular dimension. The final GCC was the average of the cognitive complexity as found by the raters. GCC was computed on the basis of three aspects related to the configuration of the map. First of all, the number of concepts used in the map was counted. Then, following the seven types of linkages among concepts identified by Goméz *et al.* (2000) (causal, association, equivalence, topological, structural, chronological and hierarchical relations), the number of distinct connections drawn between the concepts was counted (map diversity). The final aspect of the cognitive map involves the total number of connections established between concepts (map connectivity). In line with Curşeu *et al.* (2010), we computed GCC using the following formula: map complexity = (connectivity × diversity)/ number of concepts. The larger the number of distinct relations and connections established relative to the number of concepts, the higher the map complexity.

Time efficiency was measured as the total number of minutes spent by the group to construct the cognitive map. Workshop teachers recorded the amount of time used as soon as a group finished the cognitive map. We further on computed a score of *knowledge integration efficiency* by dividing the GCC by the number of minutes spent on the task. This score reflects how efficient the groups were in integrating the task-relevant knowledge.

Results

The intraclass correlation (ICC) is a measure of interrater agreement and it corrects for agreement by chance (MacLennan, 1993). An inter-reliability analysis to determine the level of consistency among the two raters for GCC (see for details Shrout and Fleiss, 1979) revealed an ICC of 0.88 ($p < 0.001$) for overall GCC. Looking at the three aspects making up map complexity, ICCs were 0.99 ($p < 0.001$), 0.70 ($p < 0.001$) and 0.95 ($p < 0.001$) for number of concepts, map diversity and map connectivity, respectively.

Table III includes the descriptive statistics and the correlational matrix for all variables included in Study 2.

A stepwise OLS regression analysis was performed to test for the effect of EIS on GCC, as well as to test its interplay with the indicators of absorptive capacity (group mean of midterm scores and gender diversity), the results of which are shown in Table IV. We decided to control for group size, as it is likely to affect group processes and outcomes (Hoegl, 2005), and the minutes spent on the map, as we hypothesized a trade-off between time spent on the map and cognitive map complexity. All independent variables were grand-mean centered to reduce multicollinearity issues (Aiken and West, 1991). Variance inflation factor (VIF) scores were all below 1.6, indicating that multicollinearity is not a problem in the subsequent analyses. The results revealed significant main effects of EIS ($\beta = 0.41$; $p = 0.001$) and group mean midterm ($\beta = 0.30$; $p = 0.006$), replicating the results of the field study. The model including the two-way interactions, namely External Information Search x group mean midterm (EIS × GMMT) and External Information Search x Gender Diversity (EIS × GD), was entered in Step 2.

The results of the final model first of all indicated that none of the effects of control variables reached significance. We found strong support for *H1*, as EIS (experimental manipulation) increased a group's cognitive complexity ($\beta = 0.45$; $p < 0.001$). This finding was confirmed by an independent samples *t*-test that compared the means of GCC in the experimental versus control condition; the experimental groups had a mean of 2.84 compared with 1.78 for the control groups ($p < 0.001$).

Table III. Means, standard deviations and correlations for Study 2

Variables	M	SD	1	2	3	4	5	6
1. Group size	4.12	1.05	1					
2. PKB	36.85	3.16	−0.19	1				
3. Gender diversity	0.45	0.28	0.25*	−0.06	1			
4. EIS (manipulation)	0.51	0.50	0.09	−0.10	−0.34**	1		
5. Minutes spent	51.66	9.42	0.09	0.00	−0.07	0.36**	1	
6. GCC	2.32	1.28	−0.16	0.29*	−0.23	0.42**	0.24*	1

Notes: PKB = prior knowledge base computed as group mean for the knowledge test, EIS = external information search, GCC = group cognitive complexity; *$p < 0.05$; **$p < 0.01$

Table IV. Results of the stepwise OLS regression for group cognitive complexity in Study 2

Step	Independent variables	Model 1	Model 2
1	Group size	−0.14 (0.14)	−0.17 (0.14)
	PKB	0.30** (0.05)	0.33** (0.05)
	Minutes spent	0.11 (0.02)	0.10 (0.02)
	Gender diversity (GD)	−0.04 (0.54)	0.05 (0.59)
	EIS (manipulation)	0.41** (0.32)	0.45** (0.32)
2	EIS × PKB		0.19 (0.09)
	EIS × GD		−0.10 (1.13)
	R^2	0.31	0.35
	Adjusted R^2	0.25	0.27
	F	5.37**	4.41**
	F change	5.37**	1.78

