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Absorptive capacity for need knowledge: Antecedents and effects for employee innovativeness

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ABSTRACT

Innovation occurs when knowledge about unmet customer needs intersects with knowledge about technological solutions. Both knowledge types are often located outside the firm and need to be absorbed in order for innovation to occur. While there has been extensive research into absorptive capacity for solution knowledge, a necessary complement − absorptive capacity for new customer needs − has been neglected. In an individual-level study of 864 employees from a home appliance firm, we show that need absorptive capacity is theoretically and empirically distinct from solution absorptive capacity, and that both are positively associated with employee innovativeness. Interestingly, we find asymmetric extra-domain effects: prior solution knowledge is positively related to need absorptive capacity (cross-pollination effect), while prior need knowledge is negatively related to solution absorptive capacity (attenuation effect). We contrast the cognitive underpinnings of the two absorptive capacity types, contributing to emerging scholarly thinking on the domain-specificity and micro foundations of absorptive capacity.

1. Introduction

In 1968, 3M engineer Spencer Silver developed an adhesive technology that had no application inside 3M owing to its poor adhesive power. It was “a solution waiting for a problem to solve” (Spencer Silver (3M, 2003, p. 38)). Years later, during choir rehearsals, 3M engineer Arthur Fry was frustrated to find that his bookmarks were prone to falling out of his scores. Confronted with his personal need for strong yet removable markers, he realized that Silver’s adhesive technology could solve his problem. The combination of Fry’s discovery of an unmet need and Silver’s technological solution resulted in a 3M blockbuster innovation, the Post-it note (3M, 2003).

As illustrated in this well-known example, two knowledge types are crucial for innovation: Need knowledge and solution knowledge (Alexander, 1964; von Hippel, 1994). Need knowledge refers to unmet needs arising in the use of a given product or service, while solution knowledge refers to solving technical problems and providing functionality (Alexy et al., 2013). If both knowledge types are available in an organization, and if there is sufficient fit between the two knowledge sets, they can be combined so as to produce innovation.

In contrast, if crucial need knowledge or solution knowledge is situated outside organizational boundaries, for instance in the customer domain or in research centers (Chesbrough, 2003b; Laursen and Salter, 2006), it must be absorbed by the firm in order to be used for innovation. Thus, absorptive capacity − i.e. the capacity to identify, assimilate, and apply external knowledge for innovation − is essential for innovation in organizations (Cohen and Levinthal, 1990).

The literature focuses almost exclusively on absorptive capacity in relation to technical solution knowledge (Lane et al., 2006; Volberda et al., 2010), which we refer to as solution absorptive capacity. It has been virtually silent on absorptive capacity in relation to need knowledge, i.e. need absorptive capacity. Yet, need knowledge and solution knowledge are fundamentally different knowledge types: need knowledge is more unstructured, more uncertain, more latent, stickier, and harder to transfer than solution knowledge (Autio et al., 2013; Nickerson et al., 2007; Slater and Narver, 1998; von Hippel, 1994). Thus, absorptive capacity in both domains may well have different antecedents and transmission mechanisms. To narrow absorptive capacity to solution knowledge, and thus to the R&D context only, is problematic since it impedes exploration of how absorptive capacity operates for other knowledge types and in other contexts (Lane et al., 2001) and leads to erroneously mistaking solution absorptive capacity

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for the whole story.

We set out to investigate the antecedents and consequences of need absorptive capacity and examine how prior knowledge in a given domain (need or solution) affects absorptive capacity within and across domains. By answering these questions, we deepen our understanding of the absorptive capacity construct and respond to calls for research (Lane et al., 2006; Volberda et al., 2010) that challenge us to "be explicit about what kind of knowledge is being absorbed" (Volberda et al., 2010, p. 943).

The research has mostly analyzed absorptive capacity at the firm, business unit, or team level (e.g. Jansen et al., 2005; Lane and Lubatkin, 1998; Lane et al., 2001; Tsai, 2001); it has only more recently begun to address the sources and nature of absorptive capacity by investigating its micro-level foundations (Colombo et al., 2013; Lowik et al., 2012; Matusik and Heeley, 2005; Ter Wal et al., 2017; Tortoriello, 2014). According to Cohen and Levinthal (1990, p. 131), organizational absorptive capacity is rooted in individual absorptive capacity, and several scholars have called for more research into absorptive capacity at the individual level (Lane et al., 2006; Volberda et al., 2010). We respond to these calls and investigate how prior need and solution knowledge shape need and solution absorptive capacity, respectively, and how both absorptive capacity types shape employee innovativeness.

Using survey data from 864 employees of a large manufacturer of home appliances and independent ratings of individual innovativeness, we find that employees' need knowledge and solution knowledge increase need absorptive capacity. In contrast, solution absorptive capacity is positively related to solution knowledge but, interestingly, is negatively related to need knowledge. In other words, solution knowledge leverages both employees' need and solution absorptive capacity. We explain this effect by arguing that solution knowledge structures provide a schema for the absorption of new need knowledge, building on the notion of fungibility of technological knowledge for different applications (Danneels, 2007). Need knowledge, by contrast, leverages employees' need absorptive capacity, but attenuates their solution absorptive capacity. We argue that this effect is rooted in the fact that need knowledge does not provide cognitive structures for the absorption of solution knowledge, only for the absorption of need knowledge. Since cognitive resources are limited, higher attention to need knowledge absorption inhibits solution knowledge absorption. Regarding the consequences of need absorptive capacity, we find that it positively affects innovativeness above and beyond solution absorptive capacity's effect.

Our principal contributions are as follows: First, we advance scholarly thinking on the absorptive capacity's domain-specificity by conceptualizing and empirically juxtaposing absorptive capacity for need and solution knowledge. We argue that need absorptive capacity is an important and to date largely under-researched complement to absorptive capacity related to technical solutions, which is the focus of the current literature. We find that need absorptive capacity is a mechanism that explains how external need knowledge is identified, assimilated, and applied for product innovation.

Second, we contribute to research into absorptive capacity by showing that prior solution knowledge is associated with increased need absorptive capacity. Referring to prior research that has dubbed the ability to invent and create new information as "the first face of R&D" and the ability to absorb technological solution knowledge "the second face of R&D" (Cohen and Levinthal, 1989), we describe the ability to recognize new needs as the third face of R&D. In contrast, we found prior need knowledge to be negatively associated with solution absorptive capacity. These results shed light on cross-domain effects of knowledge accumulation on absorptive capacity. Absorptive capacity in a given domain X can have a positive (negative) association with prior knowledge in a different domain Y − a cross-pollination (attenuation) effect that has not been studied to date. We discuss and theorize the cognitive roots of these extra-domain effects, providing a cognitive explanation for the conditions under which extra-domain knowledge positively or negatively affects knowledge absorption in a different domain.

This adds to the nascent micro-level literature on absorptive capacity (Colombo et al., 2013; Lowik et al., 2012; Matusik and Heeley, 2005; Ter Wal et al., 2017; Tortoriello, 2014) by illuminating absorptive capacity's cognitive underpinnings at the individual level and shedding light on the question how cognitive structures rooted in different knowledge domains shape innovation. This helps one to re-connect absorptive capacity to its individual cognitive foundations (Cohen and Levinthal, 1990) and counters the construct's reification (Lane et al., 2006).

Third, our conceptualization of need absorptive capacity informs research into demand-driven innovations initiated outside the firm (Anderson et al., 2014; Priem et al., 2012; von Hippel, 1994). This literature emphasizes that a significant share of innovation-related activity happens outside producer organizations in the user domain (Hippel, 1988; von Hippel et al., 2012). User innovations are tied to use experience and are based on in-depth need knowledge. Many firms struggle to incorporate user ideas as they originate in a different thought world (Dougherty, 1992a). Nonetheless, to date, existing research hardly considers how firms can absorb these ideas and innovations to ultimately profit from user innovations originating outside the firm (Anderson et al., 2014; Priem et al., 2012). Our research suggests that need absorptive capacity facilitates the absorption of user-developed innovations into the producer firm.

