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Organizational knowledge creation and the generation of new product ideas: A behavioral approach

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ABSTRACT

In this paper, we address the pre-project phase of idea generation in the product innovation process, where the effective generation of new product ideas still remains an issue of high relevance for both management scholars and practitioners. We relate Nonaka and colleagues' four knowledge creation modes of socialization, externalization, combination, and internalization to the novelty of product ideas generated. Taking a behavioral perspective on the four modes, we posit positive relationships between socialization as well as internalization and the novelty of product ideas, whereas we postulate negative relationships for externalization as well as combination. Using data from multiple respondents in 33 companies, our results confirm the proposed linkages.

1. Introduction

A new product cannot emerge without new product ideas (Koberg et al., 2003; Tauber, 1972). But just how new product ideas are effectively generated still remains an issue of high relevance for both management scholars and practitioners. In our research, we regard organizational knowledge creation processes as a means to advance the generation of novel product ideas (Davenport and Prusak, 1998; Popadiuk and Choo, 2006). This is based on the notion that the generation of *new* ideas is based on *new* knowledge (Woodman et al., 1993).

Numerous authors have investigated the general relationship between knowledge creation and innovation (Popadiuk and Choo, 2006; Helfat and Raubitschek, 2003; Pitt and Clarke, 1999; von Krogh et al., 2000). Further, the link between knowledge creation and idea generation was established conceptually by McAdam et al. (2006), whereby they understand knowledge creation in the sense of knowledge acquisition and thus focus on questions of access and integration of external knowledge sources. However, the literature on how processes of organizational knowledge creation advance the generation of new product ideas is extremely limited (Nonaka et al., 1994, 2000; Nonaka and Takeuchi, 1995; Lee and Choi, 2003).

In this paper, we refer to Nonaka and colleagues' four modes of organizational knowledge creation, i.e., socialization, externalization, combination, and internalization (Nonaka et al., 1994, 2000, 2006; Nonaka and Takeuchi, 1995). These authors have discussed the relationship between knowledge creation and idea generation, focusing on the knowledge creation mode of socialization in the idea generation phase of the innovation process. Their discussions, however, are neither tested empirically nor do they elaborate in detail the possible relationships of the other three knowledge creation modes with the generation of new product ideas. By contrast, a first empirical study by Lee and Choi (2003) on Nonaka's conceptual framework argues for, and finds, positive relationships between the four different knowledge creation modes. They conceptualize the four knowledge creation modes as related aspects of a unitary construct, termed 'organizational cre-

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ativity', measured as an organization's capability to create novel and useful ideas. These authors, however, do not specify hypotheses at the level of the four knowledge creation modes. Recognizing the profound behavioral differences underlying the four modes of knowledge creation (Schulze and Hoegl, 2006), such conceptual aggregation of the four knowledge creation modes seems questionable. Moreover, Lee and Choi's measures of the knowledge creation process relate to the degree to which the organization promotes or stresses task activities, rather than the degree to which these activities were performed during the idea generation phase of specific new product endeavors.

The objective of our research is to provide a more detailed understanding of the relationships between the four knowledge creation modes and an organization's ability to create novel product ideas. As such, this study addresses significant gaps in the literature.

First, our research builds on Nonaka's theory of knowledge creation by specifying how all four knowledge creation modes operate to increase or decrease the generation of novel product ideas. Hence, our analyses go beyond Nonaka's framework, which focuses on the knowledge creation mode of socialization and its role in organizational idea generation. Likewise, we disagree with Lee and Choi (2003) that all four of them should have uniformly positive effects on organizations' abilities to generate novel ideas. Rather, we take a more refined and differentiated approach than Lee and Choi (2003) by recognizing both positive and negative relationships of the knowledge creation modes and the novelty of product ideas.

Second, our study addresses the pre-project phase of idea generation in the product innovation process, a context that has thus far received only very limited research attention. While organizations usually provide a general direction for idea generation, defining product ranges, technologies, or customer needs for which novel product ideas are sought, this stage typically lacks well-defined processes, reliable information, and proven decision rules. Therefore, it has also been termed the "fuzzy front end" (Smith and Reinertsen, 1991; Dahl and Moreau, 2002) and is often classified as unstructured (Goldenberg et al., 1999; Tauber, 1972). This research aims to shed light on this highly relevant but under-researched phase of the product innovation process.

