Dynamics of the innovation process: The linear-recursive model of innovation and the implications for leadership and self-regulation

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CHAPTER 1

A linear-recursive model of the innovation process

In this paper, we propose a model of the innovation process that integrates both linear and recursive frameworks to describe innovation. In our linear-recursive model, we assume that the importance of innovation activities shifts over time (linear), but that all activities have relevance throughout the whole innovation process (recursive). Moreover, the pattern of shifting between activities has implications for innovation outcomes. Drawing on data from 113 innovation projects, we confirmed both linear and chaotic elements of our model. In addition, we used latent class analysis to group projects with similar innovation activity trajectories. Results confirmed that about a third of the teams followed our model and that these teams were superior in novelty of the project outcome. Our findings contribute to the understanding of how innovation processes unfold over time.

1.1 Introduction

Innovation is important not only for the success of organizations (Rosenbusch, Brinckmann, & Bausch, in press; Szymanski, Kroff, & Troy, 2007) but also for the development of nations and societies (Ahlstrom, 2010; Utterback, 1974). However, the innovation process is a complex endeavor, and the process by which innovation projects unfold over time is not well understood. Two groups of innovation models or frameworks have been proposed in the literature, with one assuming a linear succession of distinct phases and the other suggesting that the process is characterized by chaos and complexity. It is the aim of this paper to develop a new linear-recursive model of the innovation process that starts out from a linear approach, but allows for chaotic or recursive elements, and to put the validity of this model to a first empirical test.

Innovation processes are often described as linear phase models. Phase models of innovation have three assumptions in common: First, later phases (e.g., implementation, deployment of ideas, innovation diffusion) build upon earlier phases (e.g., creativity, generation of ideas, innovation production) (e.g., Amabile, 1988; Kanter, 1988). Second, the innovation process follows a linear succession (Saren, 1984). Third, the more innovation projects resemble the ideal sequence of phases, the better the outcome is. These models assume that innovation tasks need to be accomplished in a certain given order because they logically build on each other. For example, ideas need to be generated before they can be implemented. In addition, some researchers propose that innovation activities such as exploration and exploitation are conflicting and, therefore, need to be separated temporally (Gupta, Smith, & Shalley, 2006). In contrast, the counterposition assumes that innovation contains too many unforeseeable and unpredictable elements to divide it into distinct stages. Instead, innovation processes are complex and nonlinear (Anderson, De Dreu, & Nijstad, 2004; Bledow, Frese, Anderson, Erez, & Farr, 2009; King, 1992; Schroeder, Van de Ven, Scudder, & Polley, 1989; Van de Ven, Polley, Garud, & Venkataraman, 1999). These models propose that innovation processes often deviate from the neat and linear succession of phases. They assume that the different activities underlying innovation processes such as idea generation and the implementation of ideas are interdependent and interwoven and, most importantly, relevant throughout the whole innovation process and not only during certain time frames within the process.

In this paper we build upon and integrate these two frameworks to develop a new model of the innovation process that we label a “linear-recursive model of innovation”. We propose that it is unlikely to assume a strictly linear process with one activity following the other, but that it is just as unlikely to assume a purely chaotic process. Most of the existing models on the innovation process within either of these two frameworks do not take an extreme position. For example, most phase model theories acknowledge that there is some circularity of activities (e.g., Amabile, 1988). However, to date there has been no explicit attempt to integrate both theoretical positions. We take the circularity assumption as a starting point for our model and further relax some of the preconditions of linear phase models of innovation. More specifically, we introduce recursive elements into linear phase models to allow for switching back and forth between innovation activities without dismissing the general order of events within innovation processes.

The linear-recursive model of innovation focuses on the team level because innovation in organizations primarily takes place in teams (Hülsheger, Anderson, & Salgado, 2009), for example, in project teams or research and development (R&D) teams. In addition to addressing both linear and recursive elements of the innovation process, we relate these characteristics to innovation success of teams. A valid account of the innovation process and its relationship to innovation success should contribute to both future research and practice. An improved understanding on how innovation processes unfold over time provides the basis for examining how external factors influence the process. For practice, it is important to answer the question of whether teams should try to follow a phase approach of innovation activities or whether teams need to handle all innovation requirements simultaneously. In the following, we first describe both the linear and the chaotic frameworks of innovation and, subsequently, we elaborate on our integrative model of innovation.

Innovation models: Linear phase models versus chaos models

A multitude of linear innovation phase models have been proposed in the literature (Lubart, 2001). A classical example is the phase model of organizational innovation by Zaltman, Duncan, and Holbek (1973). This model describes discrete stages that start out with becoming aware of an innovation (*knowledge-awareness* stage) up until the innovation is eventually implemented throughout an organization (*continued-sustained implementation* stage). However, this model lacks a description of developing innovation and rather represents innovation adoption. Another important phase model that refers to the innovation process at the team level is the model proposed by Farr, Sin, and Tesluk (2003). This model reflects the whole innovation process from the initial development until the final realization of the innovation. The model divides the innovation process into two broad stages (creativity and implementation) that each consist of one transition and one action phase. In the first of these four phases (*problem identification*), innovative teams identify and define the problem they need to work on. In the next step (*idea generation*) teams come up with ideas to solve the problem identified previously. These ideas are then discussed and evaluated to find the idea that best solves the problem (*idea evaluation*). The selected idea is finally put into action and implemented in the last phase (*implementation*). In this paper, we build on Farr et al.'s (2003) model for two reasons. First, it is one of the most sophisticated and parsimonious models of innovation. Second, it refers to the team level, whereas most other models refer to the organizational level, such as Zaltman et al.'s (1973) model, and some to the individual level, such as Amabile's (1988) model.

Researchers arguing for the "innovation as chaos" framework often do not delineate precise models but rather describe innovation processes as being complex and not easily split into separate stages (Anderson et al., 2004; Bledow et al., 2009; Van de Ven et al., 1999). A good example of this approach is Schroeder et al.'s (1989) model of innovation. This model does not prescribe a rigid sequence of events, but rather assumes "convergent, parallel, and divergent streams of activity sequences" (Schroeder et al., 1989, p. 113). The model assumes that innovation is triggered by internal or external shocks that either stimulate the generation of ideas or acting on ideas, or drive an innovation into a new direction. Initial innovative ideas often diverge into several different paths that may or may not be conjunctive. In addition, setbacks and surprises are inherent parts of innovation and are important for learning. Old and new ideas, products, or processes coexist within the innovation process and need to be linked and integrated at some point in time. In general, Schroeder et al.'s (1989) model assumes a divergence of innovation paths in the beginning that need to converge at some point in time. However, the model does not make any assumptions about a sequence of events that leads to a structured process: With so many things happening simultaneously and teams' need to go back and forth between different activities, an ordered process of innovation becomes impossible. This model is a good starting point for describing the complexity of innovation processes.

In addition, the garbage can theory of decision making (Cohen, March, & Olsen, 1972) is helpful to describe the chaotic structure of innovation processes. The basic idea of the garbage can model is that organizational decisions are not linear problem-solving processes but rather resemble garbage cans in which problems, solutions, participants, and decision opportunities are flowing and interacting (Cohen & March, 1986). That is, participants do not develop solutions when a problem comes up and make decisions regarding how to solve the problem, but rather all four elements exist simultaneously. This means that solutions might be looking for problems as well as problems are searching for solutions. Decisions are the result of a temporal and spatial combination of participants, problems, and solutions (March, 1994). Decision making occurs under conditions of problematic preferences and ambiguous goals, unclear technology and vague means to achieve goals, and changing participants (Cohen et al., 1972; Warglien & Masuch, 1995); these are also characteristics that describe the innovation process quite well. The garbage can model explains how innovation activities do not need to proceed in a linear fashion although they seem to logically build upon each other. For example, ideas may be generated even though the problem that shall be solved by those ideas is not properly identified. Innovation teams may start to implement ideas even though they have not fully recognized what these ideas look like. Thus, in the uncertainty of innovation projects, linear problem solving is unlikely to occur and, rather, decision-making processes can be expected to follow the garbage can model.

Initial empirical tests examining the "phase" and the "chaos" frameworks against each other are supportive of the chaos idea. King (1992) tested the Zaltman et al. (1973) phase model against the chaos model proposed by Schroeder et al. (1989). He showed that the chaos model described the data of seven cases of innovations at a hospital ward better than the phase model. However, the linear innovation approach could not be rejected in this study because it also had some overlap with the innovation cases. Cheng and Van de Ven (1996) found, in two case studies, that innovation projects started with chaotic patterns of activities and outcomes and ended with periodic patterns of the same activities. Although Cheng and Van de Ven's results seem to be supportive of the phase model idea (with two phases of chaotic and periodic patterns, respectively), it is important to note that the activities were the same throughout the process; it was merely the pattern of switching between these activities that changed from the beginning to the end of the projects. Thus, these two studies seem to be supportive of the chaos position. However, these results also show that there is some truth in both approaches and either approach alone is not sufficient to describe innovation comprehensively.

The linear-recursive model of innovation

In this article, we would like to go beyond the question "Are innovation processes linear *or* chaotic?" and take a position that integrates the two described frameworks. That is, we neither expect a clear and linear succession of distinct innovation phases with one activity after the other, nor do we expect an entirely chaotic alternation of activities. In contrast, we propose a linear model of innovation that includes recursive activities. More specifically, we assume that the relative importance of innovation activities shifts over time, but nevertheless all innovation activities have some relevance throughout the innovation process.

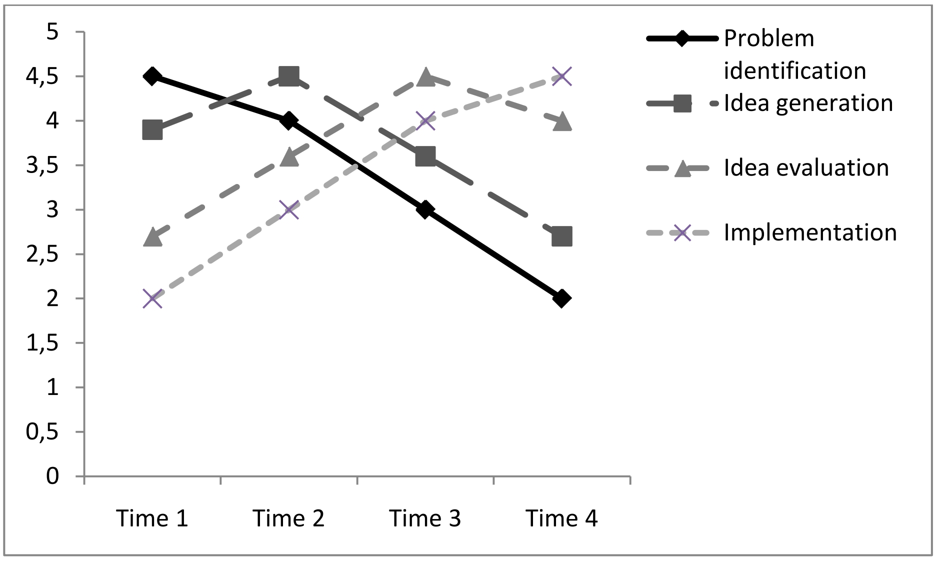

Figure 1.1 *Idealized phase trajectories of the linear-recursive model of innovation*

Our linear-recursive model of innovation starts out with the linear phase model by Farr et al. (2003). The main proposition of our model is that innovation activities change their dominance over time in the innovation process. However, in contrast to pure phase models, we reduce the assumption of distinct phases and suggest a gradual development of innovation activities over time. This idea is presented in Figure 1.1. Depicted is a simplified pattern of trajectories of innovation activities used over time. As we assume that all innovation activities are always present, the trajectories of innovation activities never drop to zero. In the beginning of this “ideal project”, problem identification activities are the most frequent, but the amount of problem identification activities drops throughout the course of the project. Idea generation activities are frequent in the beginning and have their peak before the midpoint of the project and then the amount of idea generation activities lessens until the end of the project. The trajectory of idea evaluation activities lags a little behind idea generation and peaks after the midpoint of the project. Finally, implementation activities start out low, but increase steadily throughout the project, becoming the most frequent activities at the end of the project. From this idea of gradual development follows a relative importance of innovation activities over time. That is, for example, in the beginning of an innovation project idea generation is more important than idea implementation (West, 2002a). At each point in time one of the innovation activities has the highest relative importance, without rendering the other activities to be irrelevant.

We propose that innovation teams that primarily engage in those activities that are of highest importance at any given time are more successful than teams who engage indiscriminately in different activities at all times. More specifically, we assume that to be successful, teams need to start out with a high level of idea generation activities in the beginning that will be reduced later in the project and with a low level of implementation activities in the beginning that will be increased in the latter part of the project.

Idea generation is most important in the beginning of a project. It is necessary to start out with generating a large quantity of ideas. Since quantity and quality of ideas are related, the likelihood of high quality ideas increases with the number of ideas (Diehl & Stroebe, 1987; Simonton, 1997). However, too much idea generation at the end of a project could divert attention away from the successful implementation of the chosen ideas. According to Gersick's (1988, 1989) punctuated equilibrium model, after the midpoint of a project, team members need to stop discussing what they should do and start getting things done. Ford and Sullivan (2004) proposed that novel contributions after the project midpoint are detrimental to team success, as these new ideas distract from continuing with the chosen path and lead to confusion.

Hypothesis 1: A reduction in the level of idea generation activities over time will be positively related to innovation success.

In addition, premature implementation at the beginning of a project should hinder the generation of high quality ideas. We assume that it is necessary to generate a certain amount of ideas before starting to implement them to ensure that a high quality idea is implemented. Although we assume that some amount of implementation can be functional even in the beginning of a project as it provides valuable feedback on the feasibility of initial ideas, the amount of implementation activities should increase over the course of the project as more elaborate ideas develop and need to be implemented to culminate in the final project solution. In addition, when teams worry too much about implementation in the very beginning of a project, this might prevent them from developing novel and unconventional ideas as these ideas are riskier and more difficult to implement. Therefore, concentrating on implementation very early should result in teams settling with rather conventional and easy-to-implement ideas.

Hypothesis 2: An increase in the level of implementation activities over time will be positively related to innovation success.

In addition to these two general linear assumptions, we propose that teams will differ in their paths to innovation. In other words, we assume that teams will use different patterns of innovation activities in the course of innovation projects. Our model suggests that the importance of specific innovation activities changes during a project and that teams that engage in innovation activities according to this relative importance will be more successful than teams that set different priorities. More specifically, we assume that the more teams deviate from the idealized pattern of trajectories shown in Figure 1.1, the worse the innovation success of those teams will be. To derive conditions of whether teams follow the model, we concentrate on the project beginning and the project end. As can be seen in Figure 1.1, at the beginning and the end of the innovation projects the relative importance of activities is most apparent, with problem identification and idea generation being most important in the beginning, and idea evaluation and implementation being most crucial at the end. In between it is a more delicate balance of innovation activities with only minor differences between the activities.

We frame the conditions of our model as comparisons of the relative frequencies of activities. Thus, it is important to note that we do not make any assumptions about the absolute amount of an activity at any point in time, but just compare the relative amount of activities in a certain time frame. Taken together, the conditions can be used to describe patterns of the use of innovation activities over time. The conditions are described in the following paragraphs (see Table 1.1 for an overview).

(1) *In the beginning of the project, the level of problem identification activities is higher than the level of implementation activities.* It is necessary to know something about the problem one wants to solve before starting to implement initial ideas. As innovation tasks are often complex and ill-defined, some degree of problem construction is the starting point of innovation and sets the stage for later processes (Reiter-Palmon, 2009; Reiter-Palmon, Mumford, O'Connor Boes, & Runco, 1997). Only if teams develop some understanding of the problem they need to solve, can they implement adequate problem solutions.