The remainder of this paper is organized as follows: In Section 2, we describe the theoretical background and develop our research model. In Section 3, we explicate our methodology; in Section 4, we present the empirical results. In Section 5 we discuss our findings and consider theoretical contributions, limitations, and managerial implications.

2. Theoretical background and research model

2.1. Introducing need absorptive capacity

Absorptive capacity, as defined by Cohen and Levinthal (1989, 1990, 1994), is a firm's ability "to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (1990, p. 128). Thus, absorptive capacity is the mechanism that makes external knowledge available to and usable within an organization.

Absorptive capacity depends on domain-specific knowledge, which represents the raw building material of individual creativity (Amabile, 1988; Dane, 2010) and is organized in domain-specific schemas or knowledge structures (Fiske and Taylor, 2013). The most important predictor of absorptive capacity in a given domain is prior knowledge in that domain (Cohen and Levinthal, 1990); we call this intra-domain knowledge.

Although Cohen and Levinthal (1990) originally proposed absorptive capacity as a mechanism for the absorption of different knowledge types, they subsequently focused only on technological knowledge (i.e. solution knowledge). They proposed absorptive capacity as the second face of R&D (Cohen and Levinthal, 1989), i.e. the idea that prior knowledge from in-house R&D efforts is the main feed-stock for firms' absorptive capacity. In this tradition, subsequent studies have conceptualized absorptive capacity as the ability to absorb technical knowledge and have measured absorptive capacity as R&D spending, number of patents, or number of scientists (Volberda et al., 2010). Innovations based on new technologies are clearly important and play an eminent role in shaping firm and industry evolution. Nevertheless, even if research has shown that technology push and demand pull can be equivalent sources of successful innovation (Dosi, 1982; Mowery and Rosenberg, 1979), research into absorptive capacity has mainly taken a technology-centric view.

More recently, scholars have become aware that the nature of the knowledge to be absorbed affects the absorptive capacity type that is

required, and have called for a more careful differentiation of knowledge types (Lane et al., 2006; Volberda et al., 2010). Volberda et al. (2010) argue that research into absorptive capacity must be more specific in relation to the knowledge type to be absorbed and point out that applying absorptive capacity beyond the technology domain is "entirely consistent with [Cohen and Levinthal's (1990)] definition" (p. 943). Narrowing absorptive capacity to solution knowledge, and thus to the R&D context, is problematic, since it undermines exploration of how absorptive capacity operates for other knowledge types and in other contexts (Lane et al., 2001). Knowledge from different domains differs in tacitness, complexity, embodiment, and other characteristics, which suggests that absorptive capacity in different domains may well have different antecedents and transmission mechanisms. Being explicit about the knowledge type to be absorbed deepens our understanding of the construct (Lane et al., 2006; Volberda et al., 2010).

We propose absorptive capacity related to need knowledge as the natural and necessary complement to absorptive capacity for solution knowledge. Need and solution knowledge are the two key components of innovation (Alexander, 1964; Danneels, 2002; Slater and Narver, 1999; von Hippel, 1994). Need knowledge is defined as knowledge about "a customer's hierarchy of needs" (Homburg et al., 2009, p.64) or the "needs [innovating entities] will face in current or future markets" (Alexy et al., 2013, p. 270). It comprises use-related problems and unmet requirements and is typically situated in users or customers (von Hippel, 1994). Firms need to ingest need knowledge to develop innovative solutions that can be the basis for future competitive advantage (cf. Danneels, 2002; Slater and Narver, 1999). We define absorptive capacity for need knowledge as a firm's ability to identify, assimilate, and exploit knowledge about customer needs from the environment (cf. Cohen and Levinthal, 1990).

In contrast to the abundant research on how firms absorb technological knowledge (e.g. Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Spithoven et al., 2011; Stock et al., 2001; Tsai, 2001), there is very little mention in the management literature of firms' ability to absorb need knowledge for innovation. While Lane et al. (2006) and Volberda et al. (2010) point to need absorption's importance for innovation, only a few empirical studies have pursued this idea. Jiménez-Castillo and Sánchez-Pérez (2013) show that a firm's ability to absorb information about customers and competitors depends on its prior market knowledge. Murovec and Prodan (2009) show that what they call demand-pull absorptive capacity (targeting information from competitors and customers) and science-push absorptive capacity (targeting information from universities and research institutions) facilitate innovation in firms. Sidhu et al. (2007) explore how company innovativeness is influenced by demand-side search (search for new market insights), supply-side search (search for new technologies), and spatial search (search for new geographic opportunities). While this literature acknowledges need knowledge's importance for innovation, it says little about how firms can transfer need knowledge across organizational boundaries and can exploit it internally for innovation (cf. Priem et al., 2012). We argue that need absorptive capacity is the crucial mechanism for absorbing need knowledge.

The importance of need knowledge absorption for innovation has been acknowledged in the marketing literature on market information processing (Moorman, 1995; Sinkula, 1994), which argues that "market information processing, a term that encompasses the acquisition, distribution, interpretation, and storage of market information" (Sinkula, 1994, p. 36) is key for organizational learning and innovation. Market information – i.e. "organized and structured information about the market" (Li and Calantone, 1998, p. 14) – encompasses information relating to competitors, customers, and general market conditions. While this literature has stressed the relevance of processing need knowledge for innovation, it has not investigated how organizations can tap into highly contextualized need knowledge (cf. Priem et al., 2012).

Other literature strands suggest at least two strategies for obtaining customer need information. The first involves activities that help employees to cognitively span the organizational boundary, for instance by interviewing customers (Griffin and Hauser, 1993), by taking users' perspectives (Homburg et al., 2009), or by interacting with lead users (von Hippel, 1986). The second strategy suggests employing individuals who already have customer need knowledge, for instance because they are users of the firm's products (Schweisfurth, 2017). We argue that both strategies support the absorption of external need knowledge, because they equip employees with knowledge schemata that are similar to those of users who hold need knowledge. In other words, these strategies nurture individuals' absorptive capacity for need knowledge.

2.2. Need absorptive capacity at the individual level

The ability to absorb knowledge from outside the organization is rooted in individual employees. Organizations rely on individual employees to search for and learn from external knowledge sources (Dahlander et al., 2016; Li et al., 2013). Simon (1991, p. 125) emphasizes that "[a]ll learning takes place inside individual human heads". This notion is taken up by Cohen and Levinthal in their conception of absorptive capacity as they note that an "organization's absorptive capacity will depend on the absorptive capacities of its individual members" (Cohen and Levinthal, 1990, p. 131). Thus, individual absorptive capacity forms the basis for organizational absorptive capacity and can be leveraged by organizational mechanisms such as socialization (Todorova and Durisin, 2007; Zahra and George, 2002) or coordination (Jansen et al., 2005).

Nonetheless, most of the literature has studied absorptive capacity at the firm level (Lane et al., 2006; Volberda et al., 2010), or occasionally the alliance level (e.g. Lane and Lubatkin, 1998; Lane et al., 2001) or the business unit level (e.g. Jansen et al., 2005; Tsai, 2001), neglecting the individual level of absorptive capacity. Against this background, several scholars have argued that "there should be more individual level foundation for AC [absorptive capacity]" (Volberda et al., 2010, p. 945 see also Lane et al., 2006).

In response to these calls, recent research has begun to advance our understanding of absorptive capacity from an individual-level perspective (e.g. Colombo et al., 2013; Jiménez-Castillo and Sánchez-Pérez, 2013; Lowik et al., 2012; Ter Wal et al., 2017). Individual absorptive capacity has been shown to be predicated on prior knowledge, cognition, and the diversity of external networks (Jiménez-Castillo and Sánchez-Pérez, 2013; Lowik et al., 2012), and to be related to favorable outcomes such as task performance (Deng et al., 2008; Park et al., 2007), knowledge creation (Matusik and Heeley, 2005), and innovativeness (Lowik et al., 2012; Ter Wal et al., 2017; Tortoriello, 2014). However, these studies, like those previously discussed, focus on external solution knowledge and overlook the role of need knowledge as its necessary complement for innovation.