2. Theory

2.1. Novelty of product ideas

Research on idea generation for new products is mainly centered on the notion of creativity, comprising the elements 'new' and 'valuable' (Amabile et al., 1996; Thompson, 2003). Our investigation focuses on one of these two dimensions, i.e., the novelty of product ideas. We define novelty of product ideas, this study's dependent variable, as the degree to which product ideas are new and different from existing products (Goldenberg et al., 1999; Koberg et al., 2003). As such, less novel, i.e., incrementally new, product ideas pertain to marginal improvement over or differentiation from, existing products, whereas novel product ideas can be described as fundamentally different from current products. While we recognize that often incrementally new products have very significant economical consequences, in our research we focus on novel product ideas and novel products as one of the essential bases for long-term competitiveness (Henderson and Clark, 2001).

We do not address value assessments of product ideas, as they risk to be highly subjective and domain specific, e.g., an idea may be highly valuable to one company while almost worthless to another given differences in organizational strategies and capabilities (Ford, 1996; Vissers and Dankbaar, 2002). Acknowledging that novel ideas by themselves may not be a sufficient variable to evaluate organizational idea generation, we consider novelty as a necessary condition to conceive differentiated products providing for a competitive distinction and hence create and maintain competitive advantage.

2.2. Organizational knowledge creation

This study builds on the conceptualization of organizational knowledge creation as proposed by Nonaka and several co-authors (Nonaka, 1994; Nonaka et al., 1994, 2000; Nonaka and Takeuchi, 1995). These authors specify four knowledge creation modes as the processes of interplay between tacit and explicit knowledge that lead to the creation of new organizational knowledge: socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit). This concept is also often referred to with the acronym SECI, resulting from the first letters of the four knowledge creation modes.

Nonaka's discussion of the four knowledge creation modes pertains chiefly to the organizational level of analysis, i.e., organizations as innovation systems with a generic product development process from idea generation to market launch. Likewise, we focus our conceptual and empirical analyses on the organizational level, recognizing that for the largely unstructured idea generation phase, the organization provides the primary context for the performance of the knowledge creation modes.

Socialization yields new tacit knowledge that is built through *informal* interaction, i.e., through an exchange of tacit knowledge. It occurs by spending time together, making joint hands on experiences, working in the same environment, and in informal social meetings (even outside the workplace) between members of an organization. *Externalization* is an act of codifying or converting tacit knowledge into explicit knowledge, characterized by more *formal* interactions such as expert interviews or the sharing of lessons learned in a previous project. *Combination* refers to the process by which sense is made of the relations between previously unrelated knowledge domains. It involves collecting, editing, sorting, and synthesizing existing explicit knowledge and subsequently disseminating the new knowledge. *Internalization* is the process of applying explicit knowledge, thereby absorbing, embodying, and converting it into individually held tacit knowledge. This can be done by either experiencing i.e., by day-to-day work, or by experimenting i.e., trial-and-error activities or guided testing (Kale and Singh, 1999; Nonaka et al., 2000; Zahra and George, 2002).

Nonaka and colleagues also argue that the four knowledge creation modes cannot be clearly separated as single isolated steps progressing in sequential order. While the theory specifies four distinct knowledge creation modes, in reality they are reiterative and overlapping. However, in order to be able to analyze and understand the complex process of knowledge creation, a conceptual distinction between the four modes of knowledge creation is necessary and provides the basis for the hypotheses and their quantitative empirical testing.

Below we motivate hypotheses linking the knowledge creation modes with the novelty of product ideas generated. It is important to note that our arguments pertain to the different knowledge creation modes as sets of behaviors (Cyert and March, 1963), rather than to the benefit or detriment of tacit or explicit knowledge in the idea generation phase of the new product development process. Also, tacit and explicit knowledge are two extremes along the same continuum and in reality, knowledge will hardly be entirely of one type or the other. Hence, the basis for our arguments is not the distinction between tacit and explicit knowledge, but instead the different behaviors characterizing the four knowledge creation modes as described by Nonaka and Takeuchi (1995).