(2) *In the beginning of the project, the level of idea generation activities is higher than the level of implementation activities.* As argued before, in the beginning of an innovation project, the generation of ideas is important. Although we assume some implementation activities to be useful even in the beginning, the level of idea generation activities needs to be

higher to be able to generate a fair amount of ideas. Teams that start with a higher level of implementation activities than idea generation activities are likely to miss good and valuable ideas.

(3) *In the beginning of the project, the level of idea generation activities is higher than the level of idea evaluation activities.* The model suggests that idea generation needs to be separated from idea evaluation because premature, critical evaluation of ideas can block creativity (Rietzschel, Nijstad, & Stroebe, 2006).

(4) *At the end of the project, the level of problem identification activities is lower than the level of implementation activities.* The model assumes that at the end of a project, implementation of ideas is most important. Defining and constructing the problem one wants to solve influences the solutions generated (Reiter-Palmon, 2009). Thus, redefining the problem at the very end should render earlier solutions inappropriate. Because of the nearing deadline, it is only possible to quickly generate and implement new ideas matching the new problem definition with a high amount of implementation activities, that is, more implementation than problem identification activities.

(5) *At the end of the project, the level of idea generation activities is lower than the level of implementation activities.* In a similar vein, a high amount of new ideas at the very end of a project makes it necessary that these ideas are implemented quickly within the time boundaries of the project. Thus, even if idea generation is still quite high at the end of the project, implementation of ideas needs to be even higher. At the end of a project, idea implementation is the focus because to finalize the project it is necessary to get things done, and all activities during the process need to converge into the implementation of the final project outcome.

Finally, we add two conditions about change in the level of idea generation activities and implementation activities from the beginning to the end of a project. Both conditions follow from hypotheses 1 and 2:

(6) *The level of idea generation activities is higher in the beginning than at the end of the project.*

(7) *The level of implementation activities is lower in the beginning than at the end of the project.*

As we argued before, teams that allot their time and energy to those activities that are of the highest relative importance will be more successful than teams that set priorities that differ from our assumptions. In other words, we assume that teams that deviate from our model will be less successful than teams that consider the relative importance of innovation activities. Therefore, we hypothesize:

> *Hypothesis 3:* Teams whose pattern of innovation activities fulfills the conditions of relative importance of the linear-recursive model are more successful than teams whose pattern does not fulfill these conditions.

Table 1.1

Overview on 7 conditions of the linear-recursive model

	Short Form	Condition	Probability
1	$pid_1 > im_1$	In the beginning of the project, the amount of problem identification activities is higher than the amount of implementation activities.	75.0%
2	$ig_1 > im_1$	In the beginning of the project, the amount of idea generation activities is higher than the amount of implementation activities.	68.8%
3	$ig_1 > ie_1$	In the beginning of the project, the amount of idea generation activities is higher than the amount of idea evaluation activities.	57.1%
4	$pid_2 < im_2$	At the end of the project, the amount of problem identification activities is lower than the amount of implementation activities.	37.0%
5	$ig_2 < im_2$	At the end of the project, the amount of idea generation activities is lower than the amount of implementation activities.	38.0%
6	$ig_1 > ig_2$	The amount of idea generation activities is higher in the beginning than at the end of the project.	43.3%
7	$im_1 < im_2$	The amount of implementation activities is lower in the beginning than at the end of the project.	68.7%

Note. pid = problem identification; ig = idea generation; ie = idea evaluation; im = implementation.
1 = project beginning; 2 = project end.

Finally, in addition to the relative importance of innovation activities over time, the recursive part of our model stipulates that all innovation activities are always present. That is, although a certain innovation activity is of the highest importance at a given time and needs to be focused on, the other innovation activities are not absent at that time. For example, as outlined before, we assume that a strong focus on idea implementation is rare in the very beginning of a project. Indeed, it is hard to think of a situation in which people start implementing a new idea before they have developed this idea, although the garbage can model gives a theoretical explanation for this issue (i.e., that problems and solutions exist simultaneously and independently, Cohen et al., 1972). Nevertheless, implementation will not be completely absent in the beginning part of a project as initial attempts to implement an idea may be necessary to realistically advance a project. Thus, an initial idea needs to be tested for its potential for implementation to advance it further. In other words, in addition to the linear assumptions of our model outlined so far, our model includes the recursivity of innovation activities. We propose that there are no innovation teams that show clear-cut approaches to innovation that follow strict phase models. Instead, we hypothesize:

> *Hypothesis 4:* At any point in time, innovation teams show a mix of various activities that belong to different phases in phase models.

Our model proposes that innovation activities are interwoven (Bledow et al., 2009). In other words, innovation activities cannot be dealt with one at a time, with an activity being terminated after it is completed. In contrast, we assume that innovation activities reoccur throughout the whole project. As Schroeder et al.'s (1989) model describes, setbacks and surprises are inherent to innovation. For example, while implementing an innovation, it is very likely that teams run into problems because innovation is inherently risky and failure is very likely (Sharma, 1999). To solve these problems teams need to generate new ideas, evaluate them, and implement those ideas. In addition, according to Schroeder et al.'s (1989) model, innovative teams often work on different streams of their project simultaneously or work on different ideas at the same time. In innovation projects, the direction the project will develop into is often unforeseeable (Brun & Sætre, 2009). Therefore, teams need to work in different directions at the same time. For example, a team might try to implement first ideas while constantly reinterpreting the problem that they are solving and restating the goals of the project which then leads to the generation of new ideas. These old and new ideas can coexist for a some time (Schroeder et al., 1989). In this case, teams need to engage in many different innovation activities simultaneously. Thus, innovation activities should be highly interrelated and co-occur and teams need to be able to switch back and forth between those activities to handle the tasks at hand. This intertwining of activities makes distinct stages that build upon only one of those factors difficult and ineffective and is the main reason why we expect a gradual development of innovation activities over time instead of distinct phases.

Taken together, we expect that within the outlined linear framework, innovation activities are distinguishable, but interwoven and interdependent activities. In other words, we propose that the recursivity within the innovation process becomes apparent in the simultaneous use of different but interrelated activities at any point in time. Thus, we hypothesize:

Hypothesis 5: Innovation activities are distinct but highly interrelated activities at any point in time.

1.2 Method

Sample and design

We tested our model in a sample of applied innovation projects that students worked on for the course of one semester. We used a repeated measures design with 3 to 6 observations (depending on the length of the projects). The number of working days between observations was held constant. In most cases, the time span between two observations was two weeks. We only used those observations where at least two team members answered the questionnaire. The mean number of observations was 3.4 per project.

Our sampling strategy was twofold. First, we contacted the engineering college of one public US university and deans of several German universities and asked about applied student projects. We were then referred to professors teaching such projects who were asked to participate. However, as the prevalence of such student projects was much lower in Germany than in the US, we could locate only a few projects in Germany by this strategy. Therefore, we additionally searched German university websites for applied student projects and contacted the supervising professors directly. If professors agreed to participate, we introduced our study in class. Students who were willing to participate provided us with their e-mail addresses. All questionnaires were administered online and students were invited to participate by e-mail reminders.

We decided to use student teams instead of professional teams in organizations as we aimed to obtain a detailed picture of the innovation process with more observations than would have been feasible in a professional work setting. Student teams are often used to study team processes in greater detail than is possible in organizational settings (e.g., DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004; Harrison, Price, Gavin, & Florey, 2002; Mehta, Feild, Armenakis, & Mehta, 2009). In addition, the project cycle of professional R&D teams often lasts several years. As our goal was to map the whole innovation process and not only parts of it, we decided to study the shorter student project cycles (which typically lasted one semester). However, in discussions with the supervising professors, we made sure that the student teams worked on real-world problems that were similar to problems addressed by professional R&D teams. For example, some teams developed new kinds of wind turbines with an increased efficiency and others redesigned electric toothbrushes.

Our sample consisted of 113 teams with 400 students altogether. About two thirds of the teams (67.3%) were from the US university, whereas the other third of the teams (32.7%) were from five German universities (two universities in northern Germany, two universities in central Germany, and one university in southern Germany). Most students in the sample were engineering majors (83.2%), but some students also came from business (8.8%), science (6.2%), and media (1.8%) departments. The mean age of the students was 20.3 years (SD = 3.6; range 16 to 47 years), and 21.7% of the students were female.

Measures

Innovation activities. We measured each of the four innovation activities with two to three item scales that we developed for this study. Items referred to the activities a team had performed during the last two week period. Example items are "We figured out what we needed to do to be successful" (problem identification), "We collected ideas" (idea generation), "We discussed what ideas we should follow" (idea evaluation), and "We put our ideas into action" (idea implementation). Participants responded on a 5-point scale ranging from 1 ="very false" to 5 = "very true". Scales were aggregated from the individual to the team level for each observation. ICC(1)s ranged from .06 to .59, with four out of twenty-four ICCs (four scales measured at up to six observations) being lower than .10 and one negative ICC. Mean $r_{wg(j)}$s ranged from .51 to .82, with one exception of .05. Internal reliabilities (Cronbach's α) at the individual level were .85 for problem identification, .87 for idea generation, .84 for idea evaluation, and .96 for implementation.

For the latent class analysis, we reduced the data set to the first and the last observation for each team (e.g., the third observation in a team with a total of three observations or the fifth observation in teams with a total of five observations). Fulfillment of each of the seven conditions was coded dichotomously, that is, 1 for fulfilling a condition and 0 for not fulfilling a condition (e.g., the first condition was coded 1 when idea generation at the first observation was higher than implementation, and was coded 0 when idea generation at the first observation was the same or lower than implementation).

Innovation success. Innovation success was measured at the end of the project cycle by project supervisor ratings (typically from professors who taught the course, but also including some graduate teaching assistants). Supervisors rated the novelty, usefulness, and quality of the project outcome on single item 5-point scales. For example, the item operationalizing novelty was: "Relative to other student projects in our field, this product (project outcome)… is a usual and conventional solution (1), is a solution that features only a few novel elements (2), is a solution that features some novel elements (3), is a solution that features mostly novel elements (4), is completely novel and hardly relies on conventional and usual solutions (5)". Unfortunately, we obtained usable supervisor ratings only for a subset of 72 teams (63.7% of the total sample) because some professors did not return the questionnaires and some professor questionnaires could not be matched with the respective team member questionnaires. Thus, the analyses that included supervisor ratings are based on the subsample of 72 teams.

Analyses

To ensure that the four innovation phase scales were distinct but interrelated dimensions (and thus testing hypothesis 5), we conducted a confirmatory factor analysis. Since the observations in our data set are nested in teams, the independence assumption of conventional factor analysis is violated. ICCs of the innovation activities items ranged from .18 to .52[1]; thus, a substantial proportion of variance was at the team level. We therefore used multilevel confirmatory factor analysis (B. O. Muthén, 1994). In a multilevel confirmatory factor analysis, the within-units covariance matrix and the between-units covariance matrix are analyzed simultaneously (Dyer, Hanges, & Hall, 2005).

To test hypotheses 1 and 2, we regressed innovation success on the change in innovation activities over time. This method has previously been used by Chen, Ployhart, Cooper Thomas, Anderson, and Bliese (2011). In a first step, using mixed-effect growth models (Bliese & Ployhart, 2002), we obtained empirical Bayes estimates for each team for the change in idea generation activities and for the change in implementation activities over time. In two separate hierarchical linear modeling (HLM; Raudenbush & Byrk, 2006) analyses, we regressed idea generation and implementation on time. The estimated Bayes slopes resulting from these two regressions represent the change in idea generation and implementation over time and these estimates vary between teams. Thus, in this first step we obtained for each team an estimated slope of idea generation and implementation over time.

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[1] The within-group variance used to calculate these ICCs is the variance between observations. At this point we were interested in how much variance in the innovation activities resided at the team level as compared to the observation level. Very low ICCs would have indicated that observations within teams were independent and conventional factor analysis would have been possible. In contrast, the within-group variance used to calculate the ICCs reported in the measures section is the variance between individual team members. Those ICCs reflect the agreement about innovation activities across team members and were calculated to justify aggregation of scales across team members.

In the second step, innovation success was regressed on these empirical Bayes estimates obtained in the first step. With this analysis, we tested whether the linear change (e.g., the fall or rise) in idea generation and implementation over time was related to innovation success.

We used latent class analysis (Hagenaars & McCutcheon, 2002) in Mplus (L. K. Muthén & Muthén, 1998-2009) to group teams into categories that share similar patterns of innovation activities over time[2]. We used the seven conditions of Table 1.1 as indicators for the latent class variable. To determine the appropriate number of classes, several successive analyses starting with one class were conducted until the most parsimonious model with maximum model fit was found. For each model 100 random starts with 10 final optimizations were used to make sure that global rather than local maxima of likelihood were found (Bornovalova, Levy, Gratz, & Lejuez, 2010). Several indices were used to indicate model fit. A Monte Carlo simulation study recently revealed the adjusted BIC (Bayesian information criterion) and the bootstrap likelihood ratio test (BLRT) to be the best indicators for selecting the number of classes in a latent class analysis (Nylund, Asparouhov, & Muthén, 2007); therefore, we based our decision regarding the number of classes mainly on these two indicators. The adjusted BIC (Sclove, 1987) is an information criterion used widely to compare competing latent class models that penalizes model complexity. The smallest BIC indicated the best fit. The BLRT (McLachlan & Peel, 2000) tests for a given number of classes whether reducing the number of classes by one significantly reduces the model fit. For example, a significant BLRT for a solution with three classes means that the solution with two classes fits significantly worse than the three-class solution. A nonsignificant BLRT for the three-class solution can be interpreted such that the two-class solution is not significantly worse. In addition, we report the log likelihood that is maximized in the latent class analysis procedure. Finally, we list the entropy of each solution that indicates the accuracy of assigning class membership.

In a second step we used the classes established in the first step and conducted mean comparisons of supervisor ratings to test whether classes differed in innovation success. The latent class analysis provides, for each team, posterior probabilities for each class, that is, the

[2] We used latent class analysis instead of other statistical tools that classify subjects into groups, such as cluster analysis, as latent class analysis is superior to those tools in several ways: Most importantly, latent class analysis offers a statistical basis for deciding on goodness-of-fit and on the number of classes, whereas cluster analysis mainly relies on subjective decisions (Hagenaars & Halman, 1989). In addition, latent classes are probabilistic and classes are defined on a latent level (B. O. Muthén & Muthén, 2000). Latent class analysis is often referred to as a version of factor analysis that is suitable for categorical data. Subjects grouped into one class are assumed to have similar patterns of responses.

likelihood of each team belonging to each of the classes. A team is assigned class membership to that class for which is has the highest posterior probability. However, for the mean comparisons of supervisor ratings we did not use this assigned class membership as an independent variable, but used pseudo-class draws that are based on multiple imputations (Asparouhouv & Muthén, 2007; Wang, Hendricks Brown, & Bandeen-Roche, 2005). This procedure is recommended by Clark (2010) to circumvent problems with distorted estimates and standard errors that might arise when using assigned class membership. Mplus (L. K. Muthén & Muthén, 1998-2009) uses Wald chi-square tests for mean comparisons based on pseudo-class draws.

Finally, to test hypothesis 4 that all teams use a mix of all innovation activities at all times, we tested the mean of each activity of the first, the last, and a middle observation in each class against 1, the lowest point of the Likert scale used to measure the innovation activities (a value of 1 represents that the activity was not used at the respective observation). A mean that significantly differs from 1 indicates that the respective innovation activity has been used by the teams belonging to that class at the respective observation.

1.3 Results

Relatedness of innovation activities

We started our analyses with a multilevel confirmatory factor analysis to examine whether the four innovation activities are distinct, but interrelated factors. We began with the model with four factors at the observation level (within teams) and four factors at the team level (between teams) and compared this model to models with successively reduced numbers of factors. Results are summarized in Table 1.2.