2.3. Hypotheses

2.3.1. Intra-domain knowledge and absorptive capacity

Building on Cohen and Levinthal's (1990) contention that the absorption of external knowledge in a given domain requires preexisting knowledge in that domain (Cohen and Levinthal, 1990), we argue that this applies to both prior need knowledge and prior solution knowledge. In both instances, individuals evaluate new knowledge in light of their prior knowledge and cognitive schemata, which helps them to assess its novelty and quality (Axelrod, 1973), understand the context in which the knowledge is embedded (Parker and Axtell, 2001), and exploit it for innovation (Lane et al., 2006).

Employees' need knowledge positively relates to their ability to empathize with external customers and to understand their problems. By empathizing with external customers, employees become "twin to their customers" (Leonard, 1995 p. 195), which facilitates the absorption of customer need knowledge. Research into need knowledge's role

in organizations stresses that prior need knowledge helps employees absorb new external need information (Homburg et al., 2009). Employees who are also users of their firm's products employ their need knowledge structure to process information from external users for innovation (Schweisfurth and Herstatt, 2015). Therefore, we therefore hypothesize:

H1a. Employees' prior need knowledge is positively related to their need absorptive capacity.

Concerning solution knowledge, extensive research on technological gatekeepers (e.g. Allen, 1971; Tushman and Katz, 1980) and boundary-spanners (e.g. Aldrich and Herker, 1977; Ancona and Caldwell, 1992) underpins the view that individuals' technical knowledge at the firm's boundary fosters their ability to absorb knowledge from the technical environment. To absorb technical knowledge, "individuals must have the background, experience, and training to deal with the communication impedance separating his or her unit from external areas" (Tushman and Scanlan, 1981, p. 293). This relationship between technical expertise and the ability to communicate externally is supported in empirical studies (Tushman, 1977). Thus, we propose:

H1b. Employees' prior solution knowledge is positively related to their solution absorptive capacity.

2.3.2. Extra-domain knowledge and absorptive capacity

In this section, we argue that extra-domain knowledge can affect absorptive capacity either positively or negatively. On the one hand, extra-domain knowledge can provide interpretation schemata that inform the absorption of new knowledge in a focal domain (Walsh, 1995), because a schema underlying one domain may be cross-referenced to a schema from another domain (Taylor and Crocker, 1981) such that schemata "currently activated can increase the likelihood that others will be salient or activated" (Harris, 1994, p. 314). On the other hand, if such cross-references are missing, pre-existing knowledge structures can inhibit the processing of knowledge from another domain (Taylor and Crocker, 1981; Walsh, 1995). Individuals with a high knowledge in a particular domain will specialize in that domain and are capable to absorb knowledge from it (Helfat and Peteraf, 2015), which makes processing of knowledge from other domains cognitively effortful (Kahneman, 1973).

Starting with prior solution knowledge, we hypothesize that individuals' solution knowledge relates positively to their need absorptive capacity. We argue that solution knowledge provides schemata and cues not only for processing solution knowledge but also for processing knowledge relating to new needs. For instance, an engineer designing a next-generation refrigerator must consider how it will be used, how it will be opened, how food will be stocked, etc., and must adjust their design accordingly. Having understood how a real-world user uses and opens a fridge, this prior knowledge allows for recognition of new customer needs. Also, solution knowledge comprises knowledge about the functions provided by a given technology and heuristics about the classes of problems for whose solution it can be applied (Danneels, 2007). In other words, solution knowledge encompasses knowledge about applications of technology. Many technologies are fungible[1] in the sense that they provide functionality in many different applications and can serve a latent set of user needs in different markets (Felin et al., 2014; Gruber et al., 2008). Individuals with solution knowledge, such as engineers working in product development, typically have some knowledge of the applications in which the technologies can be exploited. Even if, as has been argued (Danneels, 2007), their knowledge relates only to existing customer segments, knowledge about the intended uses of technologies relates to both the solution domain and the need domain. In fact, the solution space structures the use space (Griffith, 1999). The schemata associated with solution knowledge provide a cross-reference (Harris, 1994) to the schemata of need knowledge. We suggest that this inherent link explains why solution knowledge relates positively to need absorptive capacity.

H2a. Employees' prior solution knowledge is positively related to their need absorptive capacity.

Alongside these arguments, we expect prior need knowledge to negatively affect solution absorptive capacity. In contrast to solution knowledge, need knowledge usually does not provide schemata for processing and absorbing solution knowledge (Gick, 1986; Jonassen, 1997). Employees with rich stocks of need knowledge, and an excellent understanding of customer needs, will unlikely be able to recognize and absorb the technological solution to a problem without some understanding of the technologies and solution principles involved. It is known that different individuals faced with problems (i.e. needs) take different routes to their solution, depending on whether the problem representation activates a solution schema (Gick, 1986; Jonassen, 1997). Individuals with experience in solving a specific problem class can draw on mental solution schemata and can apply them to the given problem. That is, they use a cognitive schema to identify solutions to a given need. In contrast, individuals who have no solution schema (i.e. those in possession of only problem-related need knowledge) will have to search for solutions using a "haphazard and incoherent" process (Jonassen, 1997, p. 71). Chi et al. (1981) have shown that individuals are unable to formulate solutions to a given problem if they don't possess the required solution knowledge. They argue that "novices' schemata may be characterized as containing sufficiently elaborate declarative knowledge about the physical configurations of a potential problem [i.e. need knowledge], but lacking abstracted solution methods [i.e. solution knowledge]" (Chi et al., 1981, p. 30).

These considerations suggest a null effect of need knowledge on solution absorptive capacity, because need knowledge per se does not provide schemata to guide the absorption of new solutions. However, there is also reason to expect need knowledge to be negatively related to the processing and absorption of external solution knowledge. This is true if the knowledge structure it provides limits an individual's ability to understand the technical solution knowledge domains (Walsh, 1995). Individuals with extensive need knowledge but no solution knowledge will be inclined to devote all their attention to figuring out new needs and problems as a result of their bounded rationality and limited cognitive resources (Simon, 1991) and because dividing attention between different knowledge types is effortful (Kahneman, 1973). For these individuals, extensive need knowledge will be associated with lower solution absorptive capacity. Therefore:

H2b. Employees' prior need knowledge is negatively related to their solution absorptive capacity.

2.3.3. Innovativeness and absorptive capacity

Employees' innovativeness will be positively related to both their ability to absorb needs and their ability to absorb solutions. First, we argue that employees' need absorptive capacity positively relates to the extent to which they engage in generating innovative product ideas.

User need knowledge related to their experiences, problems during product use, and new applications is crucial for innovation. It is highly contextualized and sticky, i.e. hard to acquire and transfer (von Hippel, 2005). It usually originates outside the organization in the user domain (von Hippel, 1994). Individuals with the ability to 'unstick' this knowledge and absorb it are likely to be more innovative, because they can draw on this knowledge source and can make it accessible within the organization.

The ability to evaluate external needs, specifically their novelty and likely prevalence, is crucial for the selection of economically important

[1] An example of a highly fungible technology is laser technology (Dougherty, 1992b), which has multiple applications, including data transfer, material cutting, pattern recognition, and addresses a wide range of markets, including medicine, military, consumer electronics, etc.

directions for innovation. Some usage-related problems are idiosyncratic or experienced by only a few users; however, they may be lead users whose needs indicate a broader market trend (von Hippel, 1986). Recognizing which problems will be the most relevant for the organization's future customers is a core innovation capability.

The ability to assimilate information on external customer needs and to make it available within the organization is also crucial for employees' innovative behavior (Simon, 1991; Slater and Narver, 1998). Employees with high need absorptive capacity can frame the external need knowledge within existing cognitive schemes (assimilation), or can build new knowledge structures to accommodate it (transformation) (Todorova and Durisin, 2007), thus enabling its application in the organization's innovation activities.