2.3. Hypotheses

2.3.1. Socialization and the generation of novel product ideas

We argue that socialization is positively related to the generation of novel ideas. In today's world, it is unlikely that comprehensive new product ideas are developed by a single person. Rather, a number of people are involved, and it is the stimulation of the 'requisite variety' of sparks and the coalescence of those sparks into ideas that permit focus on actionable next steps (Leonard and Sensiper, 1998). According to several scholars, informal and face-to-face interaction of individuals, especially with different backgrounds (e.g., company representatives, lead users), gives rise to novel product ideas (Quinn et al., 1997; Van De Ven, 1986; Peltokorpi et al., 2007). When a group of individuals addresses a common challenge, each skilled person frames both the problem and its solution by applying the mental schemata and patterns he or she understands best. The result is a cacophony of perspectives, whereas these varying perspectives foster 'creative abrasion' (Kanter, 1988; Hargadon and Sutton, 1997; Henderson and Clark, 2001). However, especially a diversity in background, as it is given by representatives of different departments, can also pose challenges to effectiveness and efficiency of discussions and decision-making processes (Miller and Morris, 1998) as it may lead to disagreement over strongly held preferences and beliefs that can hardly be reconciled (Hännien and Kauranen, 2006).

Convergence is needed and happens by discussion and dialogue of employees where thoughts are exchanged informally, building on trust and informal networking as key-preconditions (Leonard and Sensiper, 1998). This group work leads from creative sparks to novel ideas (Johannessen et al., 1999; Armbrecht et al., 2001). Nonaka and Takeuchi (1995) report a practice at Honda, where team members shared their sparks and discussed the question of what an ideal car should evolve into, often over Sake and away from the office. Referring to informal gatherings and meetings outside the company, the example of Honda describes socialization, which leads to the conversion of creative sparks that people have picked up and thereby supports the creation of ideas for a novel product. Emphasizing intraorganizational socialization, O'Connor and McDermott (2004) point out that "[. . .] radical innovations thrive on informal networks [. . .]."

Overall, we argue that socialization gives rise to novel product ideas in two ways: by stimulating sparks and by taking them further. Our prediction is consistent with Nonaka and Takeuchi (1995) and others (Popadiuk and Choo, 2006; Peltokorpi et al., 2007), who propose that the idea generation phase of the innovation process largely corresponds to socialization and with it, a deep informal interaction among people. Hence, we hypothesize:

Hypothesis 1. Socialization is positively related to the novelty of product ideas.

2.3.2. Externalization and the generation of novel product ideas

We argue that externalization is negatively related to the generation of novel product ideas. While capturing customers' current needs and desires is imperative for understanding how products should be modified to meet market needs, it mostly represents the market reality at this specific time only. "When a customer's needs are solicitated in writing or through constrained dialogue [. . .], and delivered to product developers in compressed form, critical information may be missing." (Leonard and Rayport, 1997: 104). For example, customers are so accustomed to current conditions that they do not think to ask for a new solution—even if they have real needs that could be addressed. Habit tends to inure them to inconvenience. They create 'workarounds' that become so familiar, people forget that they are being forced to behave in a less-than-optimal fashion—and thus they tend to be incapable of telling market researchers what they really want (Leonard and Rayport, 1997). This is likely to be also true for lead users who "develop a solution to a need [and] might well have solved their problem and no longer feel that need." (von Hippel, 1986: 800). Since many wants lie beneath the surface and users are not willing or able to express wants and needs for nonexistent products, this gives a poorer indication of future market needs (von Hippel, 1986). Hence, relying on the method of asking buyers to describe potential future products, big leaps to novel product ideas are generally not likely (Leonard and Rayport, 1997; Leonard and Sensiper, 1998; Goldenberg and Mazursky, 2002). This applies to metaphors and images as well, which are purposefully used to better understand and elicit other's thinking in a nonverbal way (Coulter and Zaltman, 1994). While it is valuable to investigate on current perceptions of, e.g., a brand image and its potential extension, the results are ideas with a character of more incremental improvement.

To resolve this dilemma and actually utilize the potential for novel product ideas provided by 'ordinary' as well as 'lead' users a set of techniques called 'empathic design' has been proposed by Leonard and Rayport (1997). However, its foundation is observation in the field—watching consumers using products or services, thus exchanging tacit knowledge through an informal activity. This, in turn, is much more indicative of socialization.

Also, an emphasis on externalization with employees is likely to be counter-productive in the early idea generation stage as formal meetings are being called while the phase is known as a fuzzy one and participants are yet neither ready to frame (i.e., formulate) their ideas nor to create detailed descriptions of them. Hence, individuals are guided by already existing products, which may also be presently successful on the market, reinforcing the tendency to "stick to a winning formula". Dahl and Moreau (2002: 56) bring this phenomenon to the point: "Because generating new ideas is cognitively demanding [. . .], people will simplify the task by using [close] analogies that come readily to mind." Thus, the results are ideas with a character of incremental improvement.