Notes: PKB = prior knowledge base computed as group mean for the knowledge test, EIS = external information search., GMMT = group mean of midterm. Standardized regression coefficients are shown with standard errors between parentheses. All variables (except for EIS, which is a dummy variable) are grand mean centered; $^{**}p < 0.01$

The results of the OLS regression indicated that the interaction effect between EIS and GM midterm did not reach significance (β = 0.19; p = 0.11), but the sign of the coefficient was consistent with *H2a* (and opposed to our finding in Study 1). To have a more comprehensive analysis of the extent to which the results of the experimental study fit the ones reported in the field study, we used the conditional process bootstrapping procedure described by Hayes (2008) and the results of the conditional effects of EIS depending on gender diversity and GMMT are presented in Table V. Contrary to Study 1, the results show that EIS had a positive effect on GCC for average to high levels of GMMT, whereas for low levels of GMMT, the effect of EIS on GCC was not significant. Thus, Study 2 supported *H2a* and showed that group absorptive capacity as indicated by groups' prior knowledge base fostered the positive effect of EIS on GCC. Similar to Study 1, no interaction effect was found between EIS and gender diversity (β = −0.10; p = 0.40).

H3, stating that EIS would reduce the time efficiency of groups, was tested by running two separate regression analyses. In one analysis, we regressed control variables (group size and GM midterm) as well as EIS on length of time that groups

Table V. Conditional effects of external information search on knowledge elaboration (Study 1) and GCC (Study 2) at different levels of gender diversity and prior knowledge base

Moderator		Study 1 Organizational field study		Study 2 Experimental study	
PKB	GD	Estimate (SE)	T (p)	Estimate (SE)	T (p)
Low	Low	0.37 (0.13)	2.89 (0.005)	1.07 (0.53)	1.99 (0.05)
Low	Average	0.40 (0.11)	3.73 (0.004)	0.77 (0.39)	1.95 (0.05)
Low	High	0.42 (0.11)	3.82 (0.003)	0.46 (0.47)	0.98 (0.32)
Average	Low	0.19 (0.08)	2.47 (0.01)	1.54 (0.46)	3.34 (0.001)
Average	Average	0.22 (0.06)	3.94 (0.002)	1.24 (0.30)	4.15 (< 0.001)
Average	High	0.24 (0.08)	3.11 (0.002)	0.93 (0.41)	2.28 (0.02)
High	Low	0.02 (0.09)	0.19 (0.85)	2.01 (0.55)	3.63 (< 0.001)
High	Average	0.04 (0.09)	0.46 (0.64)	1.70 (0.44)	3.86 (< 0.001)
High	High	0.06 (0.11)	0.57 (0.57)	1.40 (0.53)	2.62 (0.01)

Notes: PKB = prior knowledge base (evaluated as self-reported task-related knowledge in Study 1 and as group mean of knowledge test in Study 2), GD = gender diversity, GCC = group cognitive complexity spent on constructing the map. Because the dependent variable was a count variable, we took its natural logarithm to compensate for skewness (Allison, 1999). In the other analysis, we regressed the same set of variables on the cognitive complexity per minute (an indicator of knowledge integration efficiency). The results of the analyses are shown in Table VI.

We found a significant positive effect of EIS on minutes spent on the task ($\beta = 0.39$; $p = 0.004$), lending support for *H3*. Yet, even though manipulated groups (engaging in EIS) took on average longer to construct their cognitive maps than control groups (55 versus 48 minutes, $p = 0.003$), they have higher knowledge integration efficiency ($\beta = 0.30$; $p = 0.02$) due to the stronger effect of EIS on GCC than on time efficiency. Groups that had on average a high midterm score were not significantly less time efficient ($\beta = 0.04$; $p = 0.74$), but they had higher cognitive complexity per minute ($\beta = 0.28$; $p = 0.02$), reflecting the main effect of prior knowledge base on GCC.

Discussion Study 2

Our experimental approach in Study 2 contributes to a systematic examination of the environment as a resource pool for groups and clarifies the causal link between EIS and GCC. We provide initial experimental evidence that EIS, as a boundary spanning activity, increases the complexity of groups' collective knowledge structures. As such, the results of the experimental study are aligned with the results of Study 1. Together, these studies provide empirical evidence supporting the cognitive benefits of engaging in EIS for GCC and knowledge elaboration in groups. Our results also show that average to high group absorptive capacity (as indicated by groups' prior knowledge base) is the most conducive for groups' capacity to assimilate incoming information from EIS efforts. Findings from Study 2 also show evidence that, although less efficient, groups that engage in EIS develop more complex knowledge structures per unit of time than groups that did not engage in EIS.