Need knowledge is often coded in a language specific to the user domain (Mahr and Lievens, 2011). Employees must be able to understand this language and must translate it for the wider organization (von Hippel, 1994). Need knowledge may also be located in user communities that operate according to specific norms, cultures, and rules that must be understood for the firm's employees to be able to decontextualize and distill the most useful pieces of knowledge (Mahr and Lievens, 2011; von Hippel, 2005). Also, some of the problems described by users may be signs of deeper, underlying issues that must be identified and understood to allow users' problems to be addressed. Employees who are able to recognize problems' underlying causes will contribute to innovation by focusing on needs that are crucial for customers (cf. Baer et al., 2013).

Finally, employees' abilities to apply need knowledge will be positively related to their innovative behavior. Employees with such abilities are likely to find solutions to the absorbed problems by mentally combining the newly acquired need knowledge with their own prior solution knowledge, to develop a new product design.

Based on these arguments, we propose that employees with the ability to recognize, assimilate, and utilize external need knowledge are more innovative than those who lack this ability:

H3. Employees' need absorptive capacity is positively related to their innovativeness.

Second, we argue that employees' innovativeness will be positively related to their ability to absorb solutions (Ter Wal et al., 2017). This relationship has received empirical support at the company level (Kostopoulos et al., 2011; Stock et al., 2001; Tsai, 2001), and despite the small number of empirical studies, it is acknowledged that a firm's absorptive capacity related to solutions is rooted in individual employees' capabilities and behaviors (Cohen and Levinthal, 1990; Lane et al., 2006).

To effectively use external knowledge for innovation, individuals must tap external resources and must assess the value of the knowledge to be absorbed (Dahlander et al., 2016). Employees with high solution absorptive capacity are able to identify and evaluate external solution knowledge earlier and more accurately than individuals who lack this capability. Thus, they are more likely to absorb knowledge that is useful for innovation.

Only employees capable of assimilating external solution knowledge are able to exploit it for innovation. Assimilation of knowledge is a prerequisite for innovation, because solution knowledge is coded in specific technical language which must be translated in order to be understood by those in boundary positions between the external environment and the organization (Allen et al., 1979; Tushman and Scanlan, 1981). This ability to assimilate external technological knowledge fosters innovation within the organization (Reid and de Brentani, 2004; Ter Wal et al., 2017).

Finally, employees must have the ability to apply externally acquired solution knowledge in order to innovate. Absorbed solution knowledge can be applied directly to needs identified by employees, or can be made available within the organization to enable others to use it for innovation. In both cases, the ability to implement external solution knowledge is linked to the organization's innovation activity.

Therefore:

H4. Employees' solution absorptive capacity is positively related to their innovativeness.

3. Methodology

3.1. Data collection

We collected the data from several divisions in a large manufacturer of home appliances that has offices and plants around the world, and manufactures products such as ovens, dishwashers, washers, refrigerators, etc. This context was particularly suited to our study goals, since the individuals who work in this industry are likely to have first-hand personal need knowledge and some extent of solution knowledge. This allowed us to explore how need absorptive capacity and solution absorptive capacity are formed and interoperate at the intra-individual level to affect employee innovativeness.

We announced our online survey in an email from the corporate technology office to all division and department managers in the country in which the firm has its headquarters. We then asked these managers to forward the survey link to all their subordinates and to request their participation. At the firm's request, sales agents (but not their supervisors) and shopfloor workers were excluded from the study.

Notably, we did not limit our sample to R&D staff (see also Janssen, 2005; Ng and Feldman, 2012; Reitzig and Sorenson, 2013; Yuan and Woodman, 2010). This acknowledges a view put forward in the creativity research (e.g. Ng and Feldman, 2012) and the innovation research (e.g. Reitzig and Sorenson, 2013), whereby innovative ideas can originate anywhere in the firm, for instance, from frontline employees (Stock, 2015), service workers (Madjar and Ortiz-Walters, 2008), factory workers (Axtell et al., 2000), and individuals across functions who develop ideas in their leisure time (Davis et al., 2013). Ideas need not pertain to the technical core, but can also involve new applications and markets (Yoo et al., 2012). This view is gaining prevalence as digitalization decreases communication costs and allows firms to solicit ideas from all over the firm (Malhotra et al., 2017).

Our sampling approach, which was dependent on the firm's endorsement and distribution, encouraged broad participation and yielded 864 usable answers. However, it limited our ability to calculate an exact response rate. Our contacts at the corporate technology office estimated that approximately 3500 out of the 5000 employees in the various divisions and functions we contacted received our email, a 24.7% response rate. An even higher percentage is obtained if we base our estimate on the number of visitors to the survey site, which is common practice in online surveys (cf. Balka et al., 2014). Given 2674 visitors to our survey site, the response rate became 32.3%.

To mitigate potential biases, we did not force answers and consequently missed some data for our independent variables (4.02%). As a remedy, we employed the expectation-maximization algorithm that uses maximum-likelihood estimates for imputing missing data and is suitable for large sample sizes (Allison, 2001).

To check whether our sample represented the firm's population, we used Armstrong and Overton's (1977) test for non-response bias. Late respondents are assumed to be similar in their response behavior to non-respondents, i.e. to the rest of the population. Thus, if early respondents' response behavior is the same as that of late respondents, the sample can be regarded as representative. Accordingly, we checked whether early respondents (first quartile of respondents) differed from late respondents (last quartile) (Rogelberg and Stanton, 2007). Specifically, we tested whether early and late respondents differed concerning need knowledge, solution knowledge, need absorptive capacity, solution absorptive capacity, function, openness to experience, cognitive style, gender, education, age, tenure, or hierarchy. We also checked whether early and late respondents differed concerning their likelihood

to suggest ideas or the suggested ideas' innovativeness. The only difference that was significant at the 1% level (which is appropriate, given our large sample size) relates to the sales function, since slightly more late respondents were working in sales. We also checked whether our sample was similar to observable variables which were available for the organization as a whole. We find that the mean values for our sample and the whole population are similar (age: our sample 39.7 years, whole firm ~38 years; share of females: our sample 23.7%, whole firm ~30%; tenure: our sample 11.9 years, whole firm ~10 years). Based on these findings, we are confident that our sample is generally representative of the firm's population.

292 respondents worked in development (33.8%), 78 in marketing (9.0%), 37 in sales (4.3%), 51 in operations (5.9%), 42 in human resources (4.9%), and 22 in finance (2.5%). The remainder chose 'other function' or didn't indicate their functional affiliation. This last group acts as a baseline in our analyses.

3.2. Measurement

3.2.1. Dependent variables

Our dependent variable, individual innovativeness, is based on the notion that generating innovative product ideas is a two-step process, with idea generation in the first step and the generated idea's innovativeness in the second step. Following this logic, we used a two-step operationalization of individual innovativeness with idea suggestion in step 1 (Did the individual have any ideas and did they report an idea description?) and the generated idea's innovativeness in step 2 (How innovative was the reported idea?).