Moreover, the thoughts that are expressed in formal meetings and expert interviews at this stage may disengage the participants rather than draw them closer together. For instance, as representatives from R&D, manufacturing, and marketing gather in a meeting room to develop promising novel product ideas by collectively expressing their thoughts, individuals possessing newly gathered sparks of knowledge may fear trying to express 'the inexpressible' in a formal setting to people with different (professional) backgrounds (Leonard and Sensiper, 1998). Further, none of the parties may yet be able to translate their thoughts formally into meaningful contributions to the discussion. This, in turn, likely leaves the participants with a sense of confusion and a lack of direction as to how to proceed from here, resulting in less engagement and interaction among key knowledge contributors from different areas. In this way, a potentially interesting spark might be discarded even before it is developed into a novel product idea (von Krogh et al., 2000; Crawford, 1997).

While such initial sparks provide a good starting point which can be taken further, e.g., by socialization, externalization at this point will rather hinder novel ideas to emerge. Such more formal, planned approaches (e.g., formal interviews with customers or experts) are likely to be associated with the generation of ideas for incremental modifications of existing products (Koberg et al., 2003). Therefore, we hypothesize:

Hypothesis 2. Externalization is negatively related to the novelty of product ideas.

2.3.3. Combination and the generation of novel product ideas

Collecting, editing, sorting and synthesizing explicit knowledge gives rise to systematized knowledge, such as explicitly stated technologies, product specifications, or manuals, and has been called 'lateral or kaleidoscopic thinking' (Kanter, 1988; Wielemaker et al., 2003). Kaleidoscopes allow people to shake reality into a new pattern. Here, the idea generation process is initiated by referring to existing, rather than to imaginary product features (Goldenberg et al., 1999), favoring incremental product ideas.

At the same time, such editing likely hinders the creation of novel product ideas. As Henderson and Clark (2001) emphasize, pure re-combination of existing parts must lead to incremental innovation. The sole synthesis of familiar technologies in a new way is not sufficient. For the generation of truly novel product ideas, organizations must actively create knowledge about alternative components, not only knowledge of new combinations of existing, thus familiar, components. But the effort to construct original ideas (components) can be arduous and as soon as descriptions of existing products are presented, the originality of people's ideas is significantly reduced, even though their access to documents of multiple knowledge domains may not be constrained (Dahl and Moreau, 2002; Kogut and Zander, 1992).

However, imagination is needed in visualizing the product (Dahl and Moreau, 2002; Tauber, 1972). But the more existing knowledge is provided by documents – instead of people – the lower is the ability to imagine novel products or product features. As we aim at the creation of new and different (i.e., novel) product ideas, the activity of (re)combining existing knowledge by collecting, editing, and sorting will not lead to the expected output of novel ideas. Instead, while combination increases the probability of incremental ideas, it simultaneously decreases the probability of novel product ideas (Dahl and Moreau, 2002). Hence, we propose:

Hypothesis 3. Combination is negatively related to the novelty of product ideas.

2.3.4. Internalization and the generation of novel product ideas

We argue that internalization, i.e., the absorption of existing knowledge to create new tacit knowledge, supports the generation of novel product ideas. Knowledge created by internalization can also be understood as visceral knowledge, which includes a vivid image of the product in use and a deep sense of the nuances of user problems and how the technology can solve those problems (Dougherty, 1992; Kanter, 1988). Visceral knowledge is richly grounded in professional know-how, gained by product innovators during their day-to-day work, i.e., extensive experience, but also by experiments, which help them to conceive ways in which they can create 'something useful' for potential customers. To tell technical people, for example, that the product should be 'easy to use' does not provide much insight into how easy, nor what use; internalization does (Dougherty, 1992; Kanter, 1988).

By experiencing, e.g., experimenting with existing products and their use, individuals acquire knowledge of the applied technologies for use in both current and future idea generation (Brown and Eisenhardt, 1997; Hatten and Rosenthal, 2000; Helfat and Raubitschek, 2003; Koberg et al., 2003; Leonard and Sensiper, 1998; Monteverde, 1995; Van De Ven, 1986). They acquire intimate knowledge of the limitations and possibilities of technologies beyond

what they might have learned by only talking about, looking at, or reading about those technologies (Dougherty, 1992; Hargadon and Sutton, 1997). As such, internalization entails trial-and-error simulations to gain a deep rooted comprehension of the logic or the functioning of an initial spark (Helfat and Raubitschek, 2003; Leonard and Sensiper, 1998). Experimenting utilizes existing knowledge in order for new ideas to emerge (Wielemaker et al., 2003). However, internalization differs from combination, with the latter referring solely to the editing and synthesis of documenting knowledge, whereas internalization pertains to the absorption of such knowledge to create new knowledge.