To further explore the intricacies of EIS and knowledge integration in groups, we have to address the attributes of the boundary spanner. In Study 2, we allowed multiple individuals to engage in EIS and it was not possible to fully understand the role played by the individual attributes of the boundary spanner in the knowledge transfer and knowledge integration processes in groups. To further clarify the workings of EIS, we designed another experimental study in which we manipulated the absorptive capacity (expertise) of the boundary spanner.

Table VI. OLS regression results for the efficiency of knowledge integration (minutes spent and GCC/minute) Study 2

Independent variables	Minutes spent	GCC per minute
Group size	0.04 (0.02)	−0.15 (0.00)
PKB	0.04 (0.01)	0.28* (0.00)
Gender diversity	0.07 (0.09)	−0.03 (0.01)
EIS (manipulation)	0.39** (0.05)	0.30* (0.01)
R^2	0.14	0.19
Adjusted R^2	0.08	0.14
F	2.41***	3.51*

Notes: PKB = prior knowledge base computed as group mean for the knowledge test. EIS = external information search. Standardized regression coefficients are shown with standard errors between parentheses; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{***}p < 0.10$

Study 3: the role of the boundary spanner

Theorizing on the information processing functions of boundary spanning activities, Aldrich and Herker (1977) argued that the boundary spanners are carriers of external information into the group, a process with two important steps:

(1) exposure to external information and the codification process through which the boundary spanner makes sense of the acquired information; and

(2) the communication process through which the codified information is entered into the group discussion.

We expect that the absorptive capacity of the boundary spanner is associated with the first process, whereas the similarity between the boundary spanner and the rest of the group influences the communication process.

When searching for relevant information outside the group, boundary spanners have to cope with substantial information overload and in order to simplify this incoming information, they codify it in a selective manner (Aldrich and Herker, 1977; Kouchaki *et al.*, 2012). Boundary spanners with high absorptive capacity are less likely to oversimplify the information they are exposed to and are more able to integrate it in their pre-existing mental models. Moreover, in terms of codification, the absorptive capacity of the boundary spanner plays an important role in the way in which the information is codified to serve the information needs of the group. Therefore, we expect that the absorptive capacity of the boundary spanner is beneficial for GCC:

H4. The absorptive capacity of the boundary spanner has a positive effect on group cognitive complexity.

As an indicator of the efficiency of the knowledge integration process, we intend to explore the GCC in relation to the time needed to perform the task. In Study 2, we found some indication of a trade-off between GCC and time efficiency, which was fully explained by the differential effect of EIS on GCC on the one hand and minutes spent on the task on the other hand. Groups engaging in EIS were less time-efficient in their map construction, yet their maps were more complex. With respect to the efficiency of knowledge integration, the effect of EIS on cognitive complexity was stronger than on minutes spent, and therefore groups engaging in EIS showed higher cognitive complexity per minute. Nevertheless, in Study 2, we could not further disentangle whether the attributes of the boundary spanner influenced the efficiency of knowledge integration.

The efficiency of the communication process through which the information is brought into the group and is integrated into the collective knowledge structure depends on the similarity between the boundary spanner and the rest of the group. If the boundary spanner is gender-similar to the rest of the group, it is likely that the overlap in gender-specific life experiences makes communication easier and as such the boundary spanner will be quickly able to convey the message to the other group members. In addition, the cognitive distance between the boundary spanner and the rest of the group is likely to create communication barriers (Meslec and Curşeu, 2013). Therefore, as cognitive distance increases, the efficiency of knowledge integration processes decreases. Thus, we expect that the gender similarity between the boundary spanner and the group will have a positive effect on the efficiency of knowledge integration, whereas the cognitive distance between the boundary spanner and the group will have a negative effect on the efficiency of knowledge integration. We therefore hypothesize that:

H5. The gender similarity between the boundary spanner and the group is positively associated with the efficiency of knowledge integration (group cognitive complexity per unit of time).

H6. The cognitive distance between the boundary spanner and the rest of the group is negatively associated the efficiency of knowledge integration (group cognitive complexity per unit of time).

