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How the Organizational Design of R&D Units Affects Individual Search Intensity – A Network Study

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Abstract

This study investigates how intraorganizational search behavior of R&D professionals is shaped by the organizational design for task collaboration between R&D units. More precisely, we examine how formally prescribed R&D unit task collaboration and the distinct roles of R&D units as recipients and sources in such collaboration affect how intensively unit members search for advice and knowledge. To this end, we integrate theoretical mechanisms from knowledge search and organizational design literatures into models explaining the emergence of work-related advice networks among employees in corporate R&D.

Empirically, we capture the influence of unit-level task collaboration on individual-level search by applying exponential random graph modelling to multilevel network data collected on 193 employees belonging to 38 R&D units in a leading German high-tech firm. Results show that the extent to which R&D units function as recipients in unit task collaboration on the one hand and as sources on the other influences unit members' search intensity in opposite ways. Members of units functioning as recipients for many other units search less intensively, i.e., there is a substitution effect. Conversely, if R&D units are sources for many other units, their members search more intensively. The latter complementarity effect is weaker for R&D units that are specialized on a particular product component.

Keywords: individual search, organizational design, R&D unit task collaboration, network, corporate R&D, component specialization

1. Introduction

“It is not just about transferring a single piece of information in oral or written form. It is about larger relationships and we tried to describe these relationships. You can imagine, of course, that there are no standard cases in creative work, but nevertheless certain R&D activities and the chain of successive steps are often similar, even if the content may differ. [...] For many years, we have tried to include meta-level knowledge and advice as well, so that the employees not only exchange the results of their work but also include know-how on the way they work. We are still at a level that we do not feel is sufficient.”

Head of R&D for a leading German high-tech firm describing the rationale behind the organizational design for R&D unit task collaboration and its shortcomings

Firms often struggle with organizing their R&D departments (e.g., Criscuolo et al., 2014). As described in the opening quote, many structures and systems for internal knowledge flows are ambitious and well-intended but ultimately fail to have the envisioned consequences for R&D professionals’ behavior (Gambardella et al., 2020), such as their search for knowledge from colleagues (Argyres et al., 2020). Therefore, a theoretical perspective is required that clarifies the relationship between organizational design choices and individual search behavior in corporate R&D.

While search has predominantly been studied in terms of unit or firm-level practices (e.g., Grimpe and Sofka, 2009, 2016; Posen et al., 2018), searching for knowledge is an inherently human task carried out by individual scientists and engineers (e.g., Dahlander et al., 2016; MacAulay et al., 2020; Maggitti et al., 2013). Recent research suggests that the knowledge search of individuals does not simply aggregate or replicate organizationally-designed practices (Argyres et al., 2020; Dahlander et al., 2016), such as R&D unit task collaboration (Sosa et al., 2004), and that such practices may even adversely affect the search behavior of individuals (Salter et al., 2014). This makes it salient to develop a systematic understanding of the mechanisms by which the organizational design of corporate R&D shapes individual employees’ search.

Within the broad field of organizational design choices, we draw attention to R&D unit task collaboration, i.e., intentionally designed roles of R&D units that prescribe and

structure inter-unit knowledge flows (Sosa et al., 2004) often times depicted in a flow chart. These roles determine the extent to which R&D units function as recipients of knowledge in unit task collaboration on the one hand and as sources of knowledge for other R&D units on the other. Integrating organizational design literature (e.g., Puranam et al., 2012; Raveendran et al., 2020) with theoretical mechanisms from research on the costs, benefits, and risks of individual knowledge search (e.g., Katila and Ahuja, 2002; Koput, 1997), we predict the emergence of interpersonal networks in search for work-related advice (e.g., Durmuşoğlu, 2013; Tortoriello, 2015).

Research on individual search often assumes that R&D professionals make autonomous and purposive decisions about their search behavior, purely based on individual cost-benefit considerations (e.g., Huber, 1991; Kneeland et al., 2020; Nerkar and Paruchuri, 2005). We refine this strong assumption about the agency of R&D professionals displaying free choice and actions (Emirbayer and Mische, 1998). Building on recent literature (Argyres et al., 2020), we reason that the organizational design for R&D unit task collaboration affects the costs, benefits, and risks that R&D professionals associate with individual search. Thus, organizational design and unit members' autonomy jointly shape how intensively R&D professionals search for advice from their colleagues. We predict that they exhibit lower search intensities when they work for units that the organizational design designates as recipients of knowledge from many other units and, conversely, higher search intensities when they work for R&D units serving as knowledge sources for many other units within the organizational design. To capture the complexity of individual search, we further hypothesize that R&D unit component specialization moderates the relationship between organizationally-designed task collaboration and individual search.

We test our hypotheses using survey data collected on 193 employees nested in 38 units in the R&D department of a leading German high-tech firm. We capture individual

search by examining dyadic advice relationships between the R&D employees. At the unit-level, we describe task collaboration following the organizational design between the units in which the employees are nested, similar to a flow chart or network of R&D activities. In essence, we model an intraorganizational network that spans two levels of the organization, individual and R&D unit. We build on recent developments in the analysis of so-called “multilevel networks” (Zappa and Lomi, 2015) and link unit-level task collaboration ties to individual-level search ties based on the nested structuring of organizations and apply exponential random graph modeling (ERGM) for multilevel networks (Wang et al., 2013). An important advantage of this relational approach over studies that have counted knowledge sources (Laursen and Salter, 2006) or patent technology classes (Katila and Ahuja, 2002) for capturing search is that search patterns in our study are not assumed to emerge independently at individual or organizational levels. Moreover, we are able to account for R&D unit roles and tasks such as units’ designation by design choices as recipients or as sources of knowledge and their component specialization, which have important implications for the mechanisms by which the organizational design influences individual search.

In line with our predictions, we find both substitutive relationships as well as complementary relationships between organizationally-designed R&D unit task collaboration and individual search. These findings contribute to academic research in multiple ways. First, the efficiency and effectiveness with which researchers and scientists in corporate R&D discover new knowledge and create innovations is arguably a core theme of innovation research (e.g., Argyres et al., 2020; Katila and Ahuja, 2002). However, extant research relies on strong assumptions about the agency and autonomy that these individuals have for determining the parameters of their search. We present a comparatively more realistic model for how intraorganizational search of R&D professionals unfolds, i.e., from the interplay between the considerations of individuals and organizational design choices. In doing so, we

add to recent efforts of creating a “better understanding of the limits of “self-organizing” processes” behind individual search (Clement and Puranam, 2018: 3880).

Our insights also underscore the importance of an integrated theoretical understanding that moves beyond treating the organizational design as a simple control variable in empirical models that explain R&D professionals’ behavior (McEvily et al., 2014) and contributes to a nascent literature on the influence of organizational design choices on knowledge search and work in corporate R&D (e.g., Argyres et al., 2020; Clement and Puranam, 2018; Gambardella et al., 2020; Raveendran et al., 2020). We focus on R&D unit task collaboration as a particular dimension of organizational design and distinguish between the roles of units in task collaboration as knowledge sources and recipients. Thus, we account for so far often neglected directionality of task collaboration as recently called for by Raveendran et al. (2020). Compared to budget allocations that have been used in other recent studies (Argyres et al., 2020), our perspective offers a much more fine-grained representation of organizational design enabling us to uncover design choices that are complementary or substitutive to the individual search behavior of R&D professionals.

Our research suggests that studies focusing exclusively on a single level of analysis for capturing intraorganizational search and knowledge flows as well as studies relating organizational designs of corporate R&D directly to innovation performance may suffer from biased results if cross-level interactions with individual search behaviors are not incorporated. Put differently, the performance opportunities from adjusting either individual-level search or unit-level task collaboration in isolation are likely overestimated. As a way to overcoming this bias, we offer a theoretical platform for future studies exploring cross-level effects for other search patterns within the R&D organization or involving external sources. Our findings are practically meaningful for managers putting in place distinct organizational designs in order to strengthen knowledge flows among R&D units and professionals.

2. Theory and Hypotheses

The goal of our theorizing is to explain systematic differences in R&D professionals' search for work-related advice from their colleagues caused by organizational design choices. Drawing on previous research, we start out by conceptualizing individual search and organizational design for corporate R&D units as key building blocks of our study. Subsequently, we develop hypotheses that refine the assumption of previous studies that R&D professionals make autonomous decisions about their search within an organization. We focus on organizational design choices specifying R&D units as knowledge recipients and/or sources. Within our reasoning, these designs for task collaboration between R&D units (e.g., Sosa et al., 2004), will critically affect individual search. Moreover, we account for moderating effects from whether or not units are specialized on a particular product component. Figure 1 summarizes our conceptual framework.