By internalization, product innovators come to imagine the product in use, develop a real sense for problems that a novel product can potentially solve for customers, see how customers perceive value, appreciate what customers' preferences and decision-making processes are, and understand how to specify customer needs in terms of technologies and manufacturing processes. A realistic sense of the customer's actual environment from the perspective of all functional expertise then contextualizes the fertile ground which brings about novel product ideas. Therefore, we propose the following:

Hypothesis 4. Internalization is positively related to the novelty of product ideas.

3. Methods

3.1. Sample and data collection

A total of 33 firms from Germany, Austria, and Switzerland participated in this research. The companies span across multiple industries including industrial/mechanical equipment (11), electrical products (9), medical devices (2), automotive/transportation (9), and information and communication technologies (2). Aiming at comparability, we concentrated on ideas pertaining to physical products. For example, internalization activities carried out by experiments are likely to differ significantly depending on whether they pertain to physical products or services. The unit of analysis for this research is the organization. Rather than referring to the entire organization in our data collection, we gathered data on the idea generation phase preceding multiple new products recently developed. This provided a more specific frame of reference for respondents to assess the knowledge creation modes and the novelty of product ideas; rather than referring abstractly to the whole organization. Tests for consistency of evaluations across projects from each organization (James et al., 1984) confirmed the organization-level nature of the variables investigated. Both the knowledge creation modes and the novelty of product ideas are largely similar across projects of each respective organization, with the inter-rater agreement coefficient at .75 or higher. All variables were aggregated to the organizational level for further analyses ($N = 33$).

We asked the companies to provide us lists of all novel products launched onto the market within the last three years which met the following criteria: physical product, rather than software; novel product, rather than upgrade of existing product; generally complex product, rather than, e.g., rivets and screws as simple components of other products. To ensure a common understanding of these criteria, the companies were provided with a guiding definition. From the project lists, up to five products per firm (ranging from one to five) were chosen for data collection based on the above criteria. Some companies had only one or two products that fit the criteria, while the upper limit was intended to ensure that no firm dominated the sample. On average, three products per firm were included. A total of 94 products were selected as the basis for data collection.

The companies internally communicated their participation in this research and authorized their employees to participate at their own discretion. Contact details of the individuals actively involved in the idea generation phase for the new products were provided by the companies. A total of 188 standardized questionnaires were sent out via email (i.e., 94 for the evaluation of the knowledge creation modes, and 94 for the assessments of the novelty of product ideas). Of these, 185 usable questionnaires were returned, for a response rate of 98.4%. The three missing (i.e., not returned) questionnaires were employees' evaluations of the knowledge creation modes during idea generation. This research draws on data from multiple respondents. We collected data on the four modes of knowledge creation from employees who were actively involved in the idea generation phase. Managers overseeing new product development were asked for their evaluation of the novelty of the ideas generated pertaining to the respective products. For 59 out of 94 projects, the respondents for the knowledge creation modes and the novelty of ideas were different, i.e., one person answered regarding the knowledge creation activities and a different person answered regarding the idea generation output. As for the other cases, one person was the most knowledgeable respondent for both subject matters, hence answered both questionnaires for a project.

3.2. Measures

3.2.1. Dependent variable: novelty of product ideas

The dependent variable of this research is the novelty of product ideas. We have employed a three-item measurement scale that captures the degree to which the generated ideas for a particular product or its components and features were new and different from existing products (3 items, Cronbach's Alpha = .80). The three items (all on a five-point rating scale) refer to novelty aspects such as newness to the company itself, to the company's current customers, and to the market as a whole. The items of this scale show reliability, yet are to be regarded more appropriately as an index, since different aspects of product ideas are considered. They are included in the Appendix A.