As noted earlier, the results of Study 1 pointed toward a compensatory explanation of EIS in groups, showing that EIS is positively related to knowledge elaboration in groups with poor prior knowledge base, whereas Study 2 supported the hypothesized additive interplay between EIS and prior knowledge base. In addition to testing whether the absorptive capacity of the boundary spanner impacts on GCC, we intend to explore whether the absorptive capacity of the boundary spanner supports a compensatory argument or an additive effect between EIS and prior group knowledge base. If a compensation argument is valid, then sending out the most knowledgeable individuals will pay off more in homogeneous groups with poor knowledge bases rather than in heterogeneous groups with rich knowledge bases. If, however, the additive argument is valid, sending out as scout the most knowledgeable group member will be more beneficial in heterogeneous groups with rich prior knowledge bases. Although we do not formulate hypotheses, we aim to examine in this study whether a compensatory or additive effect is at play. Therefore in a similar fashion to Studies 1 and 2, we will test the interaction effect between EIS and the two dimensions of AC.

Method

A total of 172 students (83 women) organized in 37 groups enrolled in a course at a Dutch university participated in the study as part of their regular curricular activities. In one of the interactive lectures devoted to leadership, students were divided in groups and were asked to develop a cognitive map of leadership, similar to Study 2. The cognitive mapping procedure and coding of the maps were the same as in Study 2. All groups were first asked to work with the concepts for 30 min and then the lecturer appointed a boundary spanner based on individual scores obtained in the mid-term evaluation (we used a similar knowledge test as we did in Study 2). In 19 of the groups, we appointed as the boundary spanner the most knowledgeable group member (the one with the highest score on the midterm exam), whereas in 18 groups, we appointed as the boundary spanner the least knowledgeable group members (the one with the lowest score on the midterm exam).

All groups engaged in EIS but we manipulated the IAC of the boundary spanner. The two dimensions of absorptive capacity (gender diversity and prior knowledge base) and GCC were evaluated in a similar fashion to Study 2. Moreover, to test *H4, H5* and *H6* and because we had a boundary spanner in both experimental conditions, we computed similarity measures on the two dimensions of absorptive capacity (prior knowledge base and gender diversity) between the boundary spanner and his/her group.

Gender similarity was computed using a disaggregation procedure based on the Euclidian distance between gender-based subgroups (Chattopadhyay, 1999; Tsui *et al.*, 1992;). The formula is: $Div = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(s_i - s_j)^2}$, where, $(s_i - s_j)^2$ is the summed squared differences between an individual's s_i value on a specific demographic variable and the value of the same variable for every other group member s_j, and n is the number of group members. For gender, we have two subgroups and, as such, each man will get the same score as the other men in the group and similarly each woman in the group will get the same score as the other women in the group. The disaggregated score for the boundary spanner reflects how similar he/she is, gender wise, with the generic gender composition of his/her group.

Cognitive distance between the group and the boundary spanner was computed using the Mahalanobis distance between the mid-term score of the boundary spanner and the average mid-term score of the remaining group members (we regressed the midterm exam score of the group on the midterm exam score of the boundary spanner). The Mahalanobis distance reflects the remoteness of a particular data point from the average of the remaining points in a distribution (thus is typically used to detect outliers). By considering the group mid-term score as the distribution, the Mahalanobis distance is an accurate proxy of cognitive distance and a high Mahalanobis distance score reflects a substantial expertise difference between the boundary spanner and his/her group.

Results and discussion

Means, standard deviations and correlations between the variables included in this study are presented in Table VII.

The results of the OLS regression analyses used to test *H4* are presented in Table VIII and the conditional effects of the manipulation (IAC of the boundary spanner) on GCC depending on the two dimensions of group absorptive capacity are presented in Table IX.

The main effect of IAC on GCC was positive and significant ($\beta = 0.40$; $p = 0.02$) and we can conclude that *H4* was fully supported. Groups that sent out as a boundary spanner the most knowledgeable group member developed in general more complex knowledge structures than groups that sent out as a boundary spanner the least knowledge group member. Although the two-way interaction terms were not significant, the inspection of the conditional effects of our manipulation on GCC depending on gender diversity and groups' prior knowledge base showed that the IAC manipulation had a positive effect on GCC under low-low, low-average and average-average combinations of the two dimensions of groups' absorptive capacity. Therefore, we conclude that the interplay between the IAC of the boundary spanner and the two dimensions of absorptive capacity is compensatory in nature.