--- Insert Figure 1 about here ---

2.1. *Individual search*

Search is a fundamental concept to behavioral theories of the firm (Cyert and March, 1963) and the literature on organizational learning (e.g., Huber, 1991) and has been linked to various performance outcomes, most notably to innovation (Katila, 2002). Innovation research has widely used the concept of search across different levels of the organization, referring for instance to firms searching for solutions across industry or technological boundaries (e.g., Nelson and Winter, 1982; Rosenkopf and Almeida, 2003), organizational units, such as divisions or project teams, transferring knowledge and best-practices (e.g., Hansen, 1999; Szulanski, 1996), or individuals engaging in various forms of search behaviors (e.g., Dahlander et al., 2016; Kneeland et al., 2020; Paruchuri and Awate, 2017). In this study, we focus on individual search. Moreover, while many studies have investigated knowledge search across the boundaries of the organization (for a recent review, see Posen et

al., 2018), we follow nascent efforts (MacAulay et al., 2020; Paruchuri and Awate, 2017) and focus on intraorganizational search. In particular, we seek to explain the individual search intensity of R&D professionals searching for work-related advice by creating network ties with colleagues who work in the same R&D organization.

This conceptualization of individual search is in line with what Huber (1991) has termed “focused search”, which he distinguishes from scanning and performance monitoring as other forms of search. While scanning and performance monitoring are depicted as ongoing routines, focused search is triggered by a specific topic or problem and based on cost-benefit considerations. It can be reactive or proactive. Searching via advice networks is one of multiple forms of individual search behavior, next to, for instance, searching from databases (Haas and Hansen, 2007). However, individuals prefer sourcing knowledge and information from other individuals as compared to non-human repositories (Allen, 1977). Accordingly, work-related advice networks are commonly deemed critical means through which search occurs within organizations (e.g., Brennecke and Rank, 2017; Clement and Puranam, 2018; Lomi et al., 2014; Nebus, 2006).

Search for advice it is typically considered to be more comprehensive than looking for simple information or answers to a question (Hansen, 1999; Lomi et al., 2014). Specifically, when searching for work-related advice, individuals may be looking for actual solutions to a problem, but also validation or legitimation, as well as problem reformulation and meta-knowledge and referrals pointing to the location of relevant information (Cross et al., 2001; Cross and Sproull, 2004). This form of search is dominant in innovation-intensive settings, in which employees work on complex research tasks but seldom possess all the knowledge they need to approach these tasks on their own. In these settings, employees are encouraged and expected to engage in individual search to innovate (e.g., Allen et al., 2007; Allen, 1977). The

parameters of their search behavior are typically not specified but left to the R&D professionals' discretion and autonomy (Argyres et al., 2020; Bailyn, 1985).

While individual search can be described along multiple dimensions, a particularly important search behavior in corporate R&D is intensive search (e.g., Durmuşoğlu, 2013; Li et al., 2013). Search intensity is the overall effort invested in search activities (Posen et al., 2018), which we conceptualize as number of colleagues from whom R&D professionals search work-related advice. Searching for advice from many colleagues reflects high search intensity, implying timely access to many knowledge sources, and has been shown to benefit innovative performance (Katila and Ahuja, 2002; Lai et al., 2016; Laursen and Salter, 2006). At the same time, high search intensity is costly. The more effort individuals invest to access many sources, the more time and attention they have to dedicate (Li et al., 2013), for instance to screen many potential knowledge sources (Koput, 1997) as well as to transform knowledge before it can usefully be applied (Todorova and Durisin, 2007).

Focusing on the intensity of R&D professionals' search for advice allows us to isolate the form of search instigated by individuals instead of mandated by organizations, for instance as part of organization charts (Cross and Sproull, 2004) or joint work on patents (Paruchuri and Awate, 2017). That is, individuals are assumed to have agency over their search intensity (Argyres et al., 2020; Borgatti and Cross, 2003; Nerkar and Paruchuri, 2005). They autonomously search for work-related advice from colleagues in a proactive and purposive manner, deciding to engage in search only when the anticipated benefits outweigh the search costs (Borgatti and Cross, 2003; Huber, 1991; Nebus, 2006). In this study, we demonstrate that – in addition to individual agency – the organizational design for R&D unit task collaboration plays an important role for R&D professionals' search behavior. Design choices influence the costs, benefits, and risks of search, thereby, propelling or curtailing individual search intensity in distinct ways.

2.2. *Organizational design for R&D unit task collaboration*

Firms devise organizational designs to move information processing and research tasks from individual employees with bounded rationality towards efficient and effective systems of coordinated activities (Puranam et al., 2012). An important aspect of the organizational design is the division of the overall goals of organizations, for instance the creation of new products in corporate R&D, into tasks and allocating them to individuals or groups (Puranam et al., 2014). Accordingly, R&D activities of firms are typically formally structured around employees nested in separate work groups or teams, engaged in specified research tasks (Madhavan and Grover, 1998; Tushman and Scanlan, 1981). We will refer to these groupings of R&D employees with dedicated R&D tasks and roles as R&D units. Units' purpose is to lessen coordination and search efforts, serve as repositories of specialized knowledge, and facilitate localized learning (e.g., Allen, 1977, March and Simon, 1958, Thompson, 1967). At the same time, the complexity of contemporary R&D increasingly requires inter-unit task collaboration to bring together specialized knowledge from different domains (e.g., Sosa et al., 2004; 2015).

We define R&D unit task collaboration as organizationally-designed roles of R&D units with some necessary knowledge flow. The knowledge that is transferred may be embodied in product components (e.g., software codes or technical parts) or consist of documented product- or technology-related technical knowledge (Hansen, 1999). Being more codified in nature and not comprising experiential or meta-knowledge (see the opening quote), this knowledge differs from the knowledge that R&D professionals access via individual search for work-related advice. Inter-unit task collaboration represents practices intentionally designed by management to structure interdependent work processes in corporate R&D. For instance, Sosa et al. (2004) describe design interfaces between

components prescribed by the product architecture of a firm as primary source of unit interdependence in complex engineering.

The entirety of all organizationally-designed R&D unit task collaborations resembles a flow chart that can also be understood as a network. In this network, units pass on internally-produced knowledge to designated other units, in which case the unit takes a role as a source for these other units. At the same time, they acquire the knowledge that they need to perform their tasks from specified other units, thus functioning as a recipient for the others units. Thereby, R&D units coordinate interdependent actions (Cyert and March, 1963; Galbraith, 1973). We reason that R&D units' roles as sources and recipients, as designated by the organizational design, shapes unit members' search intensity. As termed by Maggitti et al. (2013), the organizational design provides the context in which individual search unfolds.

To capture the cross-level influence of unit-level task collaboration on individual-level search, we follow the relational multilevel approach described by Zappa and Lomi (2015). We link the network of organizationally-designed R&D unit task collaboration to individual-level search intensity based on the nested structuring of organizations (March and Simon, 1958; Simon, 1996): R&D professional are hierarchically nested in units by means of unit membership. We distinguish whether (a) units function as recipients within a specific task collaboration or (b) as sources, thus accounting for the directionality of R&D unit task collaboration (Raveendran et al., 2020). Figure 2 illustrates the relational multilevel approach for the influence of organizationally-designed task collaboration on R&D professionals' search intensity that will be the core of our theorizing and hypotheses.

--- Insert Figure 2 about here ---

2.3. *Individual search intensity depending on R&D units' role as recipients*

In this section, we consider R&D units' role as recipients in organizationally-designed task collaboration for the individual search intensity of their members. Depending on design

choices, some units may hardly be involved in task collaboration with other units as recipients, while others may acquire task outcomes of a large number of other R&D units for further processing or integration (Sosa et al., 2004). We reason that for the employees in recipient units that receive knowledge from many other units the cost-benefit considerations underlying individual search are systematically different from the average R&D professional. Put differently, we predict a negative influence of the extent to which R&D units function as recipients in task collaborations on the individual search intensity of their members.