To compare models we used the adjusted Bayesian information criterion (BIC), as nonnested models (such as models with varying numbers of factors) cannot be compared using chi-square difference tests. The model with 4 factors at the observation level and 3 factors at the team level fit the data best (see Table 1.2). However, the intercorrelations of factors at the team level all exceeded .95; we therefore selected the more parsimonious model that had only one factor at the team level with only slightly worse fit. [Chi-square: 189.05 (df = 64); CFI = 0.95; RMSEA (root mean square error of approximation) = .07, SRMR (standardized root mean square residual) within = .06, SRMR between = .11]. Intercorrelations of factors at the observation level ranged from .34 to .84 (see Figure 1.2). Thus, results show four factors at the observation level that are distinct but interrelated, therefore supporting hypothesis 5 that stated that the innovation activities are distinguishable but interwoven activities.

Table 1.2

Fit indices of multilevel confirmatory factor analysis

Model	**X²**	**CFI**	**RMSEA**	**SRMR (within)**	**SRMR (between)**	**Adjusted BIC**
4 factors within / 4 factors between	167.90 (df = 59)	.960	.069	.056	.027	4,685.51
3 factors within / 3 factors between	221.37 (df = 65)	.943	.079	.065	.044	4,730.94
2 factors within / 2 factors between	612.18 (df = 70)	.802	.142	.193	.109	5,071.25
4 factors within / 3 factors between	165.90 (df = 62)	.962	.066	.057	.049	4,681.03
4 factors within / 2 factors between	186.57 (df = 64)	.955	.071	.058	.103	4,685.61
4 factors within / 1 factor between	**189.05 (df = 64)**	**.954**	**.071**	**.058**	**.106**	**4,686.31**

Note. N = 113. CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; BIC = Bayesian information criterion.

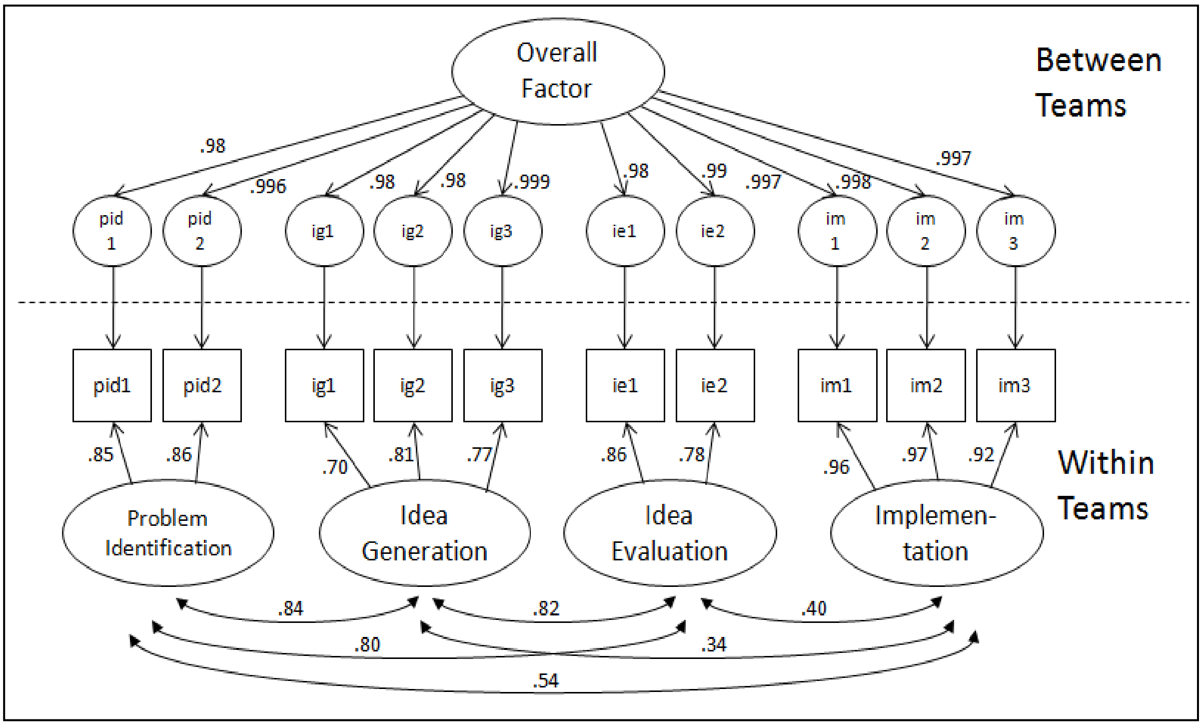

Figure 1.2. *Results of multilevel confirmatory factor analysis*

Relationship between linear development of innovation activities and innovation success

Means, standard deviations, and intercorrelations of the three innovation success measures are reported in Table 1.3. Novelty, usefulness, and originality of the project outcome are significantly correlated. Nevertheless, we used the three measures separately instead of aggregating them as we were interested in the differential effects on those concepts of success.

Table 1.3

Means, standard deviations, and intercorrelations of project success measures

	Mean	SD	Novelty	Usefulness
Novelty	3.01	1.01		
Usefulness	3.27	0.84	.51**	
Quality	3.12	0.99	.64**	.56**

Note. N = 72. ** $p < .01$.

As described in the analyses section, we regressed the three concepts of innovation success on change in both idea generation and implementation to analyze the relationship of the linear development of those activities over time with innovation success. As we were only interested in the relative shift in importance, we controlled for mean levels of all four innovation activities in these regressions. In addition, we controlled for number of observations per team, as the slope of a short project needs to be steeper to result in the same change of activities from beginning to end as in a long project. For example, the implementation slope of a team with three observations that starts out with an implementation value of 2 and ends with an implementation value of 4 is steeper than the slope of a team with the same start and end values but six observations. Results of the regression analyses are summarized in Table 1.4. Change in idea generation was negatively related to novelty of the project outcome. This result can be interpreted such that an increase in idea generation over time is negatively related to novelty or that a decrease in idea generation is positively related to novelty. However, change in idea generation was not related to any other measures of innovation success. Thus, the results only partly confirm hypothesis 1 which stated that a decrease in idea generation is positively related to innovation success. Change in implementation was positively related to novelty, usefulness, and quality; that is, an increase in implementation over time was positively associated with all three outcomes. Thus, the results confirm hypothesis 2. In addition to the results concerning the change in innovation activities, we found that the mean level of idea generation was marginally significant and negatively related to novelty of project outcome and the mean level of idea evaluation was negatively related to usefulness of project outcome, whereas the mean level of implementation was positively related to usefulness. That is, the more the teams in general engaged in idea generation activities, the less novel was their project outcome. The more they were occupied with idea evaluation activities, the less useful was their final project outcome. And the more the teams focused on implementation in general, the more useful was their project outcome.

Table 1.4

Regression of project success on change in innovation activities

	DV: Novelty		DV: Usefulness		DV: Quality	
	Model 1	*Model 2*	*Model 1*	*Model 2*	*Model 1*	*Model 2*
Number of observations	-.21†	-.17	-.23*	-.19†	-.17	-.13
Problem Identification (Mean)	.15	.23	.22	.32	.10	.21
Idea Generation (Mean)	-.43†	-.33	-.07	-.14	-.05	-.11
Idea Evaluation (Mean)	.16	.15	-.72*	-.76*	-.08	-.12
Implementation (Mean)	-.06	.22.	.49**	.68**	-.00	.21
Change in Idea Generation		-.34*		.00		-.03
Change in Implementation		.50**		.32*		.36*
R^2	.10	.22*	.27**	.33**	.03	.10
ΔR^2		.12**		.06†		.07†

Note. N = 72. ** p < .01, * p < .05, † p < .10.

Patterns of innovation activity trajectories

To group the teams in our sample in clusters with similar patterns of innovation activity trajectories, we used latent class analysis. We started our latent class analysis with the most parsimonious model, that is, the one-class model, and added one class in each step. Indicators of model fit are summarized in Table 1.5. The information obtained from the fit indices converges in the selection of the four-class model. In particular, the BLRT shows that the three-class solution fits the data significantly worse than the four-class solution, but the four-class solution does not fit worse than the five-class solution.

Table 1.5

Fit results of latent class models

	Log likelihood	**Adjusted BIC**	**BLRT (p value)**	**Entropy**
1 class	-470.633	952.235	N/A	N/A
2 classes	-420.344	864.190	< .0001	0.905
3 classes	-409.325	854.688	.04	0.808
4 classes	**-398.016**	**844.606**	**.01**	**0.947**
5 classes	-391.996	845.101	.32	0.930

Note. N = 113. BIC = Bayesian information criterion, BLRT = Bootstrap likelihood ratio test

The four-class solution of the latent class analysis yielded the following distribution of teams into classes: Class 1 is the largest class with 40.1% of the teams falling into this class. Class 2 makes up about a third of all teams (29.1%). Classes 3 and 4 incorporate about the same number of teams, with 15.4% and 15.3% respectively.

The first descriptive result a latent class analysis offers is the overall likelihood that subjects endorse the items. Table 1.1 shows the overall probabilities of the teams to fulfill the seven conditions defined in our model. The results show that the overall likelihood of fulfilling conditions 1, 2, and 7 is high, the likelihood of fulfilling condition 3 is medium, and the likelihood of fulfilling conditions 4, 5, and 6 is below 50%. That means that the teams were in general likely to start their projects with a high amount of problem identification and idea generation, and a low amount of implementation, but were also likely to increase the amount of implementation in the course of the project. Teams were also quite likely to start out with more idea generation than idea evaluation. Finally, teams were not likely to end their projects with less idea generation and problem identification than implementation and they were also not likely to reduce the amount of idea generation throughout the project.

Figure 1.3 shows the conditional probabilities of fulfilling each of the seven conditions for the four classes. A conditional probability describes the likelihood of endorsing an item (i.e., in our case, the likelihood of fulfilling a condition), depending on class membership. In the graph, the seven conditions are represented on the x-axis, while the conditional probabilities are displayed on the y-axis. For example, teams in class 1 have a conditional probability of about 95% to endorse the first item (i.e., condition 1), and a conditional probability of about 50% to endorse the third item (i.e., condition 3).

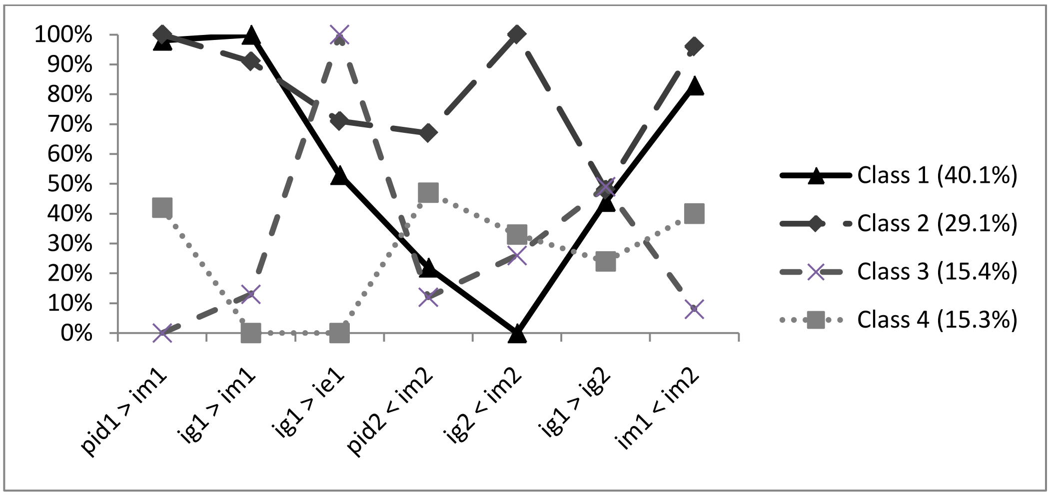

Figure 1.3. *Conditional probabilities of fulfilling the conditions of relative importance*
Note. pid = problem identification; ig = idea generation; ie = idea evaluation; im = implementation. 1 = project beginning; 2 = project end.

Class 1 we called the *high problem identification and idea generation* class. Teams in this class are highly likely to fulfill conditions 1, 2, and 7, with conditional probabilities of over 80%; they do not fulfill condition 5 and are rather unlikely to fulfill condition 4. Taken together, these results suggest that teams in class 1 start out with high problem identification and idea generation, and low implementation. They increase implementation towards the end of the project, but do not decrease problem identification and idea generation. Class 2 we called the *linear* class. Teams in class 2 are most likely to fulfill all seven conditions, with the exception of condition 6 that has a conditional probability of 47.8%. In other words, teams in this class are not very likely to decrease idea generation from the beginning to the end of the project. That is, these teams fulfill most but not all conditions. Class 3 we called the *delayed idea evaluation* class. Teams in class 3 are unlikely to fulfill conditions other than condition 3 which they always fulfill and condition 6 which they fulfill with a probability of about 50%. Thus, this class is characterized mainly by the separation of idea generation and idea evaluation in the beginning of the project. Finally, class 4 we called the *anti-phase model* class. Teams in class 4 are unlikely to fulfill any of the conditions.

Comparison of innovation success between classes

After establishing the four classes, we conducted mean comparisons to find out whether the classes differed in innovation success as measured by supervisor ratings. Results of the mean comparisons are reported in Table 1.6. Differences in innovation success could only be detected for two of the three outcome variables. For novelty, the linear class had a higher mean than any other class. That is, teams that organized their work according to the conditions of relative importance of innovation activities produced more novel and original outcomes than all other classes, but did not differ in either usefulness or quality. For usefulness, the delayed idea evaluation class had a higher mean than the high problem identification and idea generation class. Teams that were characterized by separating idea generation and evaluation produced project outcomes of higher usefulness than teams that tended to maintain a high level of problem identification and idea generation until the end of their projects. Thus, hypothesis 3 could only be confirmed partly.

Table 1.6

Mean comparison of innovation success

	High problem identification & idea generation class	*Linear class*	*Delayed idea evaluation class*	*Anti-phase model class*	Overall Test Chi-square
Novelty	3.02^{a} (0.15)	3.55^{b} (0.18)	2.65^{a} (0.33)	2.41^{a} (0.39)	10.30*
Usefulness	3.03^{b} (0.11)	3.48^{ab} (0.22)	3.63^{a} (0.24)	3.12^{ab} (0.27)	$7.27^{\dagger}$
Quality	3.17^{a} (0.17)	3.29^{a} (0.21)	3.00^{a} (0.28)	2.77^{a} (0.38)	1.74

Note. N = 72. * $p < .05$; † $p < .10$. Reported are means, standard errors are in brackets.
Means in the same row that do not share superscripts differ at $p < .05$.

Trajectories of innovation activities over time

In addition to the fulfillment of the conditions of relative importance, we also inspected the mean levels of innovation activities over time to provide a better picture of the pattern of innovation activities within classes. In Figure 1.4, the mean amount of the four innovation activities in each of the four classes is plotted. In addition to the first and the last observation used in the latent class analysis, we included one observation from the middle of the projects[3]. The graphs complement the findings of the latent class analysis. All classes share a relatively constant level of problem identification, idea generation, and idea evaluation. What mainly distinguishes the four classes is the trajectory of implementation activities and its position relative to the other activities. The high problem identification and idea generation class is characterized mainly by a high level of problem identification, idea generation, and also idea evaluation. The level of implementation activities is low in the beginning, increases over time, but never reaches the level of the other activities. In the linear class, the level of problem identification, idea generation, and idea evaluation is also quite constant, but decreases a little towards the end of the projects. In addition, the level of implementation activities is higher than the other activities at the end. In the delayed idea evaluation class, in addition to the delayed idea evaluation, teams are characterized by starting out with a high level of implementation that decreases over time and even drops below the level of the other activities at the end of the projects. Finally, in the anti-phase model class there is little distinction among the four activities that all increase to a small extent over time.