We used raters to measure the second part our dependent variable: the reported idea's innovativeness. We asked respondents whether they had one or more ideas for a new or improved product within the past year. We then asked them to "describe [their] most innovative idea − what was the problem and what was the solution". 265 respondents provided idea descriptions in a form that could be rated by all raters. To rate these ideas, we employed Amabile's (1982) consensual assessment technique (CAT), which has been widely used to assess creativity and innovativeness (Dahlander and Frederiksen, 2012; Magnusson, 2009; Mahr and Lievens, 2011). It is based on the premise that individuals sufficiently familiar with a given domain will recognize creativity, and that the combined assessment of several such individuals is a valid measure of creative achievement. Every reported idea's innovativeness was rated independently and in different orders by eight raters − two authors and six other researchers from different backgrounds (e.g. management, economics, industrial engineering, and information systems). According to Amabile (1982, p. 1002), raters should have "some experience with the domain in question". This condition was easily met: all raters had been users of these home appliances for most of their lives, and thus could compare the respondents' ideas to their own prior experience. Also following Amabile's recommendations (1982), the raters were instructed to read the full list of ideas to get a sense of the portfolio before proceeding to assess the comparative innovativeness of each idea on the scale (anchored between 1 = not very innovative and 5 = very innovative). Raters were asked to assess the ideas based on their own criteria for innovativeness (cf. Amabile, 1982). Inter-rater reliability was high: correlation analysis showed that all the judges' ratings were significantly correlated ($p = 0.000$ and $\rho = 0.429$, on average); and Cronbach's α ($\alpha = 0.851$) and the intra-class correlation coefficient (ICC = 0.833) were both well above the critical value of 0.7 (Gwet, 2014). To build scores for innovativeness of the reported ideas, we averaged the rating.

As a result, our dependent variable ranged between 0 and 5 and took the following form: For individuals who said they did not have any new idea, individual innovativeness was assigned the value 0 ($n = 440$). For those who claimed to have had ideas, individual innovativeness was given a value from 1 to 5, reflecting the judge-measured rating of the reported ideas ($n = 265$).

With 705 data points, the final sample (as just described) was smaller than the original sample of $n = 864$ owing to the fact that we could not measure individual innovativeness for individuals who claimed to have had ideas but did not report them. In terms of their innovativeness, this group differed from respondents who reported no ideas, but we could not assign a value to this. We checked whether our findings were robust to the inclusion of this group in the analysis by assigning each individual the average innovativeness of all reported ideas (2.426). The hypothesized effects remained the same in this sample.

3.2.2. Independent variables

Unless stated otherwise, all variables were measured on a 7-point Likert scale (ranging from 1 = "I do not agree at all" to 7 = "I agree to an exceptional degree").

At the start of the survey, we asked which one out of five categories of home appliances the respondent felt most knowledgeable about. These categories matched the product categories offered by the firm. In our measures (described below), "home appliances" was replaced by the product category the respondent indicated at the outset.

For need knowledge and solution knowledge, we used measures adapted from the subjective knowledge scale developed by Flynn and Goldsmith (1999) using three items from the original five-item scale that were appropriate for our purposes. Thus, we measured need knowledge by "I feel very knowledgeable about using home appliances", "Compared to most other employees in this organization, I know more about using home appliances", and "When it comes to the use of home appliances, I really know a lot" ($\alpha = 0.908$). We measured solution knowledge by "I feel very knowledgeable about the technologies in the area of home appliances", "Compared to most other employees in this organization, I know more about technologies in the area of home appliances", and "When it comes to technologies in home appliances, I really know a lot" ($\alpha = 0.953$).

For absorptive capacity, we built on the individual-level measure proposed by Lowik et al. (2012) and adapted it in two directions: First, our study requires a distinction between absorptive capacity for need knowledge and absorptive capacity for solution knowledge. This required us to omit two items that could not be modified to capture this distinction. Second, we used a three-dimensional specification of absorptive capacity, pooling the items for knowledge assimilation and transformation from Lowik et al.'s four-dimensional scale. This is in line with parts of the literature, which consider absorptive capacity to be a three-dimensional construct (e.g. Lane and Lubatkin, 1998; Todorova and Durisin, 2007). Following these adjustments, we retained six items, two each for recognizing, assimilating, and applying new knowledge. These were: "I am always searching for new 'knowledge type' to create new products", "I identify new 'knowledge type' that are most valuable to us", "I translate new 'knowledge type' into a language that my colleagues understand", "I turn existing 'knowledge type' into new ideas", "I exploit new 'knowledge type' to create new products", and "I always consider how to apply new 'knowledge type' to improve products". For each item, we replaced knowledge type by either "application problems and needs" or "technological solutions". We introduced each question with a brief description of need knowledge ("Need knowledge comprises knowledge about problems that occur during product use. Need knowledge encompasses user needs and market opportunities") and solution knowledge ("Technological knowledge comprises knowledge about technologies and techniques to solve problems and therefore satisfy user needs"), respectively. We asked individuals to think about external knowledge only when answering the absorptive capacity questions. The scales for need absorptive capacity and solution absorptive capacity had high α-values: 0.948 and 0.967.

Need absorptive capacity and solution absorptive capacity were highly correlated (0.849) in our sample; we discuss the potential reasons for this correlation in Section 5.2. Although the correlation was below the threshold required for discriminant validity (Harrington,

Table 1
Means, Range, Standard Deviation, and Correlation of our Variables.

		N	Minimum	Maximum	Mean	SD	1	2	3	4
1	Innovativeness	705	0.00	4.50	0.91	1.25				
2	Cognitive style	864	1.00	7.00	5.07	0.98	−0.063			
3	Intrinsic motivation	864	2.00	7.00	6.04	0.91	−0.025	0.481***		
4	Job satisfaction	864	1.00	7.00	5.49	1.32	−0.057	0.344***	0.454***	
5	Openness	864	1.00	7.00	4.68	1.39	0.295***	0.071*	0.178***	0.009
6	Tenure	864	0.00	47.00	11.85	9.23	−0.078	0.082*	0.045	0.045
7	Hierarchy	864	1.00	4.00	1.31	0.56	0.054*	0.001	−0.005	0.055
8	Education	864	2.00	5.00	4.51	0.82	0.140**	−0.049	0.010	0.013
9	Age	864	19.00	64.00	39.66	9.32	−0.011	0.082*	0.025	0.073*
10	Sex	864	0.00	1.00	0.24	0.43	−0.213***	0.012	0.000	0.035
11	Need knowledge	864	1.00	7.00	5.19	1.30	0.319***	0.105**	0.115**	0.044
12	Solution knowledge	864	1.00	7.00	4.69	1.58	0.390***	0.122***	0.091**	0.011
13	Need absorptive capacity	864	1.00	7.00	3.68	1.76	0.514***	0.039	0.094**	−0.015
14	Solution absorptive capacity	864	1.00	7.00	3.59	1.95	0.517***	0.067*	0.101**	−0.011

		5	6	7	8	9	10	11	12	13
1	Tenure	−0.140***								
2	Hierarchy	−0.022	0.195***							
3	Education	0.082*	−0.455***	0.210***						
4	Age	−0.080*	0.682***	0.395***	−0.167***					
5	Sex	0.011	−0.060	−0.119**	0.014	−0.130***				
6	Need knowledge	0.339***	0.033	0.104**	0.117**	0.045	−0.057			
7	Solution knowledge	0.282***	0.081*	0.089**	0.087*	0.098**	−0.322***	0.738***		
8	Need absorptive capacity	0.408***	−0.129***	0.091**	0.217***	−0.055	−0.227***	0.543***	0.619***	
9	Solution absorptive capacity	0.331***	−0.122***	0.008	0.186***	−0.068*	−0.338***	0.433***	0.656***	0.849***

* p < .05 (two-tailed test).
** p < .01 (two-tailed test).
*** p < .001 (two-tailed test).

2008), we conducted several additional analyses: correlation analysis with bootstrapping confidence intervals (Torkzadeh et al., 2003), structural equation modeling (SEM) to check the Fornell-Larcker criterion (Fornell and Larcker, 1981), SEM to check the cross-loadings between need absorptive capacity and solution absorptive capacity (Chin, 1998), SEM to compare a factor model where the correlation is restricted to 1 vs. a model where the correlation was unrestricted (Anderson and Gerbing, 1988), and finally SEM to compare our model with other possible models (cf. Sidhu et al., 2007).[2] All these analyses establish discriminant validity and provide unequivocal support for our conceptualization of need absorptive capacity and solution absorptive capacity as two distinct constructs.