We ground this expectation in professionals' benefits and corresponding costs for engaging in individual search (e.g., Borgatti and Cross, 2003; Koput, 1997; Li et al., 2013). Working for R&D units designated as recipients of knowledge from many other units should reduce the incentives of individuals to search for additional knowledge in the form of work-related advice. The tasks allocated by the organizational design afford the R&D unit and by extension its members with plenty of contact with external knowledge and, thus, opportunities to learn (Huber, 1991; Szulanski, 1996). Hence, the marginal benefits of additionally engaging in intensive individual search are limited. This argument implies a substitution effect of knowledge inflows across levels: Unit-level knowledge inflow through R&D task collaboration reduces the added value that unit members associate with individual search, leading them to search less intensively.

In addition, receiving unit-level knowledge inflows from a large number of other units is costly for R&D professionals in the recipient unit. It consumes time and effort (Li et al., 2013). The need to screen, transform, and assimilate large amounts of external knowledge prescribed by the organizational design can in this case be seen as a distraction, leading to prioritization of central tasks rather than proactive behavior (Baron, 1986; Sherf et al., 2019), such as individual search. Accordingly, R&D units' role as recipients of knowledge from many other units as prescribed by the organizational design not only reduces the benefits of

intensive individual search for their members but can also increase the costs for engaging in it. We hypothesize:

H1: The more a unit is involved in organizationally-designed R&D task collaboration as a recipient, the less intensive the unit's members search for advice.

2.4. Individual search intensity depending on R&D units' role as sources

In the second case, the organizational design for R&D unit task collaboration prescribes the extent to which a unit functions as a source, producing knowledge and passing it on for further processing to other R&D units in the organization (Sosa et al., 2004). Again, there should be variation as some units function as sources for many other units, while others do not. In many organizational designs, basic research or software development are typical examples for R&D units heavily involved in source activities, producing knowledge needed by many other R&D units in the organization (Tushman and Scanlan, 1981). Similar to the above, we argue that the extent to which R&D units function as sources for other units affects unit members' cost-benefit considerations (Borgatti and Cross, 2003) with regard to individual search. However, contrary to the above, we suggest that working for a source unit that produces knowledge for many other units creates the necessity for its members to engage in more intensive individual search.

In particular, R&D employees of units delivering knowledge to many different recipient units are never able to focus their attention strictly on their individual research tasks, that is, the research and development activities that an R&D professional is supposed to perform for the unit, such as conducting experiments or coding an algorithm. Instead, they need to account for vastly heterogeneous requirements of these other units, which increases the complexity of their work. The intraorganizational search for work-related advice should be seen as beneficial in this situation, assisting employees to deal with such complexities (Durmuşoğlu, 2013; Lomi et al., 2014) and fostering the generation of more and different solutions for the tasks at hand (Hargadon and Bechky, 2006).

Moreover, members of units that function as sources for many other units not only have to produce knowledge for further processing by many other units; they are also required to prepare the internally produced knowledge for the transfer to and use in other R&D units, for instance by providing documentation and instructions (Argote and Ingram, 2000; Vincenti, 1990). Thus, they need to be able to make the outcomes of their work broadly comprehensible. In a sense, they can be argued to necessitate broad knowledge (Boh et al., 2014), which they can gain via individual search. Overall, R&D professionals in units that function as sources for many other units should associate high benefits with intensive individual search. We propose:

H2: The more a unit is involved in organizationally-designed R&D task collaboration as a source, the more intensive the unit's members search for advice.

2.5. *The moderating role of R&D unit component specialization*

Hypotheses 1 and 2 focus on the effects of organizationally-designed R&D unit task collaboration that designate units as sources or recipients, similar to a flow chart of R&D activities in a firm. However, the strength to which organizational design can affect the search intensity of individuals likely depends on the scope of research tasks within the R&D units as well. Specifically, many R&D departments are structured around distinct tasks with some units engaging in broad research or service activities, while others are in charge of one particular component of a product (Tushman and Scanlan, 1981). At the unit level, such component specialization determines how received knowledge is used and how outgoing knowledge is useful (Madhavan and Grover, 1998). At the individual level, these differences have been shown to influence unit members' work behavior (Allen et al., 1980; Tushman and Scanlan, 1981).

We focus on component specialization as a defining feature of the scope of research tasks in R&D units since many firms use product components to decompose new product development tasks, manage complexity, and facilitate local learning (Madhavan and Grover,

1998; Sosa et al., 2004). As a result, components constitute distinct research sub-systems, such as for wings, engines, or windows of a new airplane model, and dedicated R&D units are in place to research and design these components separately and specifically (Sosa et al., 2015). Obviously, not all R&D units are specialized on particular components. For example, an airplane producer will also need R&D units with general tasks, conducting basic research on new materials or providing services such as integration or tooling (Tushman and Scanlan, 1981). The latter R&D units, whose research tasks are not tied to a particular component, are likely to deal with novel technologies or materials as well as with larger amounts of different technology domains, similar to what has been shown for specialist and generalist scientists (Teodoridis et al., 2019).

Working for (either source or recipient) units that are component specialized, R&D professionals are in an environment in which they use a limited amount of knowledge elements repeatedly, thereby becoming familiar with the knowledge (Katila and Ahuja, 2002). Such familiarity makes research tasks more predictable and allows for routine development (Levinthal and March, 1981). The distinct scope of their tasks allows component-specialized R&D units and their members¹ to build up experience and fine tune processes (Eisenhardt and Tabrizi, 1995). At the same time, component specialization enables all R&D professionals in the firm to predict clearly and accurately on which sub-system the specialized unit is working and how it relates to the final product. Hence, it is likely to affect search behaviors.

¹ As all individuals work for a single unit, unit component-specialization is likely to influence the unit members' familiarity with the distinct knowledge that is applied. For instance, R&D professionals belonging to a component-specialized unit on engines, work at least in principle on R&D activities regarding engines, leading to familiarity with tasks, technologies, and requirements regarding engines. In contrast, non-specialized units, such as service units, are unlikely to contain specialized individuals servicing exclusively engines as those individuals would be part of the engines unit. Instead, individuals in non-specialized units are likely to service at least two components (and typically work on even broader tasks), for the organization to benefit from having non-specialized units in the first place. These individuals are hence unlikely to develop the same degree of familiarity with knowledge.

Building on the distinct characteristics of component-specialized as compared to non-specialized units, we reason that R&D unit component specialization interacts with the impact of task collaboration between units on the unit members' individual search intensity. First, we address the moderating effect of component specialization for the predicted negative relationship between the extent to which R&D units function as recipients in organizationally-designed task collaboration and individual search.

Component specialization increases the odds that a unit receives knowledge from the same other R&D units repeatedly. Consequently, component-specialized R&D units functioning as recipients of knowledge from many other units should be able to develop a better understanding of the specifications or limitations of the inputs they receive (Eisenhardt and Tabrizi, 1995). There is increased predictability of task collaborations, which reinforces the unit-internal benefits of handling a limited set of technology domains and being able to develop routines. From the perspective of the component-specialized unit, it facilitates the screening, transformation, and assimilation of external knowledge as typical challenges of knowledge transfer (e.g., Cohen and Levinthal, 1990; Koput, 1997; Todorova and Durisin, 2007). Similarly, partner units can develop reliable expectations for which type of knowledge is relevant and in which format it should be provided to the recipient unit. For example, an R&D unit specialized in car engines will repeatedly require new or lightweight materials. In this case, the collaborating units can develop a shared understanding (Ring and van de Ven, 1994) for how these materials need to perform in a novel engine.

Of course, some of these specifications may still benefit from individual search. However, based on the above reasoning, component specialization should make it easier to design effective R&D unit task collaboration structures leading to close alignment between the organizational design and individual unit members' knowledge requirements (Clement and Puranam, 2018; Raveendran et al., 2020). Due to this alignment, there should be few

incentives for individual R&D professionals in recipient units to search intensively outside of the organizational design that would justify the search costs. Instead, these individuals should experience an additional dampening effect of their units' component specialization on search intensity. The same does not hold for members of R&D units with a rather general purpose, for instance those working on reducing the environmental impact of cars. For them, the extent to which their unit functions as a recipient in task collaboration should still substitute the necessity of intensive search. Put differently, there is no additional dampening effect as in the case of component specialized R&D units. On the contrary, R&D professionals in non-specialized units may be more likely to find the knowledge that they can gain from extensive R&D task collaboration with other units insufficient and, therefore, rely on individual search. We suggest:

H3a: The negative relationship between an R&D unit's involvement in organizationally-designed task collaboration as a recipient and its members' search intensity is reinforced in component-specialized units.

Turning to the relationship between the extent to which R&D units function as sources in organizationally-designed task collaboration and individual search, we predicted a positive main effect. Following a similar line of arguments as above, we expect the distinct characteristics of component-specialized units to dampen this positive main effect.