To test *H5* and *H6*, we ran an OLS regression with group size, the gender of the boundary spanner, experimental manipulation, average group score for the midterm, gender similarity between the boundary spanner and the rest of the group, as well as the cognitive distance between the boundary spanner and the rest of the group as predictors of knowledge integration efficiency (GCC/minute) as dependent variable. The results of this analysis are presented in Table X.

As shown in Table X, *H6* received full support because the effect of cognitive distance on knowledge integration efficiency was negative and significant ($\beta = -0.32$; $p = 0.04$). *H5*, however, was not supported because the effect of gender similarity on knowledge

Table VII. Means, standard deviations and correlations for the variables included in Study 3

Variables	M	SD	1	2	3	4	5
1.Group size	4.64	1.13	1				
2. Gender diversity	0.55	0.20	0.26	1			
3. PKB	39.34	3.05	0.10	0.02	1		
4. Minutes spent	51.72	9.06	0.27	0.15	0.07	1	
5. GCC	2.00	1.38	−0.16	−0.08	−0.02	0.22	1

Notes: PKB = prior knowledge base computed as group mean for the knowledge test. GCC = group cognitive complexity

Step	Independent variables	Model 1	Model 2
1	Group size	−0.10 (0.21)	−0.08 (0.21)
	IAC manipulation	0.40 (0.45)*	0.40 (0.45)*
	PKB	−0.08 (0.07)	0.09 (0.11)
	Gender diversity (GD)	−0.14 (1.08)	0.00 (1.49)
	Minutes spent	0.29 (1.26)	0.26 (1.27)
2	IAC × GMMT		−0.24 (0.15)
	IAC × GD		−0.22 (2.13)
	R^2	0.26	0.31
	Adjusted R^2	0.15	0.14
	F	2.22***	1.86
	F change	2.22***	0.98

Notes: PKB = prior knowledge base computed as group mean for the knowledge test. IAC = individual absorptive capacity of the boundary spanner. Standardized regression coefficients are shown with standard errors between parentheses. All variables (except for IAC, which is a dummy variable) are grand mean centered; * $p < 0.05$

Table VIII. Results of the stepwise OLS regression for group cognitive complexity in Study 3

Moderator		IAC effect on GCC	
PKB	GD	Estimate (SE)	T (p)
Low	Low	1.96 (0.77)	2.54 (0.02)
Low	Average	1.54 (0.62)	2.47 (0.02)
Low	High	1.11 (0.76)	1.47 (0.15)
Average	Low	1.53 (0.65)	2.33 (0.03)
Average	Average	1.10 (0.45)	2.47 (0.02)
Average	High	0.68 (0.60)	1.12 (0.27)
High	Low	1.09 (0.81)	1.34 (0.19)
High	Average	0.67 (0.64)	1.04 (0.30)
High	High	0.25 (0.75)	0.33 (0.74)

Notes: PKB = prior knowledge base computed as group mean for the knowledge test, GD = group diversity, IAC = individual absorptive capacity of the boundary spanner, GCC = group cognitive complexity

Table IX. Conditional effects of the individual absorptive capacity of the boundary spanner on GCC at different levels of gender diversity and prior knowledge base

integration efficiency was positive as hypothesized yet not statistically significant (β = 0.15; p = 0.41). We conclude that groups in which the boundary spanner is relatively similar to other group members in terms of knowledge and expertise (low cognitive distance) create more complex cognitive structures per unit of time.

General discussion

We have built on several frameworks that theorized on the interplay between groups' internal and external environments to argue that knowledge elaboration and GCC as indicators of group integrative complexity are influenced by the EIS and absorptive capacity of groups. In line with Kouchaki *et al.* (2012), we argue that individual group members are knowledge carriers and groups are information processing units (Hinsz *et al.*, 1997) in which individual knowledge is evaluated and integrated to generate more complex group-level knowledge structures (Curşeu *et al.*, 2007; Curşeu *et al.*, 2010). The group environment has most often been described as a resource pool (Kouchaki *et al.*, 2012), yet there has been no

Table X.
OLS regression results for efficiency of knowledge integration (GCC/minute) in Study 3