3.2.3. Control variables

Since individual innovativeness is known to be influenced by cognitive style, intrinsic motivation, personality, and contextual influences (Woodman et al., 1993), we controlled for these factors' potentially confounding effects. For cognitive style, we used the associative cognitive style measure, which has three items (Shalley et al., 2009) (α = 0.657): "I am consistent in the way I tackle problems", "I pay attention to the order of the steps needed to finish a job", and "I accept the usual way of doing things". Again following Shalley et al. (2009), we measured intrinsic motivation with three items (α = 0.752): "I take pride in doing my job as well as I can", "I feel a sense of personal satisfaction when I do my job well", and "I feel unhappy when my work is not up to my usual standard". We controlled for the relationship between personality and innovation (Anderson et al., 2014; Baer and Oldham, 2006) by employing two items from the openness to experience subscale proposed by Rammstedt and John (2007) (α = 0.732): "I have many artistic interests" and "I have an active imagination". To account for job-related contextual influences, we used a global job satisfaction measure, asking employees how they generally felt about their jobs (cf. Lee et al., 2008). Additionally, we controlled for employee tenure (in years), hierarchy (1 = employee, 2 = lower management, 3 = middle management, 4 = upper management), and demographic variables, specifically sex, age (in years), and highest educational attainment (1 = less than high school, 2 = high school or equivalent, 3 = technical or vocational school, 4 = college degree, 5 = university degree).

3.3. Checking for common method bias

Our dependent variable was a combination of different sources and is therefore less susceptible to relationships being inflated by common method bias (CMB) (Podsakoff et al., 2003). Still, we took additional care in our study design to minimize this risk (Podsakoff et al., 2003). We checked the wording of our questions with our primary contact person at the company for potential equivocality, assured all participants of anonymity, and used ratings of idea descriptions rather than purely perceptual items as part of our dependent variable (Ng and Feldman, 2012).

We also performed statistical tests on all self-reported constructs that may be affected by CMB, i.e. need knowledge, solution knowledge, need absorptive capacity, solution absorptive capacity, cognitive style, intrinsic motivation, openness to experience, and job satisfaction. First, we used factor analysis to check whether more than 50% of the variance was explained by a single unrotated factor, which would be an indication of CMB (a procedure called Harman's single-factor test (Podsakoff et al., 2003)). We found no evidence of CMB, since the first factor accounts for 39.4% of the variance. Second, we checked for bivariate correlations above 0.9, which would also indicate CMB (cf. Pavlou et al., 2007) and found no evidence of CMB. Third, we applied Lindell and Whitney's (2001) marker variable method. Prior to data collection, we chose a variable that theory suggested to be unrelated to the variables in our study. We chose perceived distinctiveness of the

[2] These analyses are available from the authors upon request.

organization (George and Chattopadhyay, 2005), i.e. the extent to which employees perceive their organization to be distinct from other organizations, and asked our respondents to consider the following statements: "Firm A's culture is very different from that of others in the home appliance industry", "Firm A's business fields are very different from those of others in the home appliance industry", and "Firm A's work processes are very different from those of others in the home appliance industry". Next, we took the smallest correlation of the marker variable with any of our substantive variables (correlation with need absorptive capacity, r = 0.004), and adjusted the correlation matrix by partialling out the correlation of the marker variable (cf. Lindell and Whitney (2001)). We found that all significant correlations remained significant in the corrected correlation matrix, which would not be the case in the presence of CMB. Based on all these tests, we concluded that CMB is not a concern in our study.

4. Results

The descriptive statistics and correlations are summarized in Table 1.

4.1. Antecedents of absorptive capacity

To test the first two hypotheses regarding the antecedents to need absorptive capacity, we used multiple ordinary least square (OLS) regression analysis. We checked for multicollinearity by investigating the variance inflation factors of our coefficients, all of which were below the critical value of 5 (Cohen, 2003). We included function, systematic thinking style, job satisfaction, openness to experience, tenure, hierarchy level, education, age, and gender as control variables.[3] Our results are summarized in Table 2.[4] Need knowledge is positively related to need absorptive capacity ($\beta = 0.134$; $p < .01$), which supports H1a. Solution knowledge is positively associated with need absorptive capacity ($\beta = 0.365$; $p < .001$), as predicted by H2b. This means that need absorptive capacity is nurtured by individuals' knowledge from within the domain, i.e. their prior need knowledge, but also by extra-domain knowledge, i.e. their solution knowledge. The latter finding represents a cross-pollination effect, in which extra-domain knowledge facilitates knowledge absorption in another domain.

Next, we used the same strategy to test our hypotheses related to solution absorptive capacity (see Table 2). In line with H1b, we found a strong and significant relationship between solution knowledge and solution absorptive capacity ($\beta = 0.560$; $p < .001$). We also found a significant negative effect of need knowledge on solution absorptive capacity ($\beta = -0.104$; $p < .01$), which supports H2a. This means that solution absorptive capacity is nurtured by individuals' intra-domain knowledge, i.e. their prior solution knowledge, but not by their extra-domain knowledge, i.e. their need knowledge. In contrast to what we found for need absorptive capacity, we did not find such a cross-pollination effect for solution absorptive capacity. On the contrary, extra-domain knowledge from the need domain attenuates the ability to absorb solutions.

[3] As a robustness check, we also recalculated all our models using dummy variables for hierarchy levels and education levels and added a non-linear effect of age; our findings are robust to this specification. We opted to report the most parsimonious models, using continuous specification of hierarchy, education, and age. We also checked whether our hypotheses are supported for the reduced sample that we employ in Section 4.2. (see discussion about samples in Section 3.1.). All our hypothesized effects remain significant.

[4] Please note that the functional affiliations cannot be compared with the baseline group in a meaningful way because the baseline groups includes "others" as well as employees that did not reveal their function. To check whether there were significant differences between functions we compared the effects of functional groups ex post and find following differences to be significant ($p < 0.05$). Effects on need absorptive capacity: R&D > Sales, Operations, Finance, HR; Marketing > Sales, Operations, Finance, HR. Effects on solution absorptive capacity: R&D > Sales, Operations, Finance, HR, Marketing; Marketing > Sales, HR.

4.2. Individual innovation outcomes of need absorptive capacity and solution absorptive capacity

To investigate the effects of need absorptive capacity and solution absorptive capacity on innovativeness (H3 and H4), we use regression with Tobit estimation. Tobit is a suitable estimation approach, because our dependent variable includes many individuals who did not report an idea, and only those who reported an idea could be judged based on their innovativeness. Thus, our dataset included many cases in which the dependent variable was zero. The results are reported in Table 3.

We found that need absorptive capacity is positively and significantly related to individual innovativeness ($B = 0.313$; $p = .010$), fully supporting H3. Similarly, solution absorptive capacity is positively and significantly related to innovativeness ($B = 0.330$; $p = .003$), in line with H4. The strength of the relationships between need absorptive capacity and innovativeness and solution absorptive capacity and innovativeness is similarly strong, as indicated by the coefficients.

We checked whether our findings for H3 and H4 were robust to other analytical specifications. First, using Poisson estimation, we found that both need absorptive capacity and solution absorptive capacity remain significant predictors of innovativeness ($p < .01$). Second, we used to probit estimation to confirm that need absorptive capacity and solution absorptive capacity are significantly and positively related to the likelihood of an individual reporting an idea ($p < .01$). Third, we used ML Heckman regression (Heckman, 1976) to overcome potential selection bias stemming from the fact that individual innovativeness can only be observed for employees who have reported an idea. The first step in the Heckman model estimates the likelihood of an individual reporting an idea, and the second step estimates the idea's innovativeness based on ratings of the reported idea description. We used cognitive style as instrumental variable.[5] To check our findings' robustness, we used the other variables to estimate both stages of the model. We found a positive significant effect of need absorptive capacity and solution absorptive capacity on both stages of the model ($p < .05$).

To summarize, we found that absorptive capacity from both the needs domain and the solutions domain affect individuals' innovativeness.