Component-specialized R&D units functioning as sources of knowledge for many other units based on the organizational design for task collaboration should – like recipient units – be able to develop routines and familiarity (Eisenhardt and Tabrizi, 1995) that facilitate dealing with the complexity of having to deliver outputs to a high number of other units. It should be easier for them to recognize output requirements and standardize documentation and instructions for the knowledge they produce and deliver to other units as the role of the component for the final product is clear and predictable (Sosa et al., 2004). Coming back to the above example, an R&D unit specialized in car engines can contribute to

an R&D unit task collaboration by providing prototypes or designs of a new engine. Collaborating units have an understanding of the type of technology that they will receive and how it will contribute to the overall innovation. Organizational designs can be effective (Clement and Puranam, 2018; Raveendran et al., 2020) for R&D task collaborations under these conditions since there is comparatively less need to explore fundamental details of the component via individual search. Conversely, R&D units with general tasks, such as the production of energy efficient cars, are a much less predictable source of knowledge in an R&D unit task collaboration. In the latter case, more intensive individual search is necessary to deal with the broader requirements of research tasks on the one hand (Tushman and Scanlan, 1981) as well as to identify the needs, demands, and specifications of the various recipient units on the other. Hence, we propose:

H3b: The positive relationship between an R&D unit's involvement in organizationally-designed task collaboration as a source and its members' search intensity is weaker for component-specialized units.

3. Data and Methods

3.1. Empirical setting

For our empirical analysis, we rely on data collected from employees working in the R&D department at the largest site of a leading high-tech firm within the electrics and electronics industry with headquarters in Germany. The firm is market and technology leader in its area and R&D is key to its success. Over the last decades, it has been growing continuously in terms of number of employees as well as sales. Similarly, their R&D intensity has been increasing, from 9% in 2010 to 10.1% in 2013, when we collected the data for this study, and 10.5% in 2016.

The R&D department at the site under study is formally structured into small, interdependent units ranging in size between two and 11 members, each with its own leader. By focusing on one site only, we are able to remove the complicating presence of

geographical proximity influencing individual search and networks for innovation (Boschma, 2005). Each R&D professional belongs to one unit; each unit and its members belong to one of five different divisions, one central research division and four product divisions with distinct topical foci.

As indicated by the opening quote, R&D management has made an effort to formalize and standardize task collaboration between the units as part of the organizational design while at the same time being mindful not to stifle innovative potential through excessive bureaucracy. Internally, they speak of “modules” that are transferred from one unit to another as part of the organizationally-designed R&D task collaboration. Such modules as the outcome of research tasks in a unit come in various embodiments as determined by the type of products on which units work, for instance prototypes and devices, software code, or results from technical tests. Source units are asked to provide a description of the functionality of the modules they transfer, but there are no specific requirements with regard to documentation. Instead, the exact form and content of modules is largely at the collaborating units’ discretion.

3.2. Data collection

We conducted an online survey among R&D unit leaders and members. To construct our questionnaire, we engaged in multiple in-depth discussions with senior managers of the firm, including the head of the R&D department. These discussions helped us to develop an understanding of the overall significance of individual search for employees’ work on the one hand and the organizational design for task collaboration on the other. Based on this qualitative information, we selected the network questions described below to capture individual search and R&D unit task collaboration. The head of R&D provided feedback and suggestions on the formulation of all questions. For instance, he suggested capturing R&D task collaboration between units by asking unit leaders about module transfers. As unit source

and recipient roles and the associated input and output streams are difficult to codify comprehensively given the inherent uncertainty of researching and developing new technologies, materials and processes (Raveendran et al., 2020), R&D unit leaders knew best which other unit they provided with knowledge. As required by German law, the questionnaire was discussed with and approved by the firm's workers' council. It was also pre-tested on a small sample of employees to ensure that meanings were clear.

While R&D unit leaders provided information on R&D unit task collaboration, leaders and members were asked about their individual search behavior. In addition, management provided information on the firm's hierarchical structure, brief descriptions of each R&D unit, employees' unit memberships and tenure. By combining data from these three sources, our research design mitigates single-source bias. Following Perry-Smith (2006), we used a modified four-contact strategy (Dillman, 2000) to disseminate the survey and increase the response rate: First, a firm-internal introductory email signed by the chief human resources officer and the head of R&D was sent. Then, we sent the invitation for the online survey as well as up to two reminders to all employees who had not yet responded.

There were 43 R&D units in the site under investigation; of those, we had to exclude five units due to leader non-response and, consequently, missing data on unit-level collaboration network ties. The unit-level response rate is 88 percent. Of the 247 predominantly male employees working in the 38 units retained 193 employees completed our survey, resulting in an individual-level response rate of 78 percent. To test for non-response bias, we compared early respondents with late respondents, as studies have shown that late respondents resemble non-respondents in many characteristics (e.g., Armstrong and Overton, 1977). We compared R&D employees who responded immediately after we sent the survey with individuals who responded after receiving reminders. T-tests for individual search behavior and tenure did not indicate any significant differences between the groups.

3.3. Data

The dependent variable, individual search intensity, is captured at the level of the individual employee while organizationally-designed R&D unit task collaboration as main predictor of individuals' search behavior as well as R&D unit component specialization as moderator are captured at the unit level. Control variables refer to both, individuals and units, as explained below.

Dependent variable. Following previous research (e.g., Clement and Puranam, 2018), we rely on a network approach to operationalize *individual search intensity*. Specifically, we study a work-related advice network and used the roster method to capture individuals' advice ties with colleagues belonging to the same division and a name generator for colleagues belonging to the respective other four divisions (for a similar approach see Oh et al., 2004). In line with established practice (e.g., Lomi et al., 2014; Reagans and McEvily, 2003), we asked all R&D professionals to name colleagues to whom they turned regularly in search of work-related advice. Search ties were coded dichotomously and arranged in a 193×193 binary adjacency matrix.

As we explain in greater detail in the next section introducing our analytical method, we rely on the advice network data to capture individuals' likelihood to engage in search. Specifically, in line with our conceptual definition, intensive search is the likelihood of R&D professionals to search work-related advice from a relatively high number of colleagues within their unit or beyond. In network terms, the number of colleagues from which they search is referred to as an individual's outdegree (Wasserman and Faust, 1994). The multilevel ERGM approach that we explain below enables us to estimate models describing R&D professionals' likelihood to engage in intensive individual search depending on the organizational design for unit-level task collaboration.

Independent variable. To capture *organizationally-designed R&D unit task collaboration*, we asked unit leaders to indicate “To which other units did your unit provide modules and the associated knowhow in the past?” We presented them with a roster of all units from which they could choose. Ties were recorded dichotomously and arranged in a 38 × 38 binary adjacency matrix. This matrix contains information on source-recipient relationships for each pair of units and, more broadly, allows capturing the extent to which units function as sources and recipients for other units. To create the multilevel network (Zappa and Lomi, 2015) that reflects the nested structure of our research design, we created a 193 x 38 affiliation matrix capturing individuals’ unit membership and used this matrix to link the individual-level search network to the network of unit-level R&D task collaboration.

Moderator variable. To create our moderator variable *R&D unit component specialization*, we relied on the R&D unit descriptions provided by management. We classified units as component specialized (coded as 1) or non-specialized (coded as 0). Descriptions of component-specialized units point to distinct product components reflective of a relatively narrow technological domain, such as printed circuit boards, light grids, or registration sensors; by contrast, non-specialized units are responsible for broader knowledge-domains such as vision technologies or software. There are 13 component-specialized units.

Control variables. As control variables, we include different individual and unit attributes that are assumed to influence R&D professionals’ search behavior. In terms of individual attributes, we consider *leader status*, which is a binary variable distinguishing unit leaders (1) from unit members (0). Moreover, we control for *tenure* in the organization measured in years; employees average tenure is 10 years ($SD = 8.1$). Further, we include *division membership* as a categorical variable capturing individuals’ higher-order affiliation with one of the five divisions. We also account for supervisor-subordinate relations at the

dyad level by creating two dyadic attributes capturing whether an employee is *subordinate of* or is *supervisor of* another employee. As unit-level attributes, besides R&D unit component specialization we created two additional binary variables to control for the cross-level influence of unit characteristics on individual search. Specifically, following Tushman and Scanlan (1981), we account for R&D units characterized as *central research units* (as opposed to development units), i.e., those units belonging to the central research division, and units that based on their description can be characterized as *service units*, for instance construction. The next section explains how these attributes are included into our statistical model.