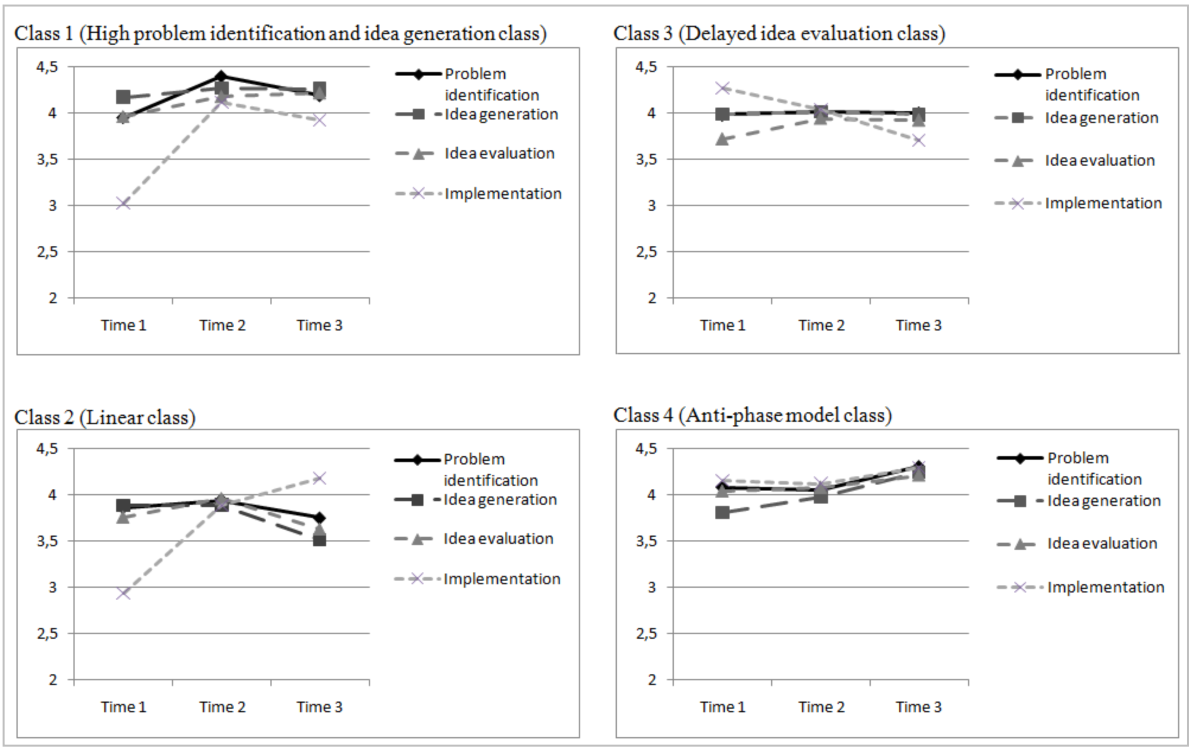

Figure 1.4. *Mean values of innovation activities within classes*

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[3] In teams with an odd number of observations we used the middle observation (e.g., the third of five observations). In teams with an even number of observations we used the first of the two middle observations (e.g., the second of four observations, or the third of six observations).

Table 1.7

Test of mean values

High problem identification & idea generation class						
	Project beginning		Project middle		Project end	
	Mean (SD)	t-Value[a]	Mean (SD)	t-Value[a]	Mean (SD)	t-Value[a]
Problem identification	3.95 (.74)	27.36**	4.40 (.53)	39.83**	4.19 (.69)	29.20**
Idea generation	4.17 (.57)	38.05**	4.27 (.55)	36.68**	4.26 (.56)	36.87**
Idea evaluation	3.96 (.67)	30.43**	4.18 (.54)	36.57**	4.22 (.57)	35.17**
Implementation	3.03 (.83)	16.84**	4.11 (.60)	32.15**	3.93 (.61)	30.17**
Linear class						
	Project beginning		Project middle		Project end	
	Mean (SD)	t-Value[a]	Mean (SD)	t-Value[a]	Mean (SD)	t-Value[a]
Problem identification	3.86 (.53)	28.88**	3.94 (.63)	23.87**	3.75 (.98)	14.51**
Idea generation	3.88 (.53)	29.32**	3.89 (.82)	18.03**	3.51 (.94)	13.90**
Idea evaluation	3.76 (.46)	32.33**	3.96 (.83)	18.11**	3.63 (1.13)	12.12**
Implementation	2.94 (.70)	14.88**	3.88 (.63)	23.33**	4.18 (.56)	29.48**
Delayed idea evaluation class						
	Project beginning		Project middle		Project end	
	Mean (SD)	t-Value[a]	Mean (SD)	t-Value[a]	Mean (SD)	t-Value[a]
Problem identification	3.98 (.81)	15.21**	4.01 (.87)	13.44**	4.00 (.84)	14.23**
Idea generation	3.99 (.88)	14.06**	4.01 (.88)	13.26**	3.98 (.78)	15.27**
Idea evaluation	3.72 (.89)	12.59**	3.94 (.93)	12.22**	3.92 (.78)	14.89**
Implementation	4.28 (.66)	20.31**	4.04 (.76)	15.49**	3.70 (.98)	10.97**
Anti-phase model class						
	Project beginning		Project middle		Project end	
	Mean (SD)	*t*-Value[a]	Mean (SD)	*t*-Value[a]	Mean (SD)	*t*-Value[a]
Problem identification	4.08 (.63)	19.48**	4.05 (.39)	27.22**	4.30 (.40)	29.83**
Idea generation	3.81 (.64)	17.67**	3.98 (.61)	17.04**	4.24 (.50)	23.16**
Idea evaluation	4.04 (.52)	23.51**	4.08 (.52)	20.50**	4.21 (.46)	25.12**
Implementation	4.15 (.62)	20.22**	4.12 (.48)	22.66**	4.29 (.38)	31.14**

Note. [a] t-Value tests against the lowest rating point of Likert scale.
** $p < .01$ (Bonferroni-adjusted)

In addition to the mere descriptive inspection of the means of activities over time, we tested the mean of each activity depicted in Figure 1.4 against the lowest rating point of the

Likert scale used to measure the innovation activities (i.e., against the value 1, indicating that the activity was not used). As we utilized multiple *t*-tests, we used the Bonferroni correction to adjust the alpha level of the individual *t*-tests (Bland & Altman, 1995). In our case of 48 tests, the nominal alpha level of .01 corresponds to an adjusted alpha level of .00021. Results are summarized in Table 1.7. The tests reveal that all activities are significantly different from 1 at the nominal alpha level of .01, in all classes and at each observation. To test the robustness up these results, we calculated the percentages of observations in which teams reported a mean of 2 or less on the five-point scale of the respective innovation activities. We used a less conservative criterion of 2 rather than 1. Even if this criterion was used, of the total of 386 observations across all teams, the mean was 2 or less only in 2.6% for problem identification, 1.6% for idea generation, 2.3% for idea evaluation, and 3.9% for implementation. That is, in only very few instances, teams reported to *not* engage in one of the innovation activities. Thus, taken together, these results confirm hypothesis 4 that all innovation activities are important throughout a project.

1.4 Discussion

In this article, we developed and tested a new linear-recursive model of the innovation process that integrates recursivity (Schroeder et al., 1989) with a linear phase model of innovation (Farr et al., 2003). The model postulates that the relative importance of innovation activities changes in the course of an innovation project. However, in contrast to extant phase models of innovation, we suggest that this change happens gradually and not in distinct and enclosed phases because all innovation activities have some relevance throughout the innovation process (Bledow et al., 2009). Our results confirmed both the phase approach and the recursive nature of innovation activities.

First, we found evidence confirming the linear elements of our model. Our results reveal that a reduction of idea generation and an increase of implementation activities over time were positively related to novelty of the project outcome. In other words, the more teams performed a shift from placing most weight on idea generation in the beginning to stressing implementation activities at the end of their projects, the more novel and original were their project outcomes. In addition, the more the teams increased the level of implementation in the course of their projects, the higher was the usefulness and quality of their innovation. Taken together, our results confirm our hypothesis that an increase in implementation over the course of an innovation project is important for innovation success (West, 2002a). Teams need to place their relative importance on implementation at the end of their project as at this point in time all project activities need to converge in the implementation of the final project outcome (Gersick, 1989). This means that our results are in line with the assumption of traditional phase models that teams need to implement their ideas as the last step of an innovation project (Amabile, 1988; Farr et al., 2003). At the same time, these results demonstrate that the strict assumption of distinct phases is not sustainable as the development of implementation and idea generation activities is indeed gradual as our linear-recursive model postulates and not abrupt as traditional phase models propose.

Moreover, we found one class in our sample that followed our linear-recursive model most closely (i.e., the linear class). Teams in this class were most successful in terms of novelty of the project outcome. That means that teams that stressed innovation activities according to the conditions of relative importance of the linear-recursive model succeeded in producing the most original outcomes. This finding is an important confirmation of the assumptions of our model and provides insight into the idea that a purely chaotic approach to innovation (Schroeder et al., 1989; Van de Ven et al., 1999) does not lead to highly innovative results. That means, a certain degree of structuring and "phases"– as represented by the conditions of relative importance – is especially necessary to handle highly original projects (Mumford, Scott, Gaddis, & Strange, 2002). However, the anti-phase model class that did not follow any of the conditions of the linear-recursive model and used the extremely recursive approach of utilizing the same amount of all activities at all times was less successful in all facets of innovation success, although the difference was not significant for usefulness and quality. That is, an innovation approach that has a stronger tendency toward the chaotic side is harmful to innovative performance in general, which further underlines that chaos models of innovation alone are not able to describe successful innovation appropriately (King, 1992). Furthermore, an inspection of the trajectories of innovation activities within the classes (see Figure 1.4) revealed that the most obvious difference between the linear class and all other classes was the trajectory of implementation activities. In contrast to all other teams, these teams were reserved in the use of implementation activities early in their projects, but placed a strong focus on implementation at the end. Thus, the success in producing novel outcomes of the teams in the linear class seems to be rooted mainly in their development of implementation activities over time.

The trajectories of innovation activities within the classes demonstrate another interesting finding of our study. Teams in the delayed idea evaluation class started out with a lot of implementation activities which they reduced over the course of the projects. This trajectory is opposite to the implementation trajectory of all other classes which all increased over time. However, these teams produced the most useful ideas. Apparently, this early focus on implementation led to an elaborate reality check that provided information about restrictions (Kristensson & Magnusson, 2010; Manske & Davis, 1968) and increased the usefulness of ideas in those teams. Moreover, both the high problem identification and idea generation class and the delayed idea evaluation class are only slightly less successful than the linear class in terms of quality of the project outcomes. On the one hand, these two results clearly underline the recursivity of our model. The development of innovation activities over time are not compatible with a strict phase approach (Amabile, 1988; Zaltman et al., 1973). On the other hand, these findings point towards equifinality of pathways to innovation (Bledow et al., 2009). In other words, high quality and useful products can be achieved in ways other than following a phase approach.

The recursivity of our linear-recursive model is further supported by the trajectories of innovation activities over time. Our results confirm that all teams used quite a lot of all activities throughout their projects, as no activity in any class at any point in time was zero. On a more descriptive level, even in the linear class, the "low" amount of implementation activities in the beginning of the projects was a mean of 2.94 on a scale ranging from 1 to 5 (see Table 1.7). Thus, this observation reveals that indeed the *relative* importance of the innovation activities is crucial, and not the absolute level. In addition, this observation confirms the recursive nature of innovation processes: All innovation activities are not only important within an enclosed window of time (as distinct innovation phases imply), but need to be handled to some extent throughout the innovation process (Bledow et al., 2009). That means that none of the teams in our sample followed a strict phase approach, but all of them used a mix of different innovation activities at all times, which clearly confirms the recursivity of our model. The confirmatory factor analysis lends further support to this finding. Whereas the general factor at the between-teams level can be interpreted as indicative of the overall activity level of teams, the high within-teams correlations specify that the innovation activities indeed are used simultaneously (Schmukle, Egloff, & Burns, 2002; Wilhelm & Schoebi, 2007). In other words, although the innovation activities are not interchangeable, they tend to co-occur in the innovation process. In particular, problem identification, idea generation, and idea evaluation are highly interrelated (with correlations of .80 to .84) and are likely to occur simultaneously within teams. This means that teams which are, for example, highly engaged in problem identification at one point in time are also engaged in all other innovation activities to a high degree at this particular time. At another point in time, these teams may have been less engaged in problem identification, but then they were also engaged less in the other innovation activities at this time. To confirm a strict linear phase model approach that assumes distinct phases, negative correlations between innovation activities at the observation level would have been necessary. For example, phase models assuming distinct phases predict that at any time at which the amount of idea generation activities is high, the amount of implementation activities will be low and vice versa. Therefore, the high intercorrelations at the within-teams level indicate a simultaneous use of all innovation activities and are incompatible with the assumption of distinct innovation phases (Amabile, 1988; Zaltman et al., 1973). Together, the results of the confirmatory factor analysis and the evidence of trajectories of innovation activities over time suggest that a phase model that assumes distinct innovation phases cannot account for our data. Instead, our findings demonstrate quite clearly that the demands for all innovation activities reoccur throughout a project and cannot be handled once and for all, which again represents a confirmation of the recursive part of our linear-recursive model.

Finally, one finding was unexpected. A reduction of the amount of idea generation activities over time was not related to quality and usefulness of the project outcome, although it was related to novelty. This result is surprising at first glance, as the generation of many ideas should be related to high novelty of ideas (Diehl & Stroebe, 1987; Simonton, 1997). However, the finding might be explained in conjunction with the observation that the mean level of idea generation was negatively related to novelty. That is, the more ideas teams generated, the more this hurt the novelty of their ideas, especially when they kept generating a lot of ideas until the end of the project. This might be the case because teams that produced too many ideas got lost in the overwhelming number of ideas (Koput, 1997) and constant reshaping of the ideas in the course of the project led to more conventional, but still high quality and useful ideas. Another explanation is that the more teams recognized that their innovations were not novel and original, the more time they spent with idea generation. Thus, especially teams that had problems developing original ideas invested a lot time and energy in idea generation activities to improve the originality of their work. However, as this finding was unexpected, it necessitates further research to explain the mechanisms involved.

One aspect of our results demands further attention. Our findings are somewhat contradictory concerning whether having a lot of ideas at the end of a project is desirable or not. It has been proposed that idea generation is important throughout innovation projects, not only in the beginning of a project (Bledow et al., 2009; West, 2002a). In line with this reasoning, most of the teams in our sample did not reduce the amount of idea generation during their projects; even those teams in the linear class that was superior to all other classes in terms of novelty. However, as just discussed, we also found that a reduction of idea generation in the course of a project was positively related to novelty of the project outcome. This finding is in accordance with linear approaches to innovation (Amabile, 1988; Zaltman et al., 1973) and the assumption that too many ideas after the midpoint of a project hinder project success (Gersick, 1989). We propose that this seeming contradiction can be resolved when taking the other conditions of relative importance of our model into account. When considered in isolation, a reduction of idea generation is beneficial for innovation success. But when other conditions are met, most importantly, when the amount of implementation activities exceeds idea generation activities at the end of a project (a condition that was always met in the linear class), the relative reduction of idea generation is less important for the success of teams. In other words, we assume that if teams concentrate on implementation at the end of their projects, the amount of idea generation is less relevant (as long as it is lower than the amount of implementation activities). This explanation is in line with the overall importance of the implementation trajectory that we found. However, these findings also underline the complexity of innovation processes and demonstrate that equifinality characterizes the innovation process (Bledow et al., 2009).