5. Discussion

In this study, we sought to advance our understanding of absorptive capacity in knowledge domains other than technological solutions, specifically in the need knowledge domain, and to analyze its principal antecedents and consequences for innovation. Using a large sample of employees in a white goods firm, we tested and confirmed several hypotheses:

[5] Such models require an instrumental variable, i.e. a variable that predicts the selection variable (here: reporting an idea), but not the outcome variable (here: innovativeness based on ratings of the reported idea description). We use systematic thinking style as our instrumental variable and expect it to be negatively associated with the selection variable, i.e. the likelihood of reporting an idea (cf. Clegg et al., 2002). Indeed, we find a significant negative relationship in a logistic regression of idea provision on systematic thinking style ($\beta = -0.142$; $p = .042$). Further, we expect that systematic thinking is not associated with the outcome variable (i.e. innovativeness of the reported idea), since soliciting ideas in a survey is neither particularly structured nor open: systematic thinking style is positively related to creativity in structured creativity tasks, but negatively related to creativity in open creativity tasks (Nijstad et al., 2010; Shalley et al., 2009; Zwick et al., 2017). Indeed, we find an insignificant relationship between systematic thinking style and innovativeness in an OLS regression ($\beta = -0.030$; $p = .435$). We checked whether the use of a Heckman model with systematic thinking style as instrumental variable was appropriate to treat the endogenous sample selection effect. We used a likelihood-ratio test to compare the likelihood of an independent probit model for the selection equation and a regression model against the likelihood of the Heckman model. We can reject the hypothesis that an independent probit and subsequent OLS model would better fit our data ($p = .0267$); thus, our treatment of the selection effect was successful.

Table 2
Regression Results for Antecedents of Need Absorptive Capacity and Solution Absorptive Capacity.

	Need absorptive capacity			Solution absorptive capacity		
	β	p-value	Sig.	β	p-value	Sig.
Sales	−0.065	0.009	**	−0.079	0.001	**
Operations	−0.046	0.065		−0.046	0.049	*
R&D	0.135	0.000	***	0.208	0.000	***
Marketing	0.085	0.001	**	−0.011	0.653	
Finance	−0.041	0.092		−0.042	0.067	
Human resources	−0.081	0.001	**	−0.077	0.001	**
Associative thinking style	−0.011	0.702		0.011	0.670	
Intrinsic Motivation	0.025	0.403		0.037	0.191	
Job Satisfaction	−0.011	0.684		−0.015	0.577	
Openness to experience	0.211	0.000	***	0.154	0.000	***
Organizational tenure	−0.064	0.090		−0.059	0.102	
Hierachical level	0.052	0.062		−0.009	0.738	
Education	0.059	0.044	*	0.054	0.052	
Age	−0.033	0.358		−0.049	0.146	
Gender	−0.077	0.005	**	−0.114	0.000	***
Need Knowledge	0.134	0.000	***	−0.104	0.004	**
Solution Knowledge	0.365	0.000	***	0.560	0.000	***
R^2		0.524			0.573	
adjusted R^2		0.515			0.565	
F-value		54.800			66.910	
Significance F-Test		0.000			0.000	
n = 864						

* p < .05.
** p < .01.
*** p < .001.

Table 3
Tobit Regression Results for Individual Innovation Outcomes of Need Absorptive Capacity and Solution Absorptive Capacity.

	B	SE	p-value	Sig.
Constant	−3.784	1.143	0.001	**
Sales	−1.820	0.763	0.017	*
Operations	0.228	0.446	0.609	
R&D	−0.187	0.384	0.626	
Marketing	−0.173	0.697	0.804	
Finance	−1.542	0.831	0.064	
Human resources	−0.049	0.228	0.831	
Associative thinking style	−0.193	0.116	0.096	
Intrinsic Motivation	−0.248	0.139	0.076	
Job Satisfaction	0.026	0.085	0.763	
Openness to experience	0.315	0.085	0.000	***
Organizational tenure	−0.001	0.018	0.951	
Hierachical level	−0.170	0.213	0.424	
Education	0.143	0.161	0.376	
Age	0.012	0.016	0.477	
Gender	−0.786	0.293	0.007	**
Need knowledge	0.224	0.138	0.105	
Solution knowledge	0.024	0.124	0.844	
Need absorptive capacity	0.313	0.120	0.010	*
Solution absorptive capacity	0.330	0.111	0.003	**
Observations	705			
Log likelihood	−770.038***			
Pseudo R^2	0.159			
n = 705				

* p < 0.05.
** p < 0.01.
*** p < 0.001.

Employees with more prior need knowledge and more solution knowledge had higher need absorptive capacity. Thus, need absorptive capacity is rooted in both intra-domain and extra-domain knowledge. We do not find a symmetric effect in the case of solution absorptive capacity: solution knowledge is positively related to solution absorptive capacity, while need knowledge has a negative direct effect on solution absorptive capacity. Finally, we found that both need absorptive capacity and solution absorptive capacity are associated with higher innovativeness of employees.

5.1. Theoretical implications

Our findings contribute to the literature in several key ways: First, we introduce need absorptive capacity as a mechanism to explain how external need knowledge is identified, assimilated, and applied for product innovation in firms. We argue that it is a necessary yet hitherto under-researched complement to absorptive capacity for technological solutions − the focus of the literature to date (Lane et al., 2006; Volberda et al., 2010). Need knowledge and solution knowledge are known to be two necessary prerequisites for innovation; they need to be co-located within the organization for innovation to occur (Alexander, 1964). In the same way that technological solution knowledge is often located outside a firm's boundaries (Chesbrough, 2003a), need knowledge is also often external (von Hippel, 1994) and must be absorbed and combined before it can be exploited. We have shown that these different knowledge types require theoretically and empirically distinct absorptive capacity types, both of which, on their own, drive innovativeness.

These results advance scholarly thinking about absorptive capacity's domain-specificity. Volberda et al. (2010) and Lane et al. (2006) emphasize the need to distinguish between different absorptive capacity types and their underlying knowledge types. They invite researchers to consider the knowledge type to be absorbed, and challenge the assumption that absorptive capacity is relevant only to the technological domain. This assumption narrows and obscures the construct's original meaning and inhibits research in this field (Lane et al., 2006). We contribute to the research by proposing theoretical arguments and conducting empirical tests to show that prior knowledge in two different domains is related to two different absorptive capacity types.

Second, our results show that absorptive capacity in a domain can be predicated on prior knowledge in a different domain. Such cross-

pollination effects of knowledge on absorptive capacity had to date not been studied. Our finding that prior solution knowledge is associated with increased need absorptive capacity is particularly intriguing. We explain this effect by arguing that solution knowledge structures provide a schema for the absorption of new need knowledge, building on the notion of fungibility of technological knowledge for different applications (Danneels, 2007). Our findings suggest that solution knowledge, in addition to increasing innovation output and intra-domain solution absorptive capacity (Cohen and Levinthal, 1990; George et al., 2001), has the additional effect of facilitating the absorption of external extra-domain knowledge, specifically new need knowledge. In this sense, referring to Cohen and Levinthal (1989), we describe need absorptive capacity as the third face of R&D.

Conversely, we also found negative attenuation effects across knowledge domains, such that prior knowledge in a given domain is associated with lower absorptive capacity in another domain. Thus, we found prior need knowledge to be negatively related to solution absorptive capacity. Individuals with more need knowledge tend to be less able to bring external solutions into the firm than those with little need knowledge. We have argued that this effect is rooted in the fact that need knowledge does not provide cognitive structures for the absorption of solution knowledge, only for the absorption of need knowledge. Since cognitive resources are limited, higher attention to the absorption of need knowledge inhibits the absorption of solution knowledge.