3.4. *Exponential random graph modeling*

To answer our research question of how R&D professionals' search is influenced by organizationally-designed task collaboration between the units for which they work, we need a methodology that is able to deal with two forms of dependence in data: a) relational dependence among observations characteristic for network data and b) multilevel dependence resulting from nested hierarchical structures. We rely on multilevel ERGM because, to the best of our knowledge, it is currently the only available methodology that addresses both forms of non-independence simultaneously.

Alternative statistical approaches that allow accounting for dependencies in relational data and treat the occurrence of network ties as the dependent variable, most notable quadratic assignment procedure (QAP) regression (Krackhardt, 1987, 1988) (for applications to innovation management research, see for instance Cantner and Graf, 2006; Guan and Yan, 2016; Kratzer et al., 2008b), do not allow uncovering patterns of tie interdependence going beyond the dyad. In other words, it is not possible using QAP to diagnose and model the forms of dependence induced by social mechanisms that exist among the ties (Desmarais and Cranmer, 2017) – which is, however, necessary to test our hypotheses. Apart from this, QAP

regression does not meet our requirement of dealing with multilevel dependencies resulting from nested hierarchical structures.

The latter form of dependence is traditionally handled by multilevel modeling techniques such as hierarchical linear modeling (HLM, Bryk and Raudenbush, 1992). The goal of HLM with random (varying across units) or fixed (constant across units) effects is usually to predict the behaviour or perceptions of individuals nested in units based on attributes of units and individuals by estimating between group variations (for applications to innovation management research, see for instance Bergmann et al., 2018; Magni et al., 2009; Stockstrom et al., 2016). As exemplified by Stockstrom et al. (2016), HLM may well include network variables as predictors of individual behaviour. For instance, the authors use network density at the unit level and degree centrality at the individual level to predict search performance of schoolchildren nested in classrooms. However, just like QAP regression, HLM is unable to directly model dependencies induced by social mechanisms (Zappa and Lomi, 2015), such as in our case the top-down mechanisms reflected in the hypotheses.

The multilevel extension of ERGM meets our statistical requirements of having to deal with the two forms of dependence. It, therefore, enables us to investigate how the organizational design of R&D units and, specifically, R&D unit task collaboration influences individual search. ERGM refers to a family of stochastic network models that is growing in popularity in management research (for applications, see for instance Brennecke, 2020; Kim et al., 2016; Sosa et al., 2015). It was originally developed to examine networks at a single level of analysis (Robins et al., 2007; Wasserman and Pattison, 1996) but has since been extended to the investigation of, for instance, two-mode (Wang et al., 2009), multiplex (Wang, 2013), and multilevel networks (Lusher et al., 2020; Wang et al., 2013). Using ERGM enables us to identify patterns of ties that characterize an observed network and, based thereon, draw conclusions on the mechanisms that determined tie formation. Different

from HLM and QAP, the multilevel extension of ERGM further enables the explicit modelling of network ties across different levels and, hence, allows uncovering cross-level mechanisms occurring in networks among nested actors, such as here unit-level R&D task collaboration and individual-level search. These mechanisms are reflected in patterns such as those depicted in Figure 2.

The aim of multilevel ERGM is to estimate parameters describing the likelihood of observing distinct tie patterns, which, for instance, capture the tendency for R&D professionals to engage in intensive individual search. To this end, ERGM assumes a stochastic process in which the presence of a specific network tie is influenced by different sets of variables reflective of tie patterns. In this study, this entails a) multilevel patterns capturing the cross-level influence of R&D unit task collaboration and unit-level characteristics on individual search, as well as b) individual-level attribute-based patterns and c) individual-level network endogenous patterns as control variables. We explain them in turn and subsequently provide further details on ERGM estimation.

Multilevel patterns. We include the following multilevel patterns as illustrated and explained in Table 1 to test our hypotheses: *Search intensity - unit as recipient* and *search intensity - unit as source* capture the influence of the extent to which a unit functions as a recipient of knowledge from other units and as a source of knowledge respectively on its members' search intensity. The interaction between R&D units' role as recipients and sources and R&D unit attributes, notably component specialization, is captured by the *search intensity – unit as recipient*unit attribute* and *search intensity – unit as source*unit attribute* patterns.

In addition to these patterns directly related to our theorizing, we control for other cross-level influences of the organizational design on individual search. First, we control for the influence of R&D professionals' unit membership on search. In line with units' function

to structure and simplify research tasks (Madhavan and Grover, 1998; Tushman and Scanlan, 1981), previous research has shown that R&D employees nested in the same unit are more likely to search from each other as opposed to searching from members of other units (Lomi et al., 2014), but do not necessarily mutually exchange advice (Brennecke and Rank, 2016). To account for these effects of joint unit membership, we include *within-unit search* and *within-unit reciprocity* patterns in our model. Following research that highlights the influence of task interdependence on individual search (Caimo and Lomi, 2015; Rank et al., 2010), we also control for whether R&D professionals are more (or less) likely to engage in unit boundary-spanning search (i.e., search for advice from colleagues who are not part of the own R&D unit) directed at colleagues in those units with which their unit is connected via R&D task collaboration. *Boundary spanning – unit as recipient* reflects the influence of a unit receiving knowledge from a specific other unit as prescribed by the organizational design on its members' likelihood to search for advice from members of this other unit. Conversely, *boundary spanning – unit as source* captures the influence of the unit providing knowledge to the other unit on its members' search for advice from members of the other unit (Zappa and Robins, 2016). We use *search intensity - unit attribute* to control for a direct cross-level influence of the three R&D unit attributes (component specialization, central research, and service) on unit members' search intensity. Finally, we include the *search intensity – unit as recipient*unit attribute* and *search intensity – unit as source*unit attribute patterns* mentioned above for research and service units.

--- Table 1 about here ---

Attribute-based patterns. Within-level attribute-based patterns capture the influence of individual characteristics on the likelihood of R&D professionals to search for work-related advice. We account for attribute search, attribute source, attribute similarity/dissimilarity, and dyadic attribute entrainment patterns as summarized in Table 2.

--- Table 2 about here ---

Following previous studies on search in terms of advice networks (e.g., Brennecke and Rank, 2017; Lomi et al., 2014), we employ *attribute search* and *attribute source* patterns for leader status and tenure as defined above to capture the influence of these attributes on R&D employees' propensity to search for advice and be the source of advice respectively. In addition, we include *attribute similarity/dissimilarity* for leader status, tenure, and division membership to account for search ties between employees who are similar or dissimilar with respect to these attributes. For binary and categorical attributes (i.e., leader status and division), attribute similarity/dissimilarity patterns capture mere similarity, with a positive parameter value indicating that connected employees tend to possess the same characteristic. For continuous attributes (i.e., tenure), they capture dissimilarity: more precisely, the difference in size between values of the attribute. A negative parameter value indicates a small absolute difference, suggesting that individuals are similar. Following Lomi et al. (2014), we account for subordinate of and supervisor of another employee as *dyadic attribute entrainment* patterns. These patterns allow controlling for formal reporting lines and capture whether subordinates search for advice from their supervisors and vice versa.

Network endogenous search patterns. In general, network endogenous patterns capture tendencies of network ties – such as in our case search – to self-organize, as tie formation is influenced by individuals' own existing network ties as well as by their network partners' ties with others, as recently discussed by Sosa et al. (2015) for corporate R&D. With regard to the study of individual search, they allow us to account for the fact that single search endeavors in a network are unlikely to be independent from each other. Ignoring endogenous dependencies can cause spurious results regarding the determinants of network ties (Krackhardt, 1987) and, thus, search. Moreover, these patterns are crucial to test our

hypotheses because they allow us to empirically isolate the cross-level influence of the organizational design on individual search intensity.

Concerning the selection of patterns, we followed Lomi et al. (2014) and Sosa et al. (2015). First, we consider general differences in individuals' intensity to search for advice (*search intensity spread*), and vice versa, to be the source of advice (*source intensity spread*). We also account for baseline tendencies towards *reciprocity*. The *brokerage* pattern controls for the correlation between R&D employees' propensity to search for and to function as a source of advice. Finally, we include patterns that capture clustering – specifically, tendencies towards *transitive closure* and *cyclic closure* – and account for *multiple connectivity*, i.e., multiple open paths between two individuals (Robins et al., 2009). Table 3 illustrates the endogenous patterns included in our models.