Summing up, our study demonstrated that neither linear phase models nor chaos or recursive models of innovation alone are sufficient to describe the innovation process appropriately, but that an integration of both frameworks in necessary. The linear-recursive model that we introduced in this paper provides such an integration. Our main findings reveal that innovative projects need to be designed in such a way that teams place most weight on idea generation in the beginning of their projects, whereas implementation activities gain importance in the course of the projects (linear part of the model). In addition, teams cannot focus solely on one activity, but need to be flexible in switching between activities (recursive part of the model). Moreover, the innovation process is characterized by equifinality of pathways to success (Bledow et al., 2009). We found this in this study to be especially true for the quality of the innovations that did not differ between classes. The combination of these findings demonstrates the complex or even paradoxical nature of innovation (Andriopoulos & Lewis, 2009).

Limitations

As with other studies, this research has limitations. First, the sample was comprised of students, posing a limitation to the generalizability of findings. However, the students worked on real-world problems with a real-life goal: Project outcomes were graded by the team supervisors (professors) and, thus, their projects had meaningful consequences that were important to the students. It can be reasonably assumed that the students were fully engaged in the projects. Nevertheless, the student teams worked together for only up to 4 months; that is considerably shorter than the applied innovation projects in organizational settings. Even so, we think it to be reasonable to assume that the underlying processes are similar in student and R&D teams. That is, the task and the requirements of this task are highly similar in our student teams and R&D teams working in an innovation setting. For example, the teams needed to work on applied projects with ill-defined problem descriptions as is often the case in professional R&D teams (Mumford et al., 2002). In addition, teams worked on their projects independent of our research. That is, they did not work in an artificial laboratory setting or on artificial problems provided by us, but in an applied setting that was determined by their professors who are very knowledgeable in their respective fields. Yet, it is important to replicate our results in professional R&D teams in order to examine the generalizability and external validity of the findings.

Second, the time frame we chose for this study (i.e., time intervals between observations of two weeks) does not allow for detailed analysis of the separation or integration of innovation activities in shorter intervals within days, hours, or minutes. For this first empirical test of our model, we chose a time frame to be able to map the overall innovation process and its chaotic and linear elements. Therefore, in this framing, teams work seemingly simultaneously on different innovation tasks. However, we assume it more likely that teams constantly switched between tasks. With our current design, we cannot differentiate between these two possibilities. Future research needs to focus on more fine-grained analyses with shorter time frames to answer this intriguing question.

Third, our study could not give definite answers to the question of whether creativity in the end of a project promotes innovation success or not. Moreover, literature gives contradictory answers to this question. Following the idea of punctuated equilibrium, Ford and Sullivan (2004) postulate that new ideas after the project midpoint hinder the successful implementation of ideas. However, others have argued that to overcome hindrances in the process of idea implementation, creative ideas are necessary, even in the very end of innovation processes (Bledow et al., 2009; West, 2002b). We therefore need more research to disentangle the dynamics of innovation processes concerning creativity in more detail. To give more definite answers about the advantages and disadvantages of creativity at the end of innovation projects, experimental work that prestructures the order of activities might be helpful.

Finally, in our sample, we could not test whether a strict separation of innovation into distinct phases is related to superior performance. None of the teams performed a strict separation of innovation activities by themselves. From this observation, we conclude that the natural path of innovation is one of interrelatedness of innovation activities. However, future research should try to experimentally separate innovation activities and test the effects of the separation on innovation success. In the literature, there are reports of organizations that split exploration and exploitation activities not only temporarily but between different teams or even different organizational units (e.g., O'Reilly & Tushman, 2004; Westerman, McFarlan, & Iansiti, 2006). Yet to date there has been no empirical test of whether the integration or separation of innovation activities leads to superior performance (Andriopoulos & Lewis, 2009). The assumption of our linear-recursive model is that an artificial "squeezing" of the innovation process into distinct stages will hurt performance.

Theoretical and practical implications

Our linear recursive model of the innovation process has important implications for future research on innovation as well as for the design of innovative project work. The results of our study imply that innovation activities cannot be studied in isolation, but need to be examined in relation to other innovation activities. Bledow et al. (2009), Cao, Gedajlovic, and Zhang (2009), Gibson and Birkinshaw (2004), He and Wong (2004) as well as others have argued that an integration of explorative (i.e., idea generation) and exploitative activities (i.e., idea implementation) is crucial in innovation processes. Our research demonstrates that this is not only true at the organizational level, but also within innovation project teams. On the other hand, teams do not use innovation activities to the same amount at all times within the innovation process, but the relative importance shifts over time. Whether teams need to incorporate some explorative activities into their routines of exploitative activities or vice versa may imply very different types of challenges for innovative teams. For example, it could be rather easy to switch to a more exploitative mindset while generating ideas, but much more difficult to switch to an open explorative mindset when trying to efficiently implement ideas. In addition, research on the cognitive and neurocognitive foundations of explorative and exploitative search has shown that individuals tend to be inertial when it comes to switching between exploration and exploitation (Hills, Todd, & Goldstone, 2010). Thus, an important challenge for future research is to examine what triggers these switches to overcome the inertia. Using the linear-recursive model as a new framework makes it feasible to examine the nature of switching between innovation activities.

A related point in this context is the selection of a time frame (Mitchell & James, 2001; Roe, 2008). We reasoned that teams need to flexibly switch between innovation activities. However, what this oscillation between activities exactly means depends heavily on the time frame one uses to describe the activities, for example, whether one uses weeks, days, or hours as a time frame. Future research should build upon our model and study the interplay of innovation activities with a stronger focus on microprocesses, that is, how the transition from one activity to another can be best achieved or what frequency of switching may be optimal. We assume that self-regulation strategies of teams and individuals play a crucial role in switching between activities and should therefore be included in future research.

An important practical implication of our research is whether or not to prescribe phase models to teams and organizations. Our results offer two answers to this question. First, a strict phase model approach is not advisable. Teams in our sample engaged in a fair amount of all activities throughout their projects. Innovation activities were interrelated and a strict separation of activities would be artificial. Second, a rough but flexible planning of the innovation process should be helpful. Teams need to invest their energies in idea generation in the beginning of a project, without neglecting implementation, and need to increase their efforts in implementing ideas towards the end of their projects, while upholding some amount of idea generation. Thus, flexible and proactive planning of innovation projects may be necessary (Frese et al., 2007). Teams need to know what activity they need to focus on at any point in time, but should be encouraged to switch to any other activity as the current situation demands. For example, leaders of innovative projects may support a transition between innovation activities by fostering exploration versus exploitative behaviors (Rosing, Frese, & Bausch, in press).

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CHAPTER 2

Explaining the heterogeneity of the leadership-innovation relationship: Ambidextrous leadership

The authors review and meta-analytically integrate the existing literature on leadership and innovation to show a complex and inconsistent picture of this relationship. Current research has mostly neglected the complex nature of innovation processes that leads to changing requirements within these processes. The main requirements of innovation are exploration and exploitation as well as a flexibility to switch between those two activities. The authors propose an ambidexterity theory of leadership for innovation that specifies two complementary sets of leadership behavior that foster exploration and exploitation in individuals and teams – opening and closing leader behaviors, respectively. We call this ambidextrous leadership because it utilizes opening and closing leader behaviors and switches between them to deal with the ever-changing requirements of the innovation process. Routes to ambidextrous leadership and opportunities for future research on leadership and innovation are discussed.

2.1 Introduction

The link between leadership and innovation has gained increasing attention in the literature. Some researchers proposed that leadership is one of the most influential predictors of innovation (Manz, Bastien, Hostager, & Shapiro, 2000; Mumford, Scott, Gaddis, & Strange, 2002). A recent special issue of "The Leadership Quarterly" on organizational learning shows the importance of leadership for innovation and organizational development (Jansen, Vera, & Crossan, 2009; Nemanich & Vera, 2009; Yukl, 2009). In this article, we answer the call by Yukl (2009) for more comprehensive models of the influence of leadership on exploration and exploitation, two activities required within the innovation process. In doing so, we build upon the theoretical framework provided by Bledow, Frese, Anderson, Erez, and Farr (2009) that elaborates a dialectical perspective on innovation.

West and Farr (1990) define innovation as "the intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organization or wider society" (p. 9). Thus, there is more to being innovative than just being creative. Creativity is defined as the generation of original and useful ideas (Amabile, 1996; West, 2002). Innovation is distinguished from creativity by the implementation, as opposed to mere generation, of ideas. Implementation requires selling ideas within the organization to other persons and/or groups (Axtell et al., 2000) and to propose the innovation for the market place; therefore, innovation includes social processes. What makes innovation processes complex is that creativity and implementation do not neatly proceed in a linear fashion (Anderson, De Dreu, & Nijstad, 2004; King, 1992; Schroeder, Van de Ven, Scudder, & Polley, 1989; Van de Ven, Polley, Garud, & Venkataraman, 1999) and, therefore, cannot be easily split into separate phases or stages. Instead, the requirements to generate and implement ideas alternate throughout the innovation process in an ever-changing manner. This factor makes innovation full of paradoxes and tensions, as described by Miron, Erez, and Naveh (2004). However, much of the literature and research has treated innovation as a rather uniform or linear process by looking for stable and broad antecedents.

The intent of this article is twofold. First, we present an overview of the existing research on leadership in the innovation process with the help of meta-analytic tools where applicable. Given the limited literature base, a full-scale meta-analysis such as Judge and colleagues (Judge & Piccolo, 2004; Judge, Piccolo, & Ilies, 2004) did on leadership and performance or Hülsheger, Anderson, and Salgado (2009) did on team level predictors and innovation is not intended. Instead, we utilize meta-analytic tools to focus and systematize our literature review with the intent to emphasize the high variation of the relationships between leadership and innovation. The heterogeneity of relationships points to inconsistencies in the findings, meaning that leadership styles have very different relationships with innovation depending on third variables.

Second, we explain this heterogeneity by developing a theoretical model towards leadership for innovation. In this theoretical model, we make two main points: First, we propose that the traditionally studied leadership styles are too broad in nature to specifically promote innovation as they might both foster and hinder innovation. For example, a transformational leader who communicates an inspiring vision may foster innovation if the vision includes fostering of experimentation. On the other hand, he or she might hinder innovation if followers are so absorbed in this vision that they stop thinking outside of it. We suggest that the crucial feature of leadership for innovation is the fostering of either exploitation or exploration via the reduction or increase in the variance of follower behaviors. Exploration and exploitation have originally been defined by March (1991) as two forms of organizational learning. In this respect, exploration is connected to increasing variance, experimentation, searching for alternatives, and risk taking; exploitation is linked to reducing variance, adherence to rules, alignment, and risk avoidance (March, 1991). As we explain later in this article, both exploration and exploitation are of crucial importance for innovation. Second, in light of the complexity of innovation endeavors, we propose that a single leadership style cannot promote innovation effectively. Instead, a combination of different leadership behaviors flexibly applied to changing requirements within the innovation process is more effective. In other words, leadership needs to match the complexity and the pace of innovation (Ancona, Goodman, Lawrence, & Tushman, 2001). In the last decades, leadership research and theory has moved away from studying stable leader traits and general leadership styles towards recognizing for the usefulness of situational variability and flexible leadership behavior (e.g., the path-goal theory of leadership; House, 1971) and leadership that is specifically tuned to individual followers (leader-member exchange theory; Graen & Uhl-Bien, 1995). We assume that the less a theory focuses on stable and inflexible leadership styles and the more it incorporates flexibility of leadership behaviors, the better it is able to explain innovation. In our approach, we take this trend one step further by proposing that temporally flexible leadership is needed when it comes to innovation: We assume that the appropriate leadership behavior in each and every situation is dependent not only on the individual follower and the specifics of the situation, but also on the timing within the innovation cycle. That is, time and timing of leadership behaviors are critical in our approach as we assume dynamic relationships between leadership and innovation. Simple linear relationships between leadership and innovation that do not account for temporal dynamics are therefore unlikely (Mitchell & James, 2001). That means that it is not sufficient to show different leadership styles, but also to flexibly adjust the leadership behaviors to the current requirements of the innovation tasks that quickly change over time and, additionally, to integrate these leadership behaviors to be overall consistent in a leadership approach.

It follows from these two assumptions that leaders for innovation need to switch flexibly between complementary leadership behaviors, that is, between reducing and increasing variance in follower behavior, adjusted to the current requirements of the innovation tasks. These leadership behaviors are complementary because they each of them corresponds to innovation requirements that the other one is not able to meet. We call this ability to show flexibility of leadership behaviors ambidextrous leadership because of its ability to foster ambidexterity in followers.

Ambidexterity literally means the ability to use both hands with equal ease. In management science ambidexterity has been linked to the balance of explorative and exploitative organizational strategies, that is, the ability to engage in exploration and exploitation equally well (Benner & Tushman, 2003; Gibson & Birkinshaw, 2004; He & Wong, 2004; Raisch & Birkinshaw, 2008). For firms to be successful in the short and long run, it is necessary to be both explorative and exploitative – that is, to be ambidextrous. Organizations that achieve a balance of these two activities are more successful than those that do not achieve such a balance (Gibson & Birkinshaw, 2004; He & Wong, 2004). The concept of ambidexterity was originally developed for the organizational level. But what ambidexterity actually means on lower levels of an organization – especially on a behavioral level for teams and individuals – has not been elaborated in the existing literature (for recent exceptions see Bledow et al., 2009, and Nemanich & Vera, 2009). In other words, although the idea of ambidextrous organizations is not new, it has not been applied to leadership, and the concept of leadership in ambidextrous organizations has not been elaborated. In our theory, we expand the concept of ambidexterity to leadership of teams and individuals. We define ambidextrous leadership as the ability to foster both explorative and exploitative behaviors in followers by increasing or reducing variance in their behavior and flexibly switching between those behaviors. That is, ambidextrous leaders are able to support their followers in the attempt to be ambidextrous. Our conception of leadership embraces both the need for specific leadership behaviors and the requirement to match the complex nature of innovation processes as stated above. We will outline our theory of ambidextrous leadership in the second part of the article. It is important to note that our theory applies mainly to the individual and team level as it is a theory of direct and frequent interaction between the leader and the follower(s); therefore it does not apply to the organizational level. However, in our literature review, we will also report relationships between leadership and innovation on the organizational level to present a more comprehensive picture of this relationship.

2.2 Literature review: Leadership in the innovation process

We will use the following structure in our review and discussion of the literature. First, we shall show that each particular leadership style is related to innovation, but that this relationship is highly variable and heterogeneous – meaning that the correlations between any particular leadership style and innovation often range from positive to negative correlations. We shall use a heterogeneity index (75% rule, Hunter & Schmidt, 1990) in the meta-analysis to substantiate this point. Second, we then suggest that the heterogeneity of results may be due to the fact that to be a good leader for innovation implies complementary processes. These complementary processes necessitate the leader to follow different task requirements when leading an innovative team. Third, we describe such an ambidextrous leadership theory and suggest a number of propositions that follow from it. Finally, we use the discussion to show similarities and differences of the ambidextrous leadership theory with other leadership and innovation theories.

For the literature review we used two different strategies to locate studies. First, we searched databases (PsycInfo, Business Source Premier) using the following search terms: leadership and innovation, leadership and innovativeness, leadership and creativity. Second, we examined the reference lists of the located papers as well as those of theoretical papers on leadership and innovation (such as the one by Mumford, et al., 2002). In cases where at least 5 independent samples on a leadership style were found, we used meta-analytic tools to integrate the findings. We utilized the usual procedures of meta-analysis (suggested by Hunter & Schmidt, 2004), such as correcting for unreliability of dependent and independent variables, aggregating correlations when several comparable correlations were reported for one sample (e.g., when several operationalizations of innovation were used), and weighting correlations by sample size to calculate a weighted and corrected mean correlation (Hunter & Schmidt, 2004). We calculated a 95% confidence interval around this mean correlation and considered the correlation significant if the confidence interval did not include zero. To test for homogeneity of findings, we applied the 75% rule proposed by Hunter and Schmidt (1990). This rule states that if at least 75% of the observed variance is due to sampling error, a relationship can be considered homogenous. In case of heterogeneity (i.e., less than 75% of variance due to sampling error), moderator analysis may be conducted. In those cases, where enough studies existed for moderator analyses, we used z-tests to test for differences between correlations (Hunter & Schmidt, 1990).