Independent variables	GCC per minute
Group size	−0.05 (0.04)
Gender BS	0.32* (0.01)
PKB	−0.07 (0.00)
Gender diversity	−0.09 (0.02)
IAC (manipulation)	0.35* (0.01)
Gender similarity BS	0.15 (0.04)
Cognitive distance	−0.32* (0.00)
R^2	0.41
Adjusted R^2	0.27
F	2.90*

Notes: BS = boundary spanner, PKB = prior knowledge base computed as group mean for the knowledge test, IAC = individual absorptive capacity of the boundary spanner, GCC = group cognitive complexity, Gender BS – gender of the boundary spanner coded as a dummy: 0 = man and 1 = woman. Standardized regression coefficients are shown with standard errors between parentheses; $*p < 0.05$

systematic approach to directly test the impact of EIS on group knowledge elaboration and the emergence of collective cognitive structures. Unlike previous research (Gibson and Dibble, 2013; Haas, 2006), we did not find contingencies under which EIS has negative effects on GCC or knowledge elaboration. All three studies pointed toward a positive main effect of EIS on knowledge elaboration and GCC. The strength of this positive effect, however, varied as a function of the prior knowledge base of the group.

A key contribution of our paper to the boundary spanning literature is the examination of the interplay between EIS and group absorptive capacity, as well as between IAC and group absorptive capacity. Our field study showed that EIS mostly benefitted groups that had low to average absorptive capacity. Furthermore, the last experimental study indicated that groups engaging in EIS benefitted from a boundary spanner with high absorptive capacity especially when the absorptive capacity of the group was low. Overall, our findings suggest that the role of absorptive capacity in groups that engage in EIS may be compensatory in nature, rather than additive as previous research has argued.

The hypotheses about gender diversity as a dimension of knowledge differentiation and thus of absorptive capacity did not receive support in any of our studies. Gender diversity did not moderate the extent to which EIS influenced knowledge elaboration and GCC. In other words, the only contingency for the effect of EIS on the complexity of collective knowledge structures was group prior knowledge base. Because we expected gender diversity to foster the positive effect of EIS on GCC and knowledge elaboration, we put forward two explanations for this unexpected finding. First, groups that are gender heterogeneous as well as knowledgeable have a variety of information and perspectives available within the group and are therefore likely to encounter information redundancy and reduced novelty when communicating to outside group members (Curşeu *et al.*, 2007). In other words, there can be a ceiling effect or saturation point in such a way that groups benefit from a diverse set of resources up to only a certain point. Second, the knowledge and information provided by other groups (in addition to the richness and depth of information among group members stemming from gender diversity and high expertise) may result in an information and attention overload for group members in such a way that external network ties block creativity and negatively affect group performance (Kratzer *et al.*, 2008). Future research could further explore the interplay of redundancy and overload in the role of absorptive capacity. Moreover, implicit coordination and cross-attuning to each other's actions (De Jong and Fodor, 2017) as well as the status of the boundary spanner (Han, 2018) could be factors that affect the integration of external information into group cognition.

Our paper also contributes to the group cognition literature by identifying antecedents of emergent group cognition. Previous studies have found that GCC is the result of individual members' cognitive complexity and group interactions (Curşeu *et al.*, 2007; Curşeu *et al.*, 2010). This paper first of all confirms the notion that group members' knowledge matters, as indicated by the positive effect of task-related knowledge (average midterm exam score) in our groups. With regard to the role of group interactions, previous studies have focused on within-group interaction, i.e. teamwork quality (Curşeu and Pluut, 2013). This study adds to these insights, as the highly significant effect of EIS indicates that interactions with outside groups also drive GCC in addition to interactions within the group.

To the best of our knowledge, this paper is among the first to explicitly consider the attributes of the boundary spanners in relation to EIS outcomes. Our results showed that it paid off to use as a boundary spanner expert members rather than members with limited task-related expertise. Yet, the added value of knowledgeable members as carriers of external knowledge was limited in groups that had high absorptive capacity (as indicated by prior knowledge base and gender diversity). Another important result refers to the cognitive distance between the boundary spanner and the rest of the group, pointing to the relevance of considering the attributes of the boundary spanner in relation to the rest of the group. These results also call for more research on the multilevel interaction between individual and group strategic human capital (Ployhart *et al.*, 2014; Wright *et al.*, 2014). To conclude, the personal knowledge of the boundary spanner, as well as cognitive similarity with the rest of the group, are important antecedents of knowledge differentiation and integration in groups.