--- Table 3 about here ---

Model estimation. Relying on multilevel ERGM, we treat the occurrence of search tie patterns as the dependent variable. It allows estimating parameters referring to patterns of theoretical interest, while at the same time controlling for the overall network structure in which the patterns are embedded (Brennecke, 2020; Lomi et al., 2014). Multilevel ERGM formally translates into the following general form (Wang et al., 2013; Zappa and Lomi, 2015):

$$\Pr(M = m|Y = y) = \left(\frac{1}{\kappa}\right) \exp\left(\sum_q \theta_q Z_q(m, y)\right)$$

This equation describes a probability distribution of networks. $M = [A, X, B]$ denotes the set of all possible multilevel networks composed of macro-level network A , here R&D unit task collaboration, micro-level network B , here individual search behavior, and an affiliation network X capturing the nested structure of individuals belonging to distinct units. Correspondingly, $m = [a, x, b]$ denotes the observed network. Similarly, Y is an array of actor

attributes with the observed realizations y . The probability of observing any particular network m given the vector of actor attributes y in this distribution is dependent, first, on $Z_Q(m, y)$ referring to a network statistic counting network patterns of type Q , such as the patterns discussed in the previous sections. Second, it depends on the values of θ_Q denoting the estimated parameter corresponding to the statistic $Z_Q(m, y)$. Finally, κ is a normalizing constant included to ensure that the above results in a proper probability distribution.

Employing MPNet software (Wang et al., 2016), we used Markov-Chain Monte-Carlo maximum-likelihood to estimate parameter values for each pattern included in the model. Zappa and Lomi (2015) provide further details on the estimation process. In line with existing ERGM applications (e.g., Zappa and Robins, 2016), we fixed network density to aid model convergence. In line with our theorizing, we also fixed the R&D unit task collaboration network and the affiliation network linking individual and unit levels treating them as exogenously given.

4. Results

Table 4 summarizes descriptive statistics for individual search and R&D unit task collaboration. Table 5 presents the results of the model estimation. The parameter values are log odds, providing information on the likelihood of observing a given search pattern versus not observing it. In the following, we first present the results for the multilevel patterns relating to our hypotheses and then summarize the remaining findings.

--- Table 4 about here ---

--- Table 5 about here ---

The parameter estimate for *search intensity – unit as recipient* is negative and significant. In support of Hypothesis 1, this indicates that the more a unit is involved in organizationally-designed R&D unit task collaboration a recipient, the less intensive its

members search for work-related advice. In contrast, the parameter estimate for *search intensity – unit as source* is positive, confirming that the extent to which R&D units function as knowledge sources for other units propels unit members' search intensity as per Hypothesis 2. The interaction pattern *search intensity – unit as recipient*unit component specialization* is insignificant and we have to reject Hypothesis 3a. By contrast, in support of Hypothesis 3b *search intensity – unit as source* unit component specialization* is negative. The positive main effect of R&D units' involvement in organizationally-designed task collaboration as sources on their members' search intensity is weaker for component-specialized units.

Regarding the control variables, the positive *within-unit search* and negative *within-unit reciprocity* parameters confirm findings of earlier research showing that individual search for advice is more likely to target members within the same unit, but that the norm of reciprocation is more predominant in boundary-spanning search (Brennecke and Rank, 2016; Caimo and Lomi, 2015). Both *boundary spanning – unit as recipient* and *boundary spanning – unit as source* are positive and significant. In line with previous research (Sosa et al., 2004; Zappa and Robins, 2016), R&D unit task collaboration designating a unit as the recipient or as the source of knowledge for another unit positively influences individual boundary-spanning search from the unit's members to colleagues in the other unit. The remaining multilevel patterns accounting for the cross-level influence of unit attributes on individual search are insignificant.

The individual attribute-based and network endogenous search patterns confirm findings of existing studies investigating employees' search for work-related advice and knowledge (e.g., Allen et al., 2007; Lomi et al., 2014). With respect to the influence of individual attributes, we find that unit leaders search less than employees without leader status (negative *leader status search* parameters) while tenure is positively related to

functioning as source of work-related advice for others (positive *tenure source* parameter). As indicated by the positive *leader similarity* and negative *tenure dissimilarity* parameters, employees with similar leader status and tenure are more likely to search work-related advice from each other, as are R&D employees belonging to the same division (positive *division similarity* parameter). Finally, subordinates tend to search from their supervisors and vice versa (positive *entrainment* parameters).

The network endogenous patterns illustrate that the search behavior of R&D professionals is characterized by an overall propensity for *reciprocity*, indicating that they mutually search for advice from each other. Moreover, we observe joint tendencies towards *transitive closure* and against *cyclic closure*, pointing towards hierarchical differences between individuals, in the sense that only one individual in a triad is approached for advice by the other two (Rank et al., 2010). Finally, there are tendencies against *multiple connectivity*, indicating that multiple open search paths connecting individuals are uncommon.

As advised by Hunter et al. (2008), we tested goodness of fit (GOF) by simulating 500 million networks from the fitted model. Comparing the characteristics of a random sample of 5,000 simulated networks to the observed network's characteristics showed that GOF statistics for all effects included in the model are below the threshold criteria suggested by Robins et al. (2009), thus indicating a very good fit. In addition, we compared network characteristics not in the model for the simulated networks' sample to their observed values. This can be seen as a stringent test of model fit as it considers the model to fit well if it is able to reproduce characteristics of the observed network that were not used to construct the model (Srivastava and Banaji, 2011). The majority of GOF statistics for network characteristics not explicitly modeled were below the recommended threshold criteria (Robins et al., 2009), while a few exceeded it, which is not uncommon in ERGM applications

(e.g., Brennecke, 2020; Srivastava and Banaji, 2011). As Robins and Lusher (2013) explain, ERG models will not perfectly fit all characteristics of an observed network, just as regression models do not explain 100 percent of the variance. The fact that the patterns of interest and most other features of the data have been adequately reproduced indicates that the observed network could have resulted from the modeled influence factors.

5. Discussion and Conclusion

We conducted this study to provide a systematic understanding of how organizationally-designed task collaboration between R&D units curtails or propels individual search of R&D professionals working for these units. The organizational design divides and allocates R&D roles and tasks to units (e.g., Argyres et al., 2020; Kratzer et al., 2008a; Puranam et al., 2014). As single R&D units are increasingly unable to manage the complexity of developing new products on their own, particularly in high-tech settings, design choices prescribe task collaboration between units (e.g., Sosa et al., 2004); R&D units are designated as sources passing on knowledge to other units and as recipients acquiring knowledge for further processing or integration.

We relate this organizational design of corporate R&D to considerations of scientists and engineers in the units to search for work-related advice. For this purpose, we review the literature on knowledge search and, specifically, tradeoffs between search costs, benefits and risks. We reason that R&D professionals compare the benefits of intensive search, such as obtaining large amounts of knowledge (e.g., Durmuşoğlu, 2013; Li et al., 2013), with the costs for establishing advice relationships (Kleinbaum et al., 2013), knowledge screening (Koput, 1997), transformation (Todorova and Durisin, 2007) and absorption (Cohen and Levinthal, 1990) given that some knowledge sources may be unreliable in providing valuable knowledge (Katila and Ahuja, 2002). Our hypotheses emerge from integrating this reasoning

with organizational design choices and, based thereon, outlining mechanisms through which organizationally-designed task collaboration affects how intensively R&D professionals search and whether these effects depend on the component specialization of the unit.

We find that the individual search intensity of R&D professionals is lower when their R&D unit is the recipient of knowledge from many other units and higher when their unit is the source of knowledge for many other units. Hence, there are substitution as well as complementarity effects of R&D unit task collaboration on individual search, depending on the role of units as recipients and sources within the organizational design. We further demonstrate that the complementarity effect for source units is weaker for those R&D units that are specialized, working on a particular product component.

5.1. Theoretical implications

Our findings have implications for research on individual search on the one hand and organizational design for corporate R&D on the other. First, in line with the significance of autonomy for knowledge-intensive work (Gambardella et al., 2020; Roach and Sauermann, 2010), many studies on search assume that R&D professionals decide independently how to search and whom to search from by weighing costs and benefits (e.g., Borgatti and Cross, 2003; Kneeland et al., 2020; Nerkar and Paruchuri, 2005; notable exceptions include Dahlander et al., 2016). Our study alleviates this strong agency assumption by demonstrating how the organizational design of R&D unit task collaboration steers search behavior of employees working for these units. It leads them to search more or less intensively because the perceived benefits and costs of individual search vary depending on their units' roles and tasks. In line with recent efforts (Argyres et al., 2020; Clement and Puranam, 2018), our research thus provides a refined understanding of R&D professionals' search, depending on both individual agency and organizational design choices alike.