In those cases where we found less than 5 independent samples on a particular leadership style, we still reviewed the results of the studies, but we did not integrate them meta-analytically. Table 2.1 provides a list of all findings, whereas Table 2.2 presents the meta-analytic results.

Table 2.1

Relationships of innovation with leadership styles

Source	**N**	**r**	**Dependent variable**
Transformational leadership			
Jaussi & Dionne (2003)	364 individuals	**-.03**	Individual creative performance
Lee (2008)	201 individuals	**.02**	Innovativeness
Basu & Green (1997)	225 individuals	**.03**	Innovative behavior
Hirst, van Dick, & van Knippenberg (2009)	111 individuals	**.11**	Creative performance
Gumusluoglu & Ilsev (2009)	163 individuals	**.17***	Creativity
Gong, Huang, & Farh (2009)	200 individuals	**.18***	Individual creativity
Stoker, Looise, Fisscher, & de Jong (2001)	601 individuals	**.19****	Perceived team effectiveness (service organization)
Shin & Zhou (2003)	290 individuals	**.22****	Individual creativity
Moss & Ritossa (2007)	263 individuals	**.23***	Creativity
Chen, Li, & Tang (2009)	320 individuals	**.30*****	Creativity
Stoker, Looise, Fisscher, & de Jong (2001)	601 individuals	**.31*****	Perceived team effectiveness (manufacturing organization)

(Table 2.1 continued)

Source	N	r	Dependent variable
Jaussi & Dionne (2003)	79 teams	**-.28****	Group creative performance
Eisenbeiss, van Knippenberg, & Boerner (2008)	33 teams	**-.07**	Team innovation
Waldman & Atwater (1994)	40 teams	**.07**	Project effectiveness
Kearney & Gebert (2009)	62 teams	**.10**	Team performance
Sosik, Kahai, & Avolio (1998)	36 teams	-.06 .01 .39* .21 ***.14***	Fluency Flexibility Originality Elaboration *Mean*
Shin & Zhou (2007)	75 teams	**.28***	Team creativity
Keller (2006)	118 teams	.40** to .46** .27** to .30** -.13 to .24** .28* to .42** .18 to .30** ***.28***	Technical quality Schedule performance Cost performance Profitability Speed to market *Mean*
Keller (1992)	48-66 teams	.27* to .40** .20 to .39** ***.32***	Project quality Budget/schedule performance *Mean*
Boerner, Eisenbeiss, & Griesser (2007)	91 teams	**.36*****	Team innovativeness
Reuvers, van Engen, Vinkenburg, & Wilson-Evered (2008)	41 teams	**.48****	Team innovative behavior
Pirola-Merlo, Härtel, Mann, & Hirst (2002)	53 teams	**.32***	Team effectiveness
Dayan, Di Benedetto, & Colak (2009)	107 teams	.43* .84* ***.64***	Speed-to-market Product success *Mean*
Osborne & Marion (2009)	93 organizations	**-.31****	Innovation performance
Jung, Wu, & Chow (2008)	50 organizations	**.09**	Organizational innovation
Jansen, Vera, & Crossan (2009)	89 organizations	.24* .16 ***.20***	Exploratory innovation Exploitative innovation *Mean*
Jung, Chow, & Wu (2003)	32 organizations	.18 .36** ***.27***	Number of patents R&D expenditure *Mean*

(Table 2.1 continued)

Source	**N**	**r**	**Dependent variable**
Jaskyte (2004)	19 organizations	**.29**	Number of innovations
Gumusluoglu & Ilsev (2009)	43 organizations	**.30***	Organizational innovation
Elenkov & Manev (2009)	153 organizations	.19** to .33*** ***.31***	Innovation adoption *Mean*
Aragón-Correa, García-Morales, & Cordón-Pozo (2007)	408 organizations	**.39*****	Firm innovation
García-Morales, Llorens-Montes, & Verdu-Jover (2008)	900 organizations	**.46*****	Innovation
García-Morales, Matías-Reche, & Hurtado-Torres (2008)	164 organizations	**.49*****	Innovation
Transactional leadership			
Moss & Ritossa (2007)	263 individuals	-.06 to .14	Follower creativity
Dayan, Di Benedetto, & Colak (2009)	107 teams	.07 .25*	Speed-to-market Product success
Jansen, Vera, & Crossan (2009)	89 organizations	-.27* .30*	Exploratory innovation Exploitative innovation
Initiating Structure			
Williams (2004)	127-208 individuals	-.13 to .12 -.13 to .13 ***-.02***	Novelty Creativity *Mean*
Stoker, Looise, Fisscher, & de Jong (2001)	359 individuals	**.19****	Perceived team effectiveness (manufacturing organization)
Stoker, Looise, Fisscher, & de Jong (2001)	242 individuals	**.24****	Perceived team effectiveness (service organization)
Keller (1992)	48-66 teams	.25* to .27* .29* to .34* ***.29***	Project quality Budget/schedule performance *Mean*
Keller (2006)	118 teams	.23* .30** .27* .34** .39* ***.31***	Technical quality Schedule performance Cost performance Profitability Speed to market *Mean*
Osborne & Marion (2009)	93 organizations	**.29****	Innovation performance

(Table 2.1 continued)

Source	N	r	Dependent variable
Consideration			
Stoker, Looise, Fisscher, & de Jong (2001)	242 individuals	.18**	Perceived team effectiveness (service organization)
Stoker, Looise, Fisscher, & de Jong (2001)	359 individuals	.24**	Perceived team effectiveness (manufacturing organization)
Keller (1992)	48-66 teams	.26* to .30* .19 to .28*	Project quality Budget/schedule performance
Osborne & Marion (2009)	93 organizations	.28**	Innovation performance
Leader-Member Exchange (LMX)			
Clegg, Unsworth, Epitropaki, & Parker (2002)	128 individuals	-.09 .30*** ***.11***	Idea suggestion Idea implementation *Mean*
Scott & Bruce (1994)	172 individuals	**.17****	Innovative behavior
Tierney, Farmer, & Graen (1999)	191 individuals	.30** .17* .06 ***.18***	Creativity rating Invention disclosure form Research reports *Mean*
Basu & Green (1997)	225 individuals	**.22****	Innovative behavior
Janssen & Van Yperen (2004)	170 individuals	**.34****	Innovative job performance
Supervisor Support			
Tierney & Farmer (2002)	104 individuals	**-.10**	Creativity ratings (operations sample)
Oldham & Cummings (1996)	171 individuals	.14 -.14 -.19 ***-.06***	Rated creativity Patents Suggestions *Mean*
Axtell, Holman, Unsworth, Wall, Waterson, & Harrington (2000)	148 individuals	-.04 .12 ***.04***	Suggestions Implementation *Mean*
Ohly, Sonnentag, & Pluntke (2006)	278 individuals	.12* .15** -.12* ***.05***	Creativity Innovation Suggestions *Mean*
Tierney & Farmer (2002)	502 individuals	**.05**	Creativity ratings (manufacturing sample)

(Table 2.1 continued)

Source	N	r	Dependent variable
Frese, Teng, & Wijnen (1999)	207 individuals	.05 .06 .18* ***.10***	Ideas Writing and submitting ideas Rewarded Suggestions *Mean*
George & Zhou (2007)	161 individuals	**.13**	Creativity
Unsworth, Wall, & Carter (2005)	1083 individuals	.11*** .17*** ***.14***	Product creativity Process creativity *Mean*
Basu & Green (1997)	225 individuals	**.17****	Innovative behavior
Choi (2004)	386 individuals	**.17****	Creative performance
Tierney & Farmer (2004)	140 individuals	**.17****	Creativity
Amabile, Schatzel, Moneta, & Kramer (2004)	211 individuals	**.18***	Creativity
Krause (2005)	382-396 individuals	.02 .33*** ***.18***	Idea Generation Idea Implementation *Mean*
Madjar, Oldham, & Pratt (2002)	265 individuals	**.20****	Creative performance
Krause (2004)	399 individuals	.28*** .22*** ***.25***	Idea generation Implementation *Mean*
Amabile, Conti, Coon, Lazenby & Herron (1996)	306 teams	**.34*****	Creativity
Participative Leadership			
Stoker, Looise, Fisscher, & de Jong (2001)	601 individuals	.04	Perceived team effectiveness (service organization)
Stoker, Looise, Fisscher, & de Jong (2001)	601 individuals	.26***	Perceived team effectiveness (manufacturing organization)
Krause, Gebert, & Kearney (2007)	388 individuals	.49***	Implementation success
Somech (2006)	136 teams	.26**	Team innovation
Noncontrolling Leadership			
Oldham & Cummings (1996)	171 individuals	.28* .07 -.20	Rated creativity Patents Suggestions
Supervisor Close Monitoring			
Zhou (2003)	25 individuals	-.45*	Creativity (study 1)
George & Zhou (2001)	149 individuals	-.26**	Creative behavior
Zhou (2003)	123 individuals	-.22*	Creativity (study 2)

(Table 2.1 continued)

Source	**N**	**r**	**Dependent variable**
Consultative-advisory Leadership			
Krause, Gebert, & Kearney (2007)	388 individuals	.35***	Implementation success
Directive Leadership			
Somech (2006)	136 teams	.28***	Team innovation

Note. *** p < .001, ** p < .01, * p < .05. Numbers in bold are used for meta-analytic calculations. Numbers in italics are aggregated values of nonindependent samples.

Table 2.2

Results of Meta-Analytic Integration

Leadership Style Moderators	**k**	**N**	**rw**	**rwc**	**Sampling error (% variance)**	**95% Confidence interval**
Transformational leadership	31	5113	.263	**.291**	14.22	.225 to .358
Organizational level	10	1951	.370	**.423**	10.28	.309 to .537
Team level	12	768	.251	**.276**	21.04	.133 to .420
Individual level	11	2738	.166	**.174**	27.14	.104 to .244
Creativity as DV	9	1680	.171	**.176**	26.01	.085 to .267
Innovation as DV	15	2542	.308	**.350**	10.29	.244 to.457
R&D performance as DV	8	1014	.292	**.325**	30.65	.225 to .425
Self-rated DV	8	2281	.346	**.389**	11.92	.288 to .490
Other-rated DV	23	2832	.197	**.213**	19.57	.133 to .293
Initiating structure	6	1012	.228	**.255**	38.56	.162 to .348
Leader-Member Exchange (LMX)	5	886	.208	**.216**	97.89	.152 to .279
Supervisor Support	16	5111	.139	**.150**	34.09	.104 to .196
Creativity as DV	10	3296	.145	**.156**	38.99	.102 to .210
Innovation as DV	8	2352	.128	**.141**	18.33	.048 to .233

Note. k = number of studies; N = overall number of observations; rw = weighted mean correlation (weighted by sample size); rwc = weighted and corrected mean correlation (corrected for unreliability)

Transformational and transactional leadership

Transformational leadership has been most strongly suggested to be related to innovation. Transformational leadership, defined as "moving the follower beyond immediate self-interests through idealized influence (charisma), inspiration, intellectual stimulation, or individualized consideration" (Bass, 1999, p.11), motivates followers to reach high performance. It seems plausible to expect a positive relationship between transformational leadership and innovation because transformational leadership enhances motivation and may encourage the followers to challenge the status quo (Keller, 2006). In contrast, transactional leadership establishes an exchange-based relationship by clarifying goals, rewarding goal achievement, and by intervening only when necessary (Bass, 1999). Transactional leadership does not encourage experimentation and we, therefore, do not expect a positive relationship with creativity and innovation.

Transformational leadership. Transformational leadership has been hypothesized to be a positive force in the innovation context. The meta-analytic integration of the 31 existing studies on the link between transformational leadership and innovation supports this hypothesis as we find a weighted and corrected mean correlation of .28 (see Table 2.2). However there is a broad range of results varying from -.31 to .84 (see Table 2.1): Osborne and Marion (2009) detected a correlation of -.31 between transformational leadership of the alliance head with innovation performance of international corporate alliances, whereas Dayan, Di Benedetto, and Colak (2004) reported a correlation of .84 between transformational leadership and product success in their research and development (R&D) teams. The range of findings is illustrated in Figure 2.1.

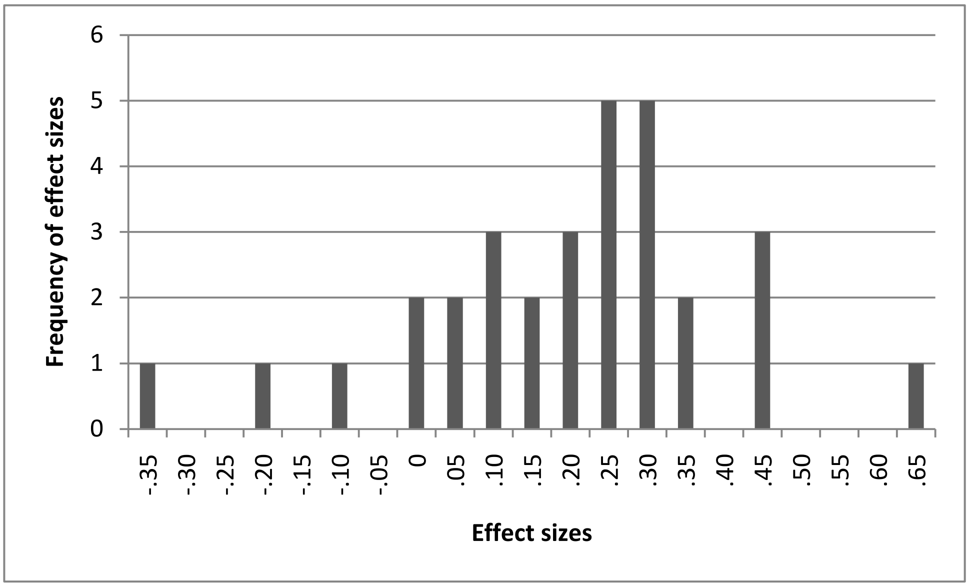

Figure 2.1. *Range of effect sizes (r) for the relationship between transformational leadership and innovation (aggregated correlations)*

In this figure we display the aggregated correlations that we used for the meta-analysis, not the original correlations of the studies that are partly nonindependent; therefore, the results vary from -.31 to .64 (instead of from -.31 to .84). This variation cannot be explained only by sampling error, as only 15.97% of the observed variance is due to sampling error; this is considerably lower than the 75% required to assume homogeneity (Hunter & Schmidt, 1990).

To test whether this heterogeneity might be due to either differences in the level of analysis (i.e., organization, team, and individual level), type of dependent variable (i.e., creativity, innovation, and performance in R&D teams) or source of innovativeness rating (i.e., self rating vs. other rating), we conducted three moderator analyses. Results of these moderator analyses show: First, correlations at the organizational level (mean $r = .42$) were significantly higher than correlations at the individual level (mean $r = .17$; $z = 3.09$, $p < .05$). However correlations at the team level (mean $r = .28$) did not differ significantly from either correlations at the organizational level ($z = 1.29$, $p > .10$) or individual level ($z = 1.06$, $p > .10$). Thus, transformational leadership has a stronger correlation with innovation at the organizational level than at the individual level of analysis. At the individual level of analysis there are many direct interactions between leaders and followers; the leaders are directly involved in the innovation process. Therefore, more flexibility on the leader's part is necessary to meet the requirements of the innovation tasks at lower levels. Hence, the specific leadership style of transformational leadership is not good enough in the direct interactions; in contrast, on an organizational level less flexibility in the use of different leadership behaviors is necessary so that transformational leadership is better able to explain organizational innovation.