3.2.2. Independent variables: knowledge creation modes.

We measure the four knowledge creation modes using the scales specified and validated by Schulze and Hoegl (2006). The items pertaining to *socialization* assess informal interactions and exchanges between individuals (4 items; Cronbach's Alpha = .83). The measurement scale for

Table 1
Descriptive statistics and correlations

	Item	Alpha	Mean	Standard deviation	(1)	(2)	(3)	(4)	(5)
(1) Novelty of product ideas	3	.80	3.65	.54					
(2) Socialization	4	.83	3.41	.70	.20				
(3) Externalization	4	.78	3.60	.63	.00	.56			
(4) Combination	4	.71	3.11	.61	−35	.25	.41		
(5) Internalization	4	.74	2.78	.70	.43	.29	.45	13	
(6) No. of employees	–	–	11,030	2257	.37	.19	.09	−45	32

$N = 33$ (companies).

externalization refers to formal codification including interviews with knowledgeable individuals and the creation of detailed descriptions (4 items; Cronbach's Alpha = .78). The indicators for *combination* highlight the systematic collection and processing of existing knowledge from various sources whereas editing can only be done when knowledge is codified (4 items; Cronbach's Alpha = .71). The items for *internalization* assess the creation of individual tacit knowledge (4 items; Cronbach's Alpha = .74). The measurement scales for the four knowledge creation modes are documented in the appendix of this article. For all variables, dependent and independent, multiple items were aggregated to form variables by calculating the arithmetic means. Table 1 provides descriptive statistics and correlations among all variables.

3.2.3. Control variables

Given that this study includes projects from different industries, we control for any effect that industry might have by including dummy variables in our analyses. This procedure effectively controls for all constant and unmeasured differences across industries that may explain differences in the variables and the relationship investigated.

Moreover, we control for the size of the organization in terms of number of employees. As firms become larger, "structural rigidity and inertial forces increase, potentially constraining the ability of the organization to innovate" (Koberg et al., 2003). Thus, the number of people in the firm is an important structural variable with potential influence on employees' knowledge creation processes targeted at generating novel ideas.

4. Results

In testing our hypotheses, we conducted regression analyses with pairwise exclusion in case of missing data. Collinearity statistics calculated for all regression analyses do not indicate distortions of results due to correlation among independent variables (variance inflation factor is below 3).

Table 2 summarizes the results from the regression analyses, which provide support for our four hypotheses. The findings document positive relationships of both socialization (Hypothesis 1) and internalization (Hypothesis 4) as well as negative relationships of externalization (Hypothesis 2) and combination (Hypothesis 3) with the novelty of product ideas.

5. Discussion

This research shows that socialization and internalization positively relate to the novelty of product ideas, whereas externalization and combination negatively relate to the novelty of product ideas. As such, our study shows that all four knowledge creation modes have significant relationships (positive and negative) with novel product ideas generated and that the idea generation phase is not exclusively dominated or influenced by only one knowledge creation mode (socialization), as Nonaka and Takeuchi's (1995) framework tends to suggest. Moreover, this study critically challenges the findings of Lee and Choi (2003) showing that the four knowledge creation modes are not uniformly positive with regard to the novelty of product ideas developed. Taken together, this research has important theoretical and empirical implications, both contrasting and integrating with prior contributions.

5.1. Theoretical implications

Socialization was found to be positively related to the novelty of product ideas. This finding is consistent with earlier conceptual arguments and related empirical research (Armbrecht et al., 2001; Kanter, 1988; Lee and Choi, 2003; Leonard and Sensiper, 1998; Nonaka and Takeuchi, 1995; Van De Ven, 1986). The results also support Boisot (2002), who emphasizes that intense group interaction at the work-

Table 2
Regression analysis

Hypotheses	Independent variables	Dependent variable, novelty of product ideas
	Industry 1 (medical devices)	.14
	Industry 2 (info. and comm. tech)	−.41*
	Industry 3 (ind./mech. equip.)	.24+
	Industry 4 (auto./transport.)	−.03
	No. of employees	.26
Hl(+)	Socialization	
Hl(−)	Externalization	−.38*
Hl(−)	Combination	−26+
Hl(+)	Internalization	.52**
R-square		.60
F		3.90**

$N = 33$ (companies).
+ Significant at the 0.1 level.
* Significant at the 0.05 level.
** Significant at the 0.01 level.

place can trigger novel ideas in the heads of participating individuals. Moreover, our findings support literature and results of experimental studies, which question the validity of the formalized approaches that have been used for idea generation, like brainstorming (Tauber, 1972), and which propose informal interaction of individuals, especially of those with different backgrounds (Hargadon and Sutton, 1997; Kanter, 1988; Leonard and Sensiper, 1998). As such, idea generation does not follow processes that are clear or codified in the organization. Rather, during this largely unstructured phase, individuals are not formally assigned to specific tasks or 'idea generation projects'. Instead, they are self selected based on informal networks of personal relationships, volunteerism, and informal recruitment through the 'champion's' personal networks (Crawford, 1997; Boutellier et al., 2000). This, too, highlights the importance of socialization as people volunteer because they want to be involved in something that is exciting and truly important (O'Connor and McDermott, 2004). At the same time, this study suggests that creative interaction in groups does not necessarily inhibit creativity (Paulus, 2000; Thompson, 2003). However, it depends on the nature of the interaction, with the informal socialization supporting the generation of novel product ideas, whereas the more formal externalization hinders it.