We also add to a nascent stream of literature on employees' intraorganizational search for innovation (MacAulay et al., 2020; Paruchuri and Awate, 2017). Moving beyond frequently-studied organizational silos, boundaries, and local as opposed to distant search (Rosenkopf and Nerkar, 2001; Tippmann et al., 2014; Tushman and Scanlan, 1981), we draw attention to search intensity. We expose conditions under which R&D professionals' capacity for intensive search is propelled or curtailed by characteristics of the R&D units for which they work – the units' role as sources and recipients as well as component specialization. In doing so, our analysis contributes to the literature on the determinants of search (Durmuşoğlu, 2013; Paruchuri and Awate, 2017) and provides a platform for investigating employees' search decisions more comprehensively. The uncovered variation in search intensity also has implications for existing research on the consequences of individual search which is potentially biased and the ramifications of this bias are unclear. For instance, the search intensity of R&D professionals working in units designated as recipients of knowledge from many other units is likely to be overestimated and the performance effects of their searches might be underestimated. The reverse is true for R&D professionals working for units designated as sources of knowledge for many other units.

Moreover, we introduce R&D unit task collaboration as an important dimension to the literature on the organizational design of corporate R&D which has so far focused on differentiating between centralized or decentralized units (Argyres et al., 2020) or research and development (Tushman and Scanlan, 1981). We choose a perspective that is closer to the frequently used flow charts of organizations, designating R&D units as sources and recipients in inter-unit knowledge flows. This perspective enables us to emphasize directionality of task collaboration (Raveendran et al., 2020) which, as we show, makes a critical difference for the considerations of R&D professionals to engage in intensive individual search. While there is a substitution effect of the extent to which R&D units function as recipients in task

collaboration on individual search, the extent to which R&D units function as sources complements their members search intensity. Moreover, the strength of the latter effect depends on the scope of research tasks within the units. These differentiated insights reinforce recent calls to move beyond treating the organizational design as simple control variable when investigating individual behavior (Argyres et al., 2020; McEvily et al., 2014). Future studies can build on our model connecting organizational designs with the decisions of R&D professionals and explore other moderators and outcomes, such as unit-internal processes, search for external knowledge, or the likelihood to commercialize knowledge in startups.

5.2. *Managerial implications*

From a practical point of view, our findings provide rich insights on the effects of organizational design on knowledge search within corporate R&D. Management is often under pressure to justify and demonstrate that the structure of R&D units has more than a symbolic role that signals stability and garners legitimacy (Clement and Puranam, 2018). We provide evidence for how design choices influence R&D professionals' search intensity by affecting the costs and benefits of individual search. In other words, similar to providing incentives (Bandiera et al., 2009) or organizing mixers (Ingram and Morris, 2007), management can use organizational design as a tool to steer professionals' search in certain directions.

Our findings illustrate under what circumstances organizationally-designed R&D unit task collaboration propels or curtails individual search, providing guideposts for organizational designers. Putting in place R&D unit task collaboration is unlikely to add to the individual search intensity of R&D professionals when their units function as recipients of knowledge from many other units. Instead, R&D professionals search less intensively, suggesting that the organizational design can be used to alleviate pressure from employees in

innovation-intensive settings, who are spurred by lay theories of networking (Kuwabara et al., 2018) and the popular management literature to search intensively. At the same time, managers need to understand that R&D professionals may no longer associate net benefits with intensive search if their units function as recipients of knowledge for many other units as prescribed by the organizational design. By contrast, the extent to which units function as sources of knowledge for other units boosts R&D professionals' incentives to search intensively. Accounting for R&D unit component-specialization provides further refinement. These complexities based on R&D units' roles as sources and recipients as well as their component-specialization cast doubt on a "one-size-fits-all" approach for the management and organizational design of corporate R&D. However, awareness of how distinct features of the formal organization shape individual search enables managers to take more targeted actions, not only with regard to organizational design, but also when providing feedback and recommendations to R&D professionals concerning their individual search behavior. After all, employees are often unaware of the exact patterns and biases that guide interpersonal search (Byron and Landis, 2020).

In sum, providing a systematic understanding of how organizational design choices for R&D units influence individual search behavior, our research demonstrates that it is not sufficient for managers to deal with collaboration and search at one level of the organization only. Instead, they need to develop an understanding of unit- and individual-level knowledge flows at the same time. To encourage and steer specific forms of individual search, they can make use of the organizational design.

5.3. Limitations and future research

There are some limitations to our study pointing towards opportunities for future research. First, in line with our theoretical predictions, we choose an empirical design that separates individual and R&D unit levels while holding the firm level constant. Concerning

the generalizability of our findings, we have no reason to believe that the R&D professionals in our sample demonstrate idiosyncratic search behaviors or that the organizational design for R&D unit task collaboration is alien to other innovative firms. However, to achieve more representative empirical tests for entire industries or economies, we would require research that captures additional levels, i.e., firm, industry, or economy levels. We encourage these studies, which would require extended theoretical reasoning on the intersection of individual, unit, and firm levels.

Second, following previous studies (e.g., Brennecke and Rank, 2017; Nebus, 2006) we focus on search via work-related advice networks as distinct form of individual search. We do so because this form of search is of particular importance in the setting under investigation (e.g., Allen et al., 2007; Allen, 1977) and previous studies have shown that individuals prefer sourcing knowledge from other individuals as compared to, for instance, electronic repositories (Allen, 1977). Obviously, individuals search for a variety of purposes and with varying motivations (e.g., for social integration or based on slack). Based on our research design, we cannot rule out that organizational design choices affect other forms of individual search behavior differently. Similarly, R&D unit task collaboration and component specialization capture idiosyncratic aspects of the organizational design for corporate R&D derived from the literature (Sosa et al., 2004; Tushman and Scanlan, 1981) and aligned with the empirical setting. It is possible that other design choices or more informal unit-level information transfers, such as those studied by Hansen (1999), exert a different influence on individual search. Moreover, the dichotomous component-specialization versus non-specialization measure that we use is coarse; future research should apply more fine-grained measures to account for heterogeneity among units. The stages of the R&D process in which a particular unit is involved might also influence the degree to which organizational designs interfere with individual search. We control for potential biases in our estimations using a

robust measure of central research units, but future studies might be able to track the stage specialization of R&D units in much more detailed ways. We call for future research to investigate such variation.

Finally, building on previous research (e.g., Kratzer et al., 2010; Lai et al., 2016), we assume functionality of the uncovered search behaviors of R&D professionals. Future research is needed to explicitly link the uncovered multilevel patterns that combine individual- and unit level-knowledge flows to innovative performance at the level of the individual employee, the R&D unit, and the organization as a whole.

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Figure 1. Conceptual framework: Influence of unit-level design choices on individual search

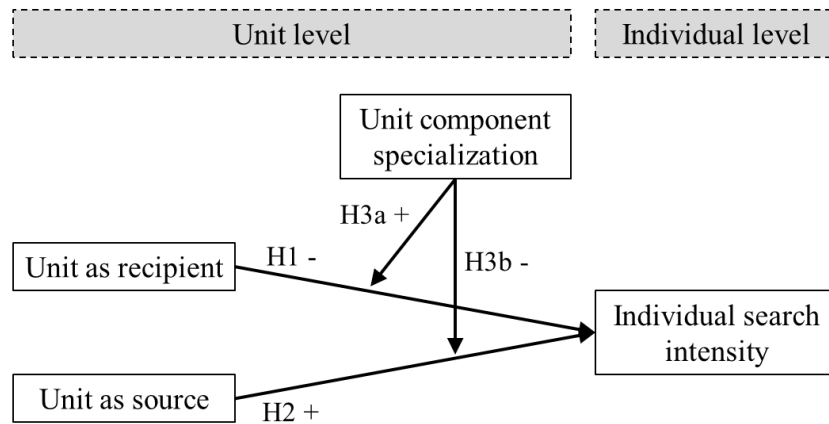
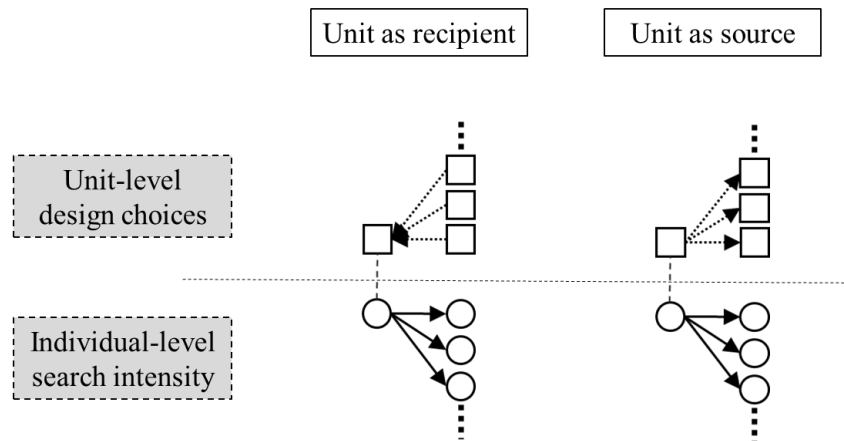