Second, the correlation with creativity as dependent variable (mean $r = .18$) was marginally significantly lower than the correlation with innovation (mean $r = .35$; $z = 1.94$, $p < .10$) and marginally significantly lower than the correlation with performance in R&D teams as dependent variable (mean $r =.33$; $z = 1.80$, $p < .10$); the correlations with innovation and performance in R&D teams did not differ from each other ($z = 0.21$, $p > .10$). This suggests that transformational leadership may help creativity but may also hinder creativity to some extent. In contrast, transformational leadership helps to increase overall innovation and performance in R&D teams.

Third, the correlation with self-rated innovation performance (mean $r = .39$) was significantly higher than the correlation with other-rated innovation performance (mean $r = .21$; $z = 2.34$, $p < .05$). However, the moderators did not do away with the heterogeneity of the results. Within each category of the moderators, the amount of variance due to sampling error did not exceed 31%. That means that the moderators account only for a small amount of the observed variation in the findings, leaving room for further moderators.

Some of the primary studies investigated moderators, and in this way they point to boundary conditions for the transformational leadership – innovation relationship. Kearney and Gebert (2009) and Shin and Zhou (2007) found a positive correlation only for high diversity teams. Keller (1992, 2006) revealed in his studies of R&D teams that transformational leadership was more strongly related to quality in research projects compared to quality estimated in development projects. He suggested that transformational leadership fosters unconventional thinking and solutions that go beyond existing knowledge. Scientists in research projects often work on more radical innovations than those in development projects. Therefore, transformational leadership is more effective in research projects than in development projects (Keller, 1992, 2006). Similarly, at the organizational level, Jansen et al. (2009) found a positive correlation of transformational leadership with exploratory innovation (which is more likely in research than in development projects), but they did not find such a correlation with exploitative innovation (which is more likely in development that in research projects). Eisenbeiss et al. (2008) observed the relationship between transformational leadership and team innovation to be contingent on high climate for excellence in the teams. They proposed that transformational leadership only leads to the generation and implementation of high quality ideas when team members share an interest for high quality performance. Under conditions of low climate for excellence, ideas may be generated, but rather uncritically, and implementation is more likely to be given up in the face of difficulties (Eisenbeiss, et al., 2008). Additionally, Jung, Wu, and Chow (2008) did not find a significant zero-order correlation between transformational leadership and innovation, but showed that the relationship between transformational leadership and organizational innovation was contingent on firm characteristics such as high climate of support for innovation, low centralization and formalization as well as environmental features such as high uncertainty and competition. Similarly, García-Morales, Lloréns-Montes, et al. (2008) found a higher correlation between transformational leadership and organizational innovation in organizations with high organizational learning as compared to organizations that emphasize less on organizational learning.

Our literature review on the relationship between transformational leadership and innovation suggests that transformational leadership correlates positively with innovation. But more importantly, there is a high degree of variation in the results. This means that the extant literature does not provide a consistent picture of this relationship (Mumford, Hunter, & Byrne, 2009; Mumford, et al., 2002). We suggest that it is insufficient to focus only on the main effect of transformational leadership on innovation without considering the variation of results. The variation of the results suggests that the relationship between transformational leadership and innovation is contingent on other variables, such as the type of dependent variable (e.g., creativity vs. innovation), the level of analysis, and source of innovativeness rating as well as the work tasks (e.g., research vs. development projects) and several features of the individuals, teams, and organizations studied (e.g., climate for excellence, centralization, etc.). Those studies that reported moderator effects suggest that a certain kind of flexibility is necessary on the part of the leader. For example, transformational leadership was only related to team innovation when climate for excellence was also high (Eisenbeiss, et al., 2008). That means that transformational leadership only fosters innovation in combination with the social control of goal attainment in the form of a high task orientation and high performance norms within the team. Similarly, transformational leadership was only related to innovation if there was simultaneously a high climate of support for innovation (Jung, et al., 2008). These results suggest that a leader with a transformational leadership style needs to complement his or her visionary and stimulating influences by focusing on different aspects of the innovation process, such as social control and an overall supporting environment. These findings imply that transformational leadership is not necessarily related to innovation under all circumstances, but some specific conditions need to be met. Our literature review indicates that more research that focuses more clearly on the mechanisms that link transformational leadership and innovation as well as the conditions that constrain this relationship is needed. In a later part of this article we shall come back to these conditions and argue that ambidextrous leadership may explain some of the moderator results of transformational leadership.

Transactional leadership. Only a few studies have looked at the link between transactional leadership and innovation; therefore, we did not use meta-analytic tools for this relationship. However, Table 2.1 shows that there is a high degree of variability in this relationship, too. Dayan et al. (2004) reported a positive correlation between transactional leadership and product success in R&D teams, but a nonsignificant correlation with speed-to-market. Another study on the relationship between transactional leadership and innovation indicated a negative correlation between transactional leadership and exploratory innovation under conditions of high environmental dynamism, but a positive correlation between transactional leadership and exploitative innovation which was independent of the environmental dynamism (Jansen, et al., 2009). Moss and Ritossa (2007) found correlations between -.06 and .14 for different facets of transactional leadership and follower creativity. Lee (2008) found a significant negative correlation between transactional leadership and innovation. Finally, the experimental studies by Sosik, Avolio, and Kahai (1997) and Kahai, Sosik, and Avolio (2003) discovered a stronger effect for transactional leadership on team creativity than for transformational leadership (these studies are not included in Table 2.1 as they refer to the comparison of transformational and transactional leadership and do not report the zero-order relationship with creativity). In conclusion, results on the relationship between transactional leadership and innovation are mixed and vary widely. Thus, to be able to draw reliable conclusions, more studies are needed to investigate this link and, more importantly, the boundary conditions of this relationship. Again, we propose moderators of complementary leadership behaviors that focus on different aspects of the innovation process. The study by Jansen et al. (2009) suggests that transactional leadership is more closely related to exploitative activities than to explorative activities, therefore, leadership behavior that fosters exploration is needed to complement transactional leadership.

Initiating Structure and Consideration

Initiating structure is defined as leader behaviors that structure tasks, define goals, and control goal attainment (Fleishman, 1953). Consideration refers to the leader's concern and respect for the feelings of the subordinates, and the leader's appreciation and support of subordinates (Fleishman, 1953). Both leadership styles might be argued to be positively related to innovation. Initiating structure concerns the task-related behaviors of leaders that achieve high quality outcomes. Consideration is person-related and represents leader behaviors that support and motivate followers in accomplishing their work. However, our reasoning is that one needs to change from one leadership style to the next depending upon the innovation requirements; simply keeping up with both styles does not lead to higher innovation.

Initiating Structure. The integration of the results of six studies on the relationship between initiating structure and innovation yielded a corrected and weighted mean correlation of .26 (see Table 2.2). But again, only 38.65% of the observed variance was due to sampling error, which is far less than the 75% necessary to assume the relationship to be homogenous (Hunter & Schmidt, 1990). Most of the studies were using performance in R&D teams as the dependent variable (Chen, et al., 2009; Keller, 1992, 2006). These studies reported results ranging from .23 to .39 (see Table 2.1). On the organizational level, Osborne and Marion (2009) provided a positive correlation of initiating structure of the alliance head and the innovation performance of international corporate alliances. However, one study by Williams (2004) used several operationalizations of individual creativity as dependent variables and reported correlations ranging from -.13 to .13 (all of them nonsignificant). Two studies by Keller (1992, 2006) looked for boundary conditions and showed that the correlation between initiating structure and project or technical quality was higher in development projects than in research projects. Keller suggested that, in development teams, the internal coordination of knowledge is most important; therefore, initiating structure is more effective in development teams than in research teams. This means that exploitative activities (i.e., coordination of existing knowledge) are more important than explorative activities for development projects. The streamlining nature of initiating structure supports exploitative activities, but not explorative activities. In contrast, in research projects, exploration is as necessary as exploitation; thus, leadership behavior needs to support both exploitation (related to initiating structure) and exploration. To conclude, overall, initiating structure has a positive relationship with performance in R&D teams, that is, innovation. However, this conclusion is built on only six independent correlations and, more importantly, initiating structure seems not to have a comparable influence on creativity (which requires more exploration). Therefore, moderators, such as complementary leadership behaviors, need to be considered.

Consideration. To our knowledge, only three studies analyzed the relationship between consideration and innovation; therefore, we could not use a meta-analytic integration of results. Keller (1992) found a positive correlation between consideration and both project quality and budget/schedule performance in R&D teams. In addition, the recent study by Osborne and Marion (2009) displayed a positive correlation between consideration of the alliance head and the innovation performance of international corporate alliances. Finally, Stoker et al. (2009) reported positive correlations between consideration and perceived team performance in R&D teams in both a service organization and in the manufacturing industry. Taken together, these studies suggest a small positive relationship of consideration and innovation, although the empirical evidence base is too small to draw reliable conclusions.

Leader-Member Exchange (LMX)

As discussed before, we believe that leadership theories that imply a certain degree of fluidity and flexibility can understand the relationship with innovation better than more static leadership theories. Leader-member exchange (LMX) theory may be such a fluid theory because it includes a dynamic viewpoint on leader-follower dyads and on the quality of these relationships (Gerstner & Day, 1997; Graen & Uhl-Bien, 1995). LMX implies that leadership behavior depends on the relationship with the individual follower, and varies between followers. According to LMX theory, high quality exchange relationships are characterized by mutual trust and respect. LMX should be positively related to creativity and innovation because followers in high quality relationships may be inclined to trust their supervisor and to risk something new more so than followers in low quality relationships. In addition, we expect LMX to be more consistently related to innovation than other leadership styles that do not take into account the calibration of leadership behaviors to individual followers.

The integration of findings of the five studies performed on LMX at the individual level yielded a corrected and weighted mean correlation of .22 (see Table 2.2). The studies that analyzed this relationship are quite consistent in their results (97.89% of the observed variance is due to sampling error). Thus, leader-member exchange displays a moderate, but consistent relationship with innovation. Nevertheless, some studies looked for moderators of this relationship. The study of Tierney, Farmer, and Graen (1999) presents a more differentiated picture, as they found positive correlations between LMX and both creativity ratings and invention disclosure forms describing inventions, but not for research reports describing discoveries or new ideas. Furthermore, Tierney et al. (1999) observed a significant interaction of LMX and individual cognitive style on creativity, such that LMX had an enabling effect for individuals with low innovative cognitive style. Finally, a study by Clegg et al. (2002) detected a positive correlation with LMX only for idea implementation, but not for idea suggestion.

Thus, we found a positive and consistent relationship of LMX with innovation. Maybe this reflects the fact that LMX includes a person specific approach or maybe this is the result of the small number of studies in this area (the results are based on only five independent correlations). Moreover, some studies found moderators, which suggest some variation in this relationship not detected by the meta-analytic correlation.

Supervisor Support

Supervisor support is not a clearly defined leadership style, but rather a cluster of leader behaviors that are supportive of subordinates' innovative behaviors. Active support by the supervisor to be innovative may enhance subordinates' creative self-efficacy, which in turn may positively relate to creativity and innovation (Tierney & Farmer, 2004). In addition, support of the supervisor provides access to resources, assistance, and encouragement in the face of difficulties. Thus, supervisor support should be positively related to creativity and innovation.

Supervisor support has been studied frequently in the innovation context. The integration of results of sixteen studies leads to a weighted and corrected mean correlation of .15 (see Table 2.2). Although this integration shows a small positive correlation, results vary from -.10 to .34 (see Table 2.1). The range of results is displayed in Figure 2.2. Sampling error accounts for only 34.09% of the observed variance.

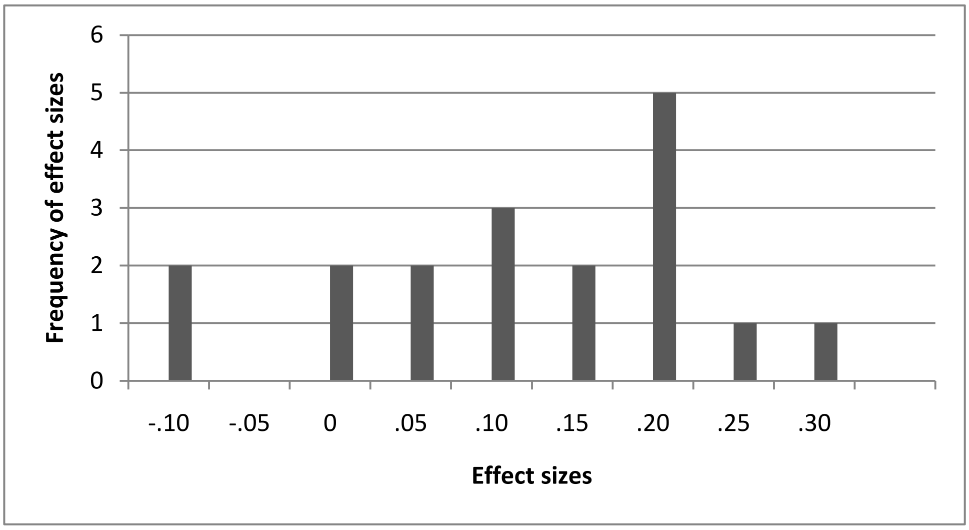

Figure 2.2. *Range of effect sizes (r) for the relationship between supervisor support and innovation (aggregated correlations)*

Some studies displayed a more differentiated picture for supervisor support. Ohly, Sonnentag, and Pluntke (2006) detected a positive correlation of supervisor support with creativity and innovation, but a negative correlation with suggestions made as part of an organizational suggestion system. Similarly, Oldham and Cummings (1996) identified a nonsignificant positive correlation of supervisor support with rated creativity and nonsignificant negative correlations with patents and suggestions made. In contrast, Frese, Teng, and Wijnen (1999) found a positive correlation of supervisor support only with rewarded suggestions, but not with having an idea, writing the idea up, or submitting ideas to a suggestion system. They interpreted this to mean that individuals may have ideas and even submit them independently of the support by the supervisor; however, for the outside perception of quality of ideas supervisor support is important. Similarly, Axtell et al. (2000) discovered a small nonsignificant correlation of supervisor support only for implementation, but not for suggestions. Taking these results together, it suggests that supervisor support is more important for acting on ideas (i.e., implementation) than for generating ideas. However, this assumption is not supported when type of dependent variable (i.e., creativity and innovation) is used as a moderator (the mean r for creativity is .16 and for innovation it is .14; $z = 0.32$, $p > .10$). Nevertheless, given the broad range of results, it makes sense to assume that the relationship between supervisor support and innovation is moderated by third variables which we propose might be complementary leadership behaviors.

Other Leadership Styles

There are several other leadership styles that were studied in the innovation context. Participative leadership – shared decision making by supervisor and employee – has been studied at the individual and the team level. Krause, Gebert, and Kearney (2007) found a positive correlation between participative leadership and individual implementation success. Somech (2006) observed a positive correlation with team innovation. In addition, in a study by Stoker et al. (2009), participative leadership was positively related to R&D performance in a manufacturing sample, but not in a service sample.

Oldham and Cummings (1996) detected a positive correlation between noncontrolling leadership and rated individual creativity, but not with patents or suggestions. George and Zhou (2001) and Zhou (2003) demonstrated detrimental effects of supervisor close monitoring (negative correlations with creativity and creative behavior).

Finally, for consultative-advisory leadership (providing advice and guidance), Krause et al. (2007) found a positive correlation with implementation success. Similarly, Somech (2006) reported a positive correlation between directive leadership (providing a framework for decisions and actions) and team innovation.

Summary and Conclusions

The meta-analytic integration of findings on the relationship between leadership and innovation showed positive corrected and weighted mean correlations for the following leadership styles: transformational leadership, initiating structure, LMX, and supervisor support, with transformational leadership producing the highest and supervisor support being involved in the lowest correlations. In addition, consideration, participative leadership, and noncontrolling leadership seem to be positively related to innovation. However, despite the overall positive correlations, transformational leadership, initiating structure, and supervisor support were found to have a wide range of correlations, with some studies even reporting negative correlations. Only LMX led to a consistent relationship with followers' individual innovation. This may be due to the fact that LMX is the only leadership style in our literature review that explicitly takes into account the need for differing leadership behaviors with different followers. However, LMX theory does not theorize the need for varying leadership behaviors over time. That is, we assume that a high quality and individualized relationship between leader and follower are a good basis for innovation, but more specific (complementary) leadership behaviors that explicitly foster innovation need to build on this basis.