Externalization showing a negative relationship with novel idea generation support findings of Dahl and Moreau (2002), Goldenberg et al. (1999), and Koberg et al. (2003). These authors found that people operating in a more formal system or people who are either not ready or generally not able to formulate their sparks will rather utilize close analogies and come up with incremental innovation ideas. Thereby, the resources of those people are mistakenly directed towards the elaboration of incremental ideas. Often, this is the case as many firms consider externalization as the most important of the knowledge creation modes. However, this assumption does not seem to hold true, particularly in early stages of new product development processes (Schulze and Hoegl, 2006).

Our research results support the notion that *combination* of existing explicit knowledge does not lead to truly novel product ideas. Instead, combination as a knowledge creation mode hampers idea generation for new and different products. Thus, at first sight, our results seem contrary to scholars suggesting that novel product ideas involve the 'unique' combination of existing knowledge domains or categories (Goldenberg et al., 1999; Hargadon and Sutton, 1997; Kanter, 1988; Koberg et al., 2003; O'Connor and McDermott, 2004; Tauber, 1972; Wielemaker et al., 2003). However, it is important to recognize that these studies make little distinction whether elements of explicit knowledge (e.g., from documents) are actually edited and synthesized (combination), or whether people holding knowledge of different domains join their often latent (tacit) thoughts and bring sparks forward to become innovative product ideas (socialization).

Internalization, showing a significant positive relationship with the novelty of product ideas, supports related conceptual contributions in the innovation literature. As such, our findings support Dougherty (1992) and Hargadon and Sutton (1997), who discuss how experiencing enhances the absorption of existing knowledge, which in turn enables individuals to create new visceral knowledge and hence novel ideas. Further, results of our study go along with the opinion of a number of scholars who point to the fact that experiencing by experimenting pays off in terms of generating innovative ideas (Brown and Eisenhardt, 1997; Hatten and Rosenthal, 2000; Helfat and Raubitschek, 2003; Koberg et al., 2003; Leonard and Sensiper, 1998; Monteverde, 1995; Van De Ven, 1986). Specifically, Henderson and Clark (2001) argue that usually the emergence of a new technology is a period of considerable confusion. There is little agreement about what the major subsystems should be and how they should be put together. Hence, experimentation is necessary.

5.2. Managerial implications

Based on this study's results, leaders and members of innovation teams should be made aware of the different effects of the four knowledge creation modes. Rather than employing all knowledge creation modes 'across the board' for the generation of novel ideas, organizations should foster socialization and internalization and at the same time reduce a focus on combination and externalization.

Managers can emphasize *socialization*, e.g., by fostering informal face-to-face meetings involving employees from different departments as well as external people like customers or lead users. Examples are joint coffee or lunch breaks. On an organizational level, management can institutionalize such periodical informal meetings or events relating to the innovation process, so that people from all departments can meet in person to socialize in a non-project specific context.

Further, mangers can encourage *internalization* by allowing employees to experiment during their working hours (Koberg et al., 2003). An example would be 3M. The company seeks to balance the pressure for near-term results against the creation of novel ideas and innovative products by giving employees the "freedom to innovate" with 15% of their time. Many engineers, then, dedicate their time to experimenting within projects on their own (Coyne, 2001). Thus, fundamental innovative ideas are encouraged to emerge.

Lastly, managers must be aware of the possible detrimental effects of combination and externalization on the generation of novel product ideas. For instance, internally available reports from former projects or articles about new technical developments may tempt employees to engage in *combination* and thus adopt more readily available solutions. With respect to *externalization*, the codification of sparks for product ideas or even detailed, explicit concepts may, at this stage, be decidedly detrimental. Instead, management should let people consciously work with each other informally without requesting elaborate descriptions of their work too soon. Our recommendation is not to mean that managers cannot demand results at some point. Our research does suggest, though, that the success of the so-called 'fuzzy front end' phase of idea generation is not supported (but rather hindered) by formalizing interaction

and focusing on readily available combinations of existing knowledge.