To summarize and generalize, we expect knowledge from domain X to increase the absorptive capacity for knowledge from domain Y, if this knowledge of X provides schemata for the interpretation of knowledge Y, i.e. a cross-reference to the other knowledge domain (Harris, 1994). Conversely, knowledge structures that do not provide such a cross-reference sustain absorptive capacity in their native domain X only, and may even diminish absorptive capacity for other domains, because individuals' attentional and perceptive capabilities are limited. Building knowledge in one domain will lead to increased attentional and perceptive capabilities for this specific domain (Helfat and Peteraf, 2015). However, superior knowledge in this domain may also lead to cognitive entrenchment and to reduced receptiveness to ideas from other domains (Dane, 2010), if it does not provide cognitive references to those other domains. In this case, individuals with deep knowledge in one domain are likely to focus all cognitive resources, attention, and effort on absorbing knowledge from that domain, which makes it harder for them to engage in other knowledge absorption types. Overall, these considerations provide a cognitive explanation for the conditions under which extra-domain knowledge has a positive or negative effect on knowledge absorption in another domain, opening up opportunities for future research on extra-domain effects between knowledge domains.

Third, our conceptualization of need absorptive capacity informs work on the management of demand-driven innovations initiated outside the firm (Anderson et al., 2014; Priem et al., 2012; von Hippel, 1994). This literature points out that a large share of innovation originates outside the firm's boundaries in the form of open innovation (Chesbrough, 2003a,b), customer co-creation (Gemser and Perks, 2015; O'Hern and Rindfleisch, 2009), or user innovation (von Hippel, 1986; von Hippel, 1988). Especially when external ideas stem from the user domain, they are very different from intra-firm ideas (Poetz and Schreier, 2012) and are hard to understand and absorb by firms. Here, Priem et al. (2012, p. 365) point out that "given that user innovations typically occur outside established firms, [a] key question is, how should established firms should obtain and manage user-based innovations". Our research has provided insights into this question, and suggests that need absorptive capacity facilitates the passage of user-developed innovations into the producer firm. This is supported indirectly by a number of studies that show that entities inside the producer organization, whether individuals (Schweisfurth, 2017; Schweisfurth and Raasch, 2015) or business units (Block et al., 2016; Roy and Cohen, 2015; Roy and Sarkar, 2015) that have situated need knowledge, drive innovativeness. Need absorptive capacity can be seen as a mediator between such situated need knowledge and innovation as well as serving as a theoretical explanation of this effect.

5.2. Limitations and future research

Our study has limitations. First, the correlation between need absorptive capacity and solution absorptive capacity in our data is fairly high. We conducted extensive tests that uniformly confirmed discriminant validity. Still, our data's specificity, which we attribute to our sampling strategy, merits further consideration. Employees in the home appliances industry are almost always users of their firm's products. For this reason, they are very likely to possess need knowledge and need absorptive capacity. At the same time, the technologies incorporated in home appliances are relatively accessible to non-experts and are not overly complex, at least in relation to their general principles. Most of our respondents were well educated and have likely accumulated some understanding of how the appliances they use in their homes and work on in their jobs actually function. In other words, they are particularly likely, compared to employees in other industries, to have both usage and technological experience. The situation would be different in the case of firms operating in a business-to-business context, for instance. Employees in firms that comprise upstream and downstream business units are unlikely to have both usage and technological experience, and need absorptive capacity and solution absorptive capacity are likely to be organizationally separated in the user unit and the manufacturing unit.

More generally, the cross-sectional nature of our data precludes causal inferences. However, we are confident that the implied causality is correct, since our model follows the understanding well established in the literature of the direction of causality among prior knowledge, absorptive capacity, and innovative outcomes (Cohen and Levinthal, 1990; Volberda et al., 2010). Future studies should use longitudinal data to investigate learning effects in greater detail.

In our view, there is an important opportunity for researchers to broaden the focus in the literature on solution absorptive capacity, to other knowledge domains and other absorptive capacity types and an understanding of their interrelationships. In relation to innovation, need absorptive capacity is a necessary complement to solution absorptive capacity. Both capabilities accrue at the individual level, but can be expected to aggregate to higher levels. These aspects warrant in-depth analysis. At the individual level, we need to understand how contextual factors can leverage absorptive capacity's effect on employee innovativeness. Factors such as leadership style, job autonomy, and organizational culture, among others, will change the extent to which employees can use the absorbed external knowledge for innovation, and will therefore moderate the relationship between individual absorptive capacity and employee innovativeness. Organization researchers may find it fruitful to investigate how need absorptive capacity and solution absorptive capacity inter-operate at higher levels (cf. Backmann et al., 2015). Exploration of the collective mechanisms that coordinate need absorptive capacity and solution absorptive capacity, and those that promote their aggregation at the organizational level, would seem particularly promising. It is also worth investigating the extent to which these two capabilities are complements or substitutes in terms of their effects on organizational innovativeness. This would shed light on the optimal configuration of need absorptive capacity and solution absorptive capacity for company innovativeness.

Moving from aggregation to disaggregation, future research could explore how need absorptive capacity differs depending on the sources of the knowledge to be absorbed. For instance, to absorb knowledge from new customer segments, a firm's need absorptive capacity must be sufficient to support search breadth, while the absorption of knowledge from existing customers seems to require greater depth of absorptive capacity. It may also be the case that the different need absorptive capacity types are nested in different functions within the organization, and are built by different mechanisms.

5.3. Managerial implications

We have developed the notion of absorptive capacity for need knowledge, and have stressed its importance for innovation. To innovate, organizations must focus on recognizing, valuing, and utilizing external knowledge about new technologies and emerging customer needs. Our findings suggest that there are two pathways to build absorptive for need knowledge: One via prior need knowledge and one via prior solution knowledge. Both types can create blockbuster innovations.

The first path is exemplified by the case of stain-free deodorants produced under Beiersdorf's Nivea brand (Lakhani et al., 2014). The development of the stain-free product idea, which later proved to be the most successful deodorant launch ever and turned into an entire product line, was driven by a scientist and leader of prototype development for whom shirt stains created by the combination of deodorant and sweat were a personal problem. He soon realized that this was a more general problem and began to search for solutions while conducting more systematic market research. His observation of a personal need helped to save more than a year of market research efforts normally required for generating new customer need insights. In other words, his prior deep need knowledge facilitated the identification of new needs. This is a common phenomenon in many consumer goods industries, where employees are likely to possess rich personal need knowledge; some may even be lead users.

The second path to need absorptive capacity, based on prior solution knowledge, is exemplified by the case of shockwave lithotripsy (Gelijns and Rosenberg, 1995). In the 1960′s, engineers of Dornier, a German aircraft manufacturer, were investigating how shockwaves caused by micro particles destroyed surface factors of aircraft. They soon realized that such waves destroyed solid material, but travelled through soft material like tissue without doing harm or losing substantial energy. This lead to the insight that the technology could be used to destroy unwanted solids in the human body such as kidney stones. Dornier, in collaboration with local physicians, developed the first shockwave lithotripter for kidney stones and entered the medical application area as a new market segment. At the time, Dornier's device was approved in the U.S. as "an authentic modern miracle" (Mulley 1986), and shockwave lithotripsy is now the standard procedure for treatment of kidney stones. Such innovations, where technological knowledge facilitates the identification of new application areas that satisfy customer needs, are called exaptations and represent a crucial innovation type in some industries, such as pharmaceuticals (Andriani et al., 2017).

Our findings suggest that individuals with strong technological knowledge may well be able to absorb new need knowledge from outside an organization and may well apply it to produce innovation. This finding provides a complementary perspective on R&D, which we suggest involves more than the development of technological products and the building of technological knowledge; in many industries, it also involves the promotion of innovation based on the absorption of external needs, representing the third face of R&D.

At the same time, this is not to say that solution knowledge can replace need knowledge as a feed-stock of need absorptive capacity. Rather, we may speculate that need absorptive capacity may produce different outcomes, depending on whether it originates from need knowledge or from solution knowledge. Employees whose need absorptive capacity originates from deep prior need knowledge are more likely to absorb customer needs that are related to existing customer segments or to their own usage experience. In contrast, employees who draw on solution knowledge to absorb new need knowledge for innovation may tend to explore new customer segments, i.e. have greater search breadth. Thus, both need and solution knowledge will likely trigger different innovation types based on the acquired external need knowledge.

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