Limitations

This paper has some limitations related to the sample and measurements. Our experimental studies used student groups, limiting the generalizability of the findings. Nevertheless, experimental research is more difficult to conduct in general organizational settings because it attempts to directly manipulate variables to clarify causal claims and as such it has to simplify the complex nature of EIS (Kouchaki *et al.*, 2012). In our experimental studies, boundary spanners collected information from groups involved in similar tasks, whereas in more general R&D settings, cross-fertilization may occur among apparently unrelated domains and new task-relevant knowledge can be created through analogy (Rosenkopf and Nerkar, 2001). Future research should use either field experiments or longitudinal data to replicate the results reported here in other contexts.

The manipulation of EIS is another limitation of this research, as it captured only the presence (yes/no) of EIS or who played the boundary spanning role. Future research should use a more elaborate measure of EIS, capturing the activity's intensity (duration and depth) and frequency (number of times each group is approached). Such an operationalization will provide more specific insights into the relationship between EIS and group outcomes. Furthermore, external tie strength should be considered because it is likely to influence the effectiveness of both the search for novel information and the transfer of complex information (Hansen, 1999; Han, 2018).

Finally, our study did not explicitly address the processes through which groups worked with and made use of the information resulting from EIS. Although we allowed the role of boundary spanner to be shared among group members (in Study 2) and we manipulated the expertise of the boundary spanner (Study 3), we did not measure the extent to which information was shared and as such could not assess how this influenced the group debate. A future direction for research is therefore to explore the extent to which external information is shared and used in the group. Moreover, as groups are likely to differ in terms of knowledge structures, as well as their procedures and capabilities of working with knowledge, future research could explore differences (in terms of processes) in the way groups with low versus high absorptive capacity use new information collected through boundary spanning activities.

Practical implications

This study has valuable implications for teams involved in innovative projects. The horizontal knowledge transfer associated with EIS efforts increases the complexity of collective knowledge structures and potentially increases the creative potential of groups. The organizational environment and more specifically (line) managers can stimulate and facilitate such interactions between groups, by for instance developing and assigning boundary spanning roles (Tushman, 1977). Yet, the findings of our studies point to some of the complexities involved when attempting to foster the development of team cognition and creativity. Managers first of all need to consider the critical importance of groups' absorptive capacity and its antecedents. Our findings suggest that domain-specific knowledge of group members is an important dimension of absorptive capacity that helps the group in making better use of incoming information. Although in this particular sample, EIS did never impair GCC; this possibility should not be disregarded in other contexts. For example, when teams have to perform highly complex tasks and are presented with complex and difficult to understand information from other groups, absorptive capacity is likely to be a necessary condition for developing accurate task related insights. Without this capacity, EIS (or boundary spanning in general) can even be undesirable.

Furthermore, our findings point to the importance of selecting a knowledgeable group member as the boundary spanner, especially in groups that do not have high absorptive capacity. High levels of IAC of boundary spanners compensate for a group's limited internal resources or combinatorial capabilities. Finally, when deciding to simulate interactions between groups, managers should be aware of the implications for time efficiency. In our sample, the positive effect of EIS on GCC was stronger than the negative effect on efficiency, yet this is likely to depend on the type of task or context. Not only do the competitive environments of today require that creative outcomes go hand in hand with rapidly changing work processes, but also the occurrence of certain events can lead to a shift in dominance from creativity goals to efficiency goals (Drazin *et al.*, 1999). It is therefore of high relevance for managers to consider the trade-off between creativity and efficiency as a result of engaging in EIS, and to determine what is required more in a specific situation.

Conclusions

This paper provides an integrative, multi-study investigation of the effect of EIS on knowledge elaboration and GCC under the moderating effect of absorptive capacity (operationalized as prior knowledge base and diversity). Across the three studies, we systematically show that EIS is conducive for group integrative complexity (evaluated as group knowledge elaboration in Study 1 and as GCC in Study 2). Although we hypothesized that two dimensions of absorptive capacity (prior knowledge and gender diversity) will moderate the impact of EIS, this moderation claim was not supported. We have identified a pattern of results that supports the compensatory interplay between EIS and absorptive capacity. In the second study, we show that EIS increases the time spent on the task as well as the efficiency of knowledge integration (GCC realized per unit of time). In the last experimental study, we show that the absorptive capacity of the boundary spanner compensates for the lack of absorptive capacity of the group. Moreover, we show that a substantial expertise difference between the boundary spanner and the rest of the group has a negative influence on the efficiency of group knowledge integration.

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