6. Limitations and outlook

A few limitations of this study along with questions for future research should be noted. *First*, the data for this research are cross-sectional rather than longitudinal. As this study demonstrates associations between variables, it cannot fully establish causality. *Second*, the present study was conducted in Germany, Austria, and Switzerland, raising the question of transferability of results to other cultures such as those of North America or Asia. While this study is not internationally comparative in nature and therefore cannot offer any answers to this question, the theoretical considerations presented in this article are not country-specific, but rather based on international scholarly work and empirical findings. Further research in other countries is encouraged to increase our understanding of the possible influences of country contexts on the relationships investigated here. *Third*, the empirical basis for our analyses comprises ideas regarding products that were eventually launched onto the market. Ideas pertaining to other initiatives that never completed the innovation process were not expressly considered, however, we have no indication that ideas pertaining to such new product initiatives were any more or less novel. As such, our data show the novelty of product ideas as an organization-level phenomenon, documented by the homogeneity of this variable across projects within one organization. However, further research should address possible differences in the novelty of ideas of completed and non-completed projects. *Fourth*, the level of analysis of this study was the organization. As the SECI model can be understood as a spiral that is consistently moving from the individual to the group to the organization, involving more and more people, further empirical research should include a cross level analysis.

Considering the dearth of empirical research on knowledge creation and idea generation, there are relevant questions to be addressed by further research. One such question could be the possible effect of geographical distance (Allen, 1985) between individuals or teams as a determinant of socialization. Further, results of this first empirical study could be refined in terms of measuring novelty through a more differentiated multi-dimensional approach or by investigating whether there are different amounts of knowledge contributed by socialization on the one hand and internalization on the other hand. A qualitative approach to capturing the SECI modes, measuring how well the activities have been conducted, moving beyond measuring intensity also seems promising. Notwithstanding the benefits of quantitative inquiry, a qualitative approach would have the added benefit of considering contextual detail, such as the type of knowledge that has been combined leading potentially to a breakthrough in new knowledge. The conceptual arguments and the empirical evidence from this study may provide a starting point for such necessary further inquiry that should build on contributions from both the knowledge creation as well as the innovation management literatures.

Appendix A

Measurement scales for the independent variable

Socialization (4 items, Cronbach's Alpha = .83)	
Item 1	We spent a lot of time in personal interaction aside from organized meetings with other people in the team in order to discuss suggestions, ideas, or solutions.
Item 2	We spent a lot of time in personal interaction aside from organized meetings with people from other departments in the company in order to discuss suggestions, ideas, or solutions.
Item 3	We spent a lot of time in intense discussions about suggestions, ideas, or solutions in face-to-face meetings with people from other departments in the company.
Item 4	We spent a lot of time in the conscious creation of a common understanding of a problem with people from other departments in the company.
Externalization (4 items, Cronbach's Alpha = .78)	
Item 5	We spent a lot of time reflecting collectively and framing our ideas or solutions with regard to customer needs.
Item 6	We spent a lot of time interviewing competent people about ideas or solutions with regard to relevant technologies.
Item 7	We spent a lot of time interviewing competent people about ideas or solutions with regard to customer needs.
Item 8	We spent a lot of time creating detailed descriptions (e.g., protocols, presentations, reports) containing newly developed knowledge about customer needs.
Combination (4 items, Cronbach's Alpha = .71)	
Item 9	Focusing on the project, we systematically edited the technical knowledge collected.
Item 10	Focusing on the project, we systematically edited the knowledge collected about customer needs.
Item 11	Focusing on the project, we systematically edited the knowledge collected about the procedure of creating novel product ideas.
Item 12	Within the organization, we distributed our newly gained insights about customer needs.
Internalization (4 items, Cronbach's Alpha = .74)	
Item 13	We spent a lot of time in trial-and-error (experimenting), thereby developing a sense for the feasibility of our thoughts regarding the functionality of the technology.
Item 14	We spent a lot of time in trial-and-error (experimenting), thereby developing a sense for the feasibility of our thoughts regarding customer needs.
Item 15	We spent a lot of time in trial-and-error (experimenting), thereby developing a sense for the feasibility of our thoughts regarding the procedure of creating novel product ideas.
Item 16	We spent a lot of time systematically testing our theoretical knowledge about customer needs.

Measurement scales for the dependent variable

Novelty of product ideas (3 items, Cronbach's Alpha = .80)	
Many of the ideas generated were . . .	
. . . new to the company.	
. . . new to our existing customers.	
. . . new to the market.	

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