Figure 2. Schematic depiction of organizational design-driven influences on individual search intensity




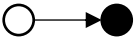
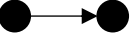
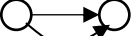
Notes. \square = unit; \bigcirc = individual; $\square_x \cdots \rightarrow \square_y$ = organizationally-designed R&D unit task collaboration (knowledge flow from unit x to unit y); $\bigcirc_i \rightarrow \bigcirc_j$ = individual search (employee i searching advice from employee j); $\square_x \cdots - \bigcirc_i$ = unit membership (employee i belonging to unit x)

Table 1. Multilevel patterns included in the model

Pattern	Use	Visualization	Interpretation
Search intensity – unit as recipient	H1		Influence of the extent, to which a unit is involved in organizationally-designed R&D task collaboration as a recipient of knowledge from other units on its members search intensity
Search intensity – unit as source	H2		Influence of the extent, to which a unit is involved in organizationally-designed R&D task collaboration as a source of knowledge for other units on its members search intensity
Search intensity – unit as recipient*unit attribute	H3a and control variables		Influence of the interaction between the extent, to which a unit is involved in organizationally-designed R&D task collaboration as a recipient of knowledge from other units, and the unit's attribute on its members' search intensity
Search intensity – unit as source*unit attribute	H3b and control variables		Influence of the interaction between the extent, to which a unit is involved in organizationally-designed R&D task collaboration as a source of knowledge for other units, and the unit's attribute on its members' search intensity
Within-unit search	control variable		Propensity for R&D professionals to engage in within-unit search
Within-unit reciprocity	control variable		Propensity for R&D professionals to engage in reciprocated within-unit search
Boundary spanning – unit as recipient	control variable		Influence of a unit designated by the organizational design as a recipient of knowledge from another unit on individual boundary-spanning search directed from the recipient unit's members to the source unit's members
Boundary spanning – unit as source	control variable		Influence of a unit designated by the organizational design as a source of knowledge for another unit on individual boundary-spanning search directed from the source unit's members to the recipient unit's members
Search intensity – unit attribute	control variables		Influence of R&D units' attribute on their members' search intensity

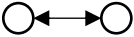
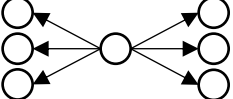
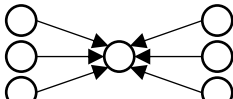
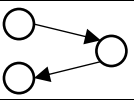
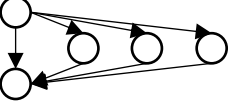
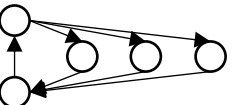
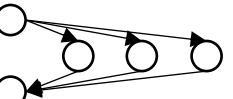
Notes. \square = unit; \blacksquare = unit with attribute; \bigcirc = individual; $\square_x \cdots \rightarrow \square_y$ = organizationally-designed R&D unit task collaboration (knowledge flow from unit x to unit y); $\bigcirc_i \rightarrow \bigcirc_j$ = individual search (employee i searching advice from employee j); $\square_x \cdots \bigcirc_i$ = unit membership (employee i belonging to unit x)

Table 2. Within-level attribute-based patterns included as control variables in the model

Pattern	Visualization	Interpretation
Attribute search		Propensity for R&D professionals with a specific continuous or binary attribute to search for advice
Attribute source		Propensity for R&D professionals with a specific continuous or binary attribute to be a source of advice
Attribute similarity/dissimilarity*		Propensity for search to occur between dyads of R&D professionals who are (dis-)similar with respect to a categorical, continuous, or binary attribute
Dyadic attribute entrainment		Propensity for search to occur between dyads of R&D professionals if a dyadic attribute is present

Notes. ○ = R&D professional; ● = R&D professional with binary or categorical attribute or high values on a continuous attribute; → = search tie; ↷ = dyadic covariate. * For binary and categorical attributes, the variable captures similarity. For continuous attributes, it captures dissimilarity, particularly the difference in size between values of the attribute. A negative parameter value indicates a small difference, suggesting that employees are similar.

Table 3. Within-level network endogenous patterns included as control variables in the model

Pattern	Visualization	Interpretation
Reciprocity		Propensity towards reciprocation
Search intensity spread		Propensity for variation in the number of search ties an R&D professional creates
Source intensity spread		Propensity for variation in the number of search requests an R&D professional receives
Brokerage		Correlation between R&D professionals' propensity to search for and to function as a source of advice
Transitive closure		Propensity for triadic closure, indicative of transitivity
Cyclic closure		Propensity for cyclic closure, indicative of a prevailing generalized exchange
Multiple connectivity		Propensity for search ties to form as part of formations involving multiple short paths

Notes. ○ = R&D professional; → = search tie

Table 4. Descriptive network statistics

Statistic	Individual search for advice	R&D unit task collaboration
# of actors	193	38
# of ties	1915	283
Network density	0.052	0.201
Reciprocity rate	0.382	0.225
Mean in-/outdegree	9.922	7.447
Standard deviation outdegree	5.978	5.820
Minimum outdegree	0	0
Maximum outdegree	29	25
Standard deviation indegree	5.045	2.777
Minimum indegree	1	3
Maximum indegree	29	15

Notes. Outdegree reflects the number of colleagues, from whom an R&D professional searches and the number of units, for which a unit functions as a source by providing knowledge; vice versa, indegree reflects the number of colleagues, to whom an R&D professional provides advice and the number of units, for which a unit functions as a recipient.

Table 5. Multilevel ERG model for the influence of R&D unit task collaboration on individual search

Pattern	Parameter Estimate (SE)
<i>Multilevel patterns</i>	
Search intensity – unit as recipient (H1)	-0.033** (0.011)
Search intensity – unit as source (H2)	0.046** (0.019)
Search intensity – unit as recipient*unit component specialization (H3a)	0.012 (0.013)
Search intensity – unit as recipient*unit component specialization (H3b)	-0.037* (0.018)
Within-unit search	2.287** (0.192)
Within-unit reciprocity	-1.922** (0.274)
Boundary spanning – unit as recipient	0.158** (0.022)
Boundary spanning – unit as source	0.107* (0.055)
Search intensity – unit component specialization	0.167 (0.156)
Search intensity – central research unit	-0.321 (0.167)
Search intensity – service unit	-0.011 (0.199)
Search intensity – unit as recipient*central research unit	0.007 (0.021)
Search intensity – unit as recipient*central research unit	-0.006 (0.010)
Search intensity – unit as recipient*service unit	0.015 (0.022)
Search intensity – unit as recipient*service unit	-0.025 (0.018)
<i>Within-level attribute-based patterns</i>	
Leader status search	-0.170* (0.079)
Tenure search	0.001 (0.003)
Leader status source	-0.123 (0.073)
Tenure source	0.009** (0.003)
Leader status similarity	1.240** (0.111)
Tenure dissimilarity	-0.015** (0.004)
Division similarity	0.214** (0.039)
Is subordinate of entrainment	0.990** (0.289)
Is supervisor of entrainment	3.310** (0.500)
<i>Within-level network endogenous patterns</i>	
Search intensity spread	0.121 (0.151)
Source intensity spread	-0.313 (0.319)
Reciprocity	2.275** (0.150)
Brokerage	-0.007 (0.006)
Transitive closure	1.395** (0.058)
Cyclic closure	-0.276** (0.032)
Multiple connectivity	-0.078** (0.007)

Notes. $N = 193$ individuals nested in $M = 38$ units; density fixed; unstandardized estimates; two-tailed significance tests are reported; * $p < .05$; ** $p < .01$