In conclusion, the review on the relationship between leadership and innovation suggests that different leadership behaviors such as transformational leadership and initiating structure may be important for the innovation process. Most meta-analytic correlations are small to moderate in size and, in nearly all cases, the correlations are heterogeneous. The latter implies that the same leadership behaviors were related to innovation in some studies, but not in others. This observation leads us to two conclusions: First, there are different pathways leading to the same result of innovation (Bledow, et al., 2009). Second, leadership behaviors may have a wide range of possible consequences, depending upon moderator variables. We suggest that complementary leadership behaviors may be effective moderators and may be necessary for successful leadership for innovation. A leadership style is positively related to innovation when complemented by another leadership style that focuses on and fosters the different aspects of the innovation process. The same leadership style may have no or even a negative relationship to innovation when a complementary leadership style is low or missing. This leads us to the question: Which complementary leadership behaviors are necessary for innovation?

2.3 Ambidexterity in the Innovation Processes

In the following, we will outline two important characteristics of innovative performance that make it different from general task performance. First, innovation encompasses two different and even opposing processes, creativity and implementation, which are linked to two different activities, namely, exploration and exploitation. Second, innovation processes are complex and nonlinear, which leads to an ever-changing cycle of the requirements for exploration and exploitation. Taken together, this leads us to the proposition that innovative performance requires ambidexterity.

Most theoretical models of innovation differentiate at least two processes of innovation: idea generation (or creativity) and idea implementation (e.g., Amabile, 1988; Farr, Sin, & Tesluk, 2003; West, 2002). These two processes encompass very different activities that are linked to very different requirements. First, creativity requires thinking “outside the box”, going beyond routines and common assumptions, and experimentation. Creativity is closely linked to explorative activities as defined by March (1991). Second, idea implementation requires efficiency, goal orientation, and routine execution, that is, implementation is linked to exploitative activities as defined by March (1991). However, creativity also requires exploitation, whereas idea implementation also calls for exploration. Creative ideas must not only be new, but also useful and require the exploitation of existing knowledge. Creative tasks are often ill-defined and need some structuring and direction (Bain, Mann, & Pirola-Merlo, 2001). In addition, implementing new ideas can usually not just be executed along existing routines; therefore, implementation also requires exploration of new strategies. Similarly, radically new ideas might require new ways of implementation that need to be explored. Moreover, the implementation of new ideas is often resisted in organizations (Van de Ven, 1986); therefore, new ideas on how to overcome this resistance are often required (thus, exploration is important in implementation as well). Therefore, exploration and exploitation are important for both creativity and implementation, even if creativity is linked more closely to exploration and idea implementation more closely to exploitation.

The second important characteristic about innovation is its complex and nonlinear nature (Anderson, et al., 2004; Bledow, et al., 2009; King, 1992; Schroeder, et al., 1989; Van de Ven, et al., 1999). A shortcoming of the existing research on leadership in the innovation context and indeed of the innovation research per se is that it does not take this complex nature of innovation processes into account (Fehr, 2009; Simonton, 2003). Although innovation attempts can be highly structured and planned, the uncertainty involved in innovation processes makes it difficult to anticipate more than the next few steps. The distinction between the creativity and implementation stage of innovation described above is widely accepted in the literature (Farr, et al., 2003; King, 1990). However, these stages cannot be easily separated. Cheng and Van de Ven (1996) showed that innovation processes follow complex patterns, especially in the beginning. This means that there are no distinct phases in neat succession, but rather events that unfold in sequences that are often unpredictable. Thus, the timing of events cannot be easily planned, but rather emerges within the process and time plans will need to be incessantly adapted to the unfolding events (Blount & Janicik, 2001). Research needs to account for this temporal variability to explain innovation (Mitchell & James, 2001). This further implies that the requirements for exploration and exploitation alternate consistently within the innovation process. As these activities – that is, exploration and exploitation – are very different in nature, flexibly switching between them is a highly challenging task. March (1991) was explicit in his conceptualization of exploration and exploitation that these activities are fundamentally disparate (Gupta, Smith, & Shalley, 2006). We do not concur with March (1991) that exploration and exploitation are mutually exclusive, but rather suggest them to be mutually dependent (Bledow, et al., 2009). However, March's (1991) reasoning underscores that the two activities are difficult to align.

As both exploration and exploitation are fundamental activities inherent to creativity and innovation, we suggest that ambidexterity is a central feature of innovation. It is insufficient to be able to handle the different requirements of the innovation process one at a time, but it is necessary to flexibly switch between those different requirements. That means that teams involved in innovation need to show exploration and exploitation in an unpredictably alternating sequence. This characteristic of innovation processes makes it unfeasible to separate exploration and exploitation, for example, between different teams (i.e., teams that specialize in *either* exploration *or* exploitation). In the literature, there are reports of cases where organizations utilize different teams or even different organizational units for exploration and exploitation (e.g., O'Reilly & Tushman, 2004). However, we assume that even teams that specialize in exploration (e.g., research teams) need to exploit to some extent as they would not be able to produce any tangible results without exploitation. On the other hand, teams that specialize in exploitation also need to engage in some exploration, for example, when problems arise or errors occur that need to be solved. In addition, we propose teams to be more innovative if they engage in both exploration and exploitation, as they are able to take advantage of the synergies of exploration and exploitation (Bledow, et al., 2009), than when exploration and exploitation are separated.

Taken together, we assume that it is necessary not only to be able to balance exploration and exploitation, but to be able integrate exploration and exploitation and flexibly switch between both as the situation requires. That is, an integrative form of ambidexterity is necessary in the innovation process that goes beyond merely balancing exploration and exploitation. Thus, what makes innovation different from general performance is its need for ambidexterity.

We will now discuss a theoretical model of leadership for innovation that describes the leader behaviors that are supportive of follower ambidexterity: How can leaders help teams and individuals to be innovative?

2.4 Ambidextrous Leadership – Towards a Theory of Leadership for Innovation

Extending the concept of ambidexterity to leadership, we suggest that ambidextrous leadership is necessary for an effective innovation process. Our literature review revealed that some leadership styles show positive relationships with innovation. However, most of these leadership styles (except LMX) displayed a broad range of relationships from negative to positive correlations with innovation. Thus, these leadership styles are not consistently related to innovation, but are dependent on moderating conditions. We suggest that these moderating conditions are likely complementary leadership behaviors, that is, leadership behaviors that foster different aspects of the innovation process (i.e., exploration and exploitation), or team characteristics that substitute these leadership functions (e.g., a high climate for excellence that ensures high task orientation to complement transformational leadership; we will come back to this line of reasoning later in the article). In addition, we assume that the traditionally studied leadership styles are too broad in nature as they encompass a multitude of behaviors that might both foster and hinder innovation. Instead, we propose leadership behaviors that specifically match the requirements that teams and individuals face within the innovation process. The requirement of ambidexterity in the innovation process implies that individuals working in an innovation context need to both explore and exploit, and switch between those two activities. Therefore, an effective leader of an innovative workforce needs to foster both exploration and exploitation, and has to be capable of flexibly switching between both. Thus, ambidextrous leadership consists of three elements (1) opening leader behaviors to foster exploration, (2) closing leader behaviors to foster exploitation, (3) and the temporal flexibility to switch between both as the situation requires. Figure 2.3 gives an overview of our theoretical model. This figure is meant to state the main relationships of our model and shall guide the reader through our theoretical discussion. Nevertheless, it is only a heuristic that simplifies the actual relationships.

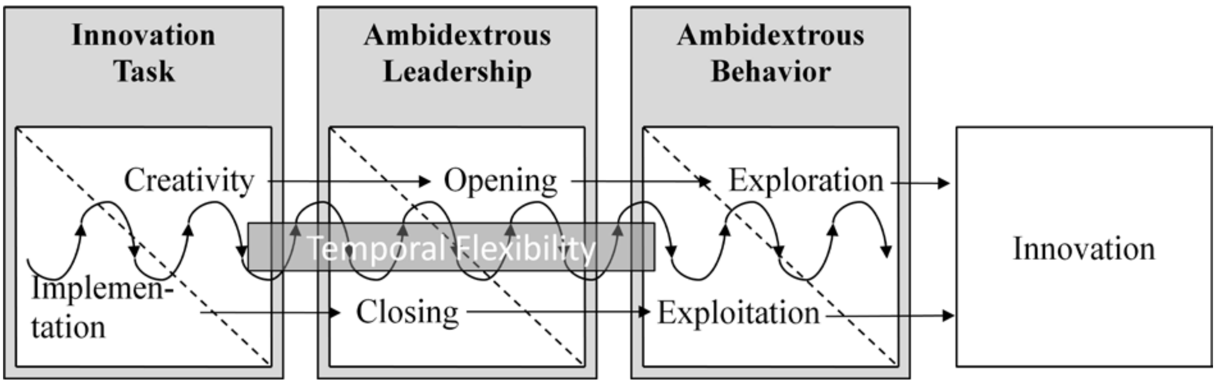

Figure 2.3. *Overview of the proposed model*

Fostering exploration. The core of exploration is the increase of variance (Gupta, et al., 2006; March, 1991). Therefore, fostering exploration means in particular fostering the increase of variance in followers' behavior. The term "opening" may be useful to describe this increase in variance as it figuratively illustrates the breaking up of routines and thinking in new directions. We define "opening leader behavior" as a set of leader behaviors that includes encouraging doing things differently and experimenting, giving room for independent thinking and acting, and supporting attempts to challenge established approaches. Table 2.3 gives examples for opening leader behaviors. Thus, we propose that in situations that require employees to explore (and these situations are mainly those when the innovation task requires creativity, see Figure 2.3), leaders need to show opening leader behaviors.

Proposition 1. Opening leader behaviors are positively related to follower explorative activities.

Table 2.3

Examples for Opening and Closing Leader Behaviors

Opening Leader Behaviors	Closing Leader Behaviors
◆ Allowing different ways of accomplishing a task ◆ Encouraging experimentation with different ideas ◆ Motivating to take risks ◆ Giving possibilities for independent thinking and acting ◆ Giving room for own ideas ◆ Allowing errors ◆ Encouraging error learning	◆ Monitoring and controlling goal attainment ◆ Establishing routines ◆ Taking corrective action ◆ Controlling adherence to rules ◆ Paying attention to uniform task accomplishment ◆ Sanctioning errors ◆ Sticking to plans

Fostering exploitation. The core of exploitation is the reduction of variance (Gupta, et al., 2006; March, 1991). Therefore, fostering exploitation mainly means fostering the reduction of variance in followers' behavior. The term "closing" figuratively describes the streamlining and narrowing down that is necessary for such a reduction of variance. We define "closing leader behavior" as a set of leader behaviors that includes taking corrective action, setting specific guidelines, and monitoring goal achievement. Table 2.3 gives examples for closing leader behaviors. In situations that require employees to exploit (and these situations are mainly those when the innovation task requires implementation, see Figure 2.3), leaders need to show closing leader behaviors.

Proposition 2. Closing leader behaviors are positively related to follower exploitative activities.

The temporal flexibility to switch. As we discussed above, the requirements to explore and to exploit alternate in a complex manner within the innovation process. To be ambidextrous as a leader it is not enough to show opening and closing leader behaviors to foster exploration and exploitation. That means – in line with our reasoning above – that neither opening nor closing leader behaviors are sufficient. We suggest that, methodologically, opening leader behavior is a moderator of the relationship between closing leader behavior and innovation and, vice versa, closing leader behavior is a moderator of the relationship between opening leader behavior and innovation. However, even the ability to show both opening and closing behavior is not enough. As we argue that there is no systematic process model that predicts when it is useful to explore and when it is useful to exploit, it is difficult to predict when opening leader behaviors are necessary and when closing leader behaviors are required (Bledow et al., 2009). Therefore, these behaviors need to be shown ad hoc. It is the temporal flexibility to adapt these behaviors to the requirements of the innovation tasks that is essential for ambidextrous leadership. With this temporal flexibility we mean that leaders must be able to switch flexibly between behaviors as the current situation requires (M. W. Lewis, Welsh, Dehler, & Green, 2002) because teams need to constantly switch back and forth between different innovation requirements (creativity and innovation). The flexible switching between innovation requirements, between leadership behaviors, and between follower behaviors is represented by the oscillating arrows in Figure 2.3. In a similar vein, Quinn and colleagues (Denison, Hooijberg, & Quinn, 1995; Quinn, 1988) suggested a paradoxical use of different leader behaviors to produce good team performance in general, and not just within an innovation context.

The two sets of leadership behavior that we propose to stimulate exploration and exploitation – opening and closing – need to be carried out by the team leader in a well-balanced and integrated way. A first empirical study of a similar idea found that emergent project management styles that take the ambiguity of product development into account and encourage improvisation were positively linked to project innovation (M. W. Lewis, et al., 2002). Planned project management styles that manage product development as a top-down process and focus on discipline and structure were positively related to project efficiency (M. W. Lewis, et al., 2002). Lewis et al. (2002) suggest that these two management styles are not mutually exclusive but rather complementary and that both are necessary for project success. However, Lewis et al. (2002) did not explicitly study the necessity to switch between these management styles.

Proposition 3. The interplay of opening and closing leadership behavior is positively related to innovation; insofar that innovation is highest when both opening and closing leadership are high.

Proposition 4. Leaders need temporal flexibility to switch between opening and closing leader behaviors according to the requirements of the innovation tasks in order to support their followers in switching between exploration and exploitation.

Taking together propositions 1 through 4, we propose:

Proposition 5. Ambidextrous leadership is positively related to follower ambidextrous behavior.

The general role of an ambidextrous leader. One important point that we did not discuss so far is the general role of the ambidextrous leader in the innovative effort. Our theory does not make assumptions about the degree of involvement of the leader in the innovation process. Both opening and closing leadership behaviors can be used more or less actively or passively. That means, leaders may only initiate explorative or exploitative behaviors of their followers and then step back to leave them to work on the task. But leaders may also actively engage in explorative and exploitative activities. For closing leader behaviors, this could mean that the leader sets goals and only passively monitors goal attainment or it could mean that he or she actively structures the task, corrects errors, and helps with getting the work done. For opening leader behaviors likewise, this implies that the leader may just encourage experimentation and tolerate deviations from previously made plans, or that he or she actively introduces new perspectives to problems and helps with thinking in different directions. Our point here is that ambidextrous leaders may be more or less involved in the process. This involvement may vary over time, depending on the requirements in a special situation, and it may also vary between teams, depending for example, on the expertise of both the team members and the leader (Kerr & Jermier, 1978), or even within teams, depending on the needs of the individual followers.

An example of ambidextrous leadership. An example may illustrate ambidextrous leadership: A project team gets the assignment to come up with ideas on how to improve an existing work process. The team members are near the completion of their project and in the midst of implementing their ideas. To efficiently implement their ideas, team members have to exploit. Thus, their team leader needs to support them in doing so with closing leader behaviors. While implementing, the team members might encounter some flaws and problems in their ideas. Now, they start to explore ways to handle these flaws by developing new solutions or better ideas. To support this exploration, the leader has to change his behavior and has to display opening leader behaviors to encourage the team members to think in different ways, to go beyond existing patterns, and to risk pursuing even unlikely paths. When getting to solutions, these solutions need to be applied to the problems which again call for closing leader behaviors. Finding alternative ways of implementing the ideas when team members encounter difficulties and barriers again call for exploration and, therefore, for opening leader behaviors. Although this example seems to be in line with a phase model, we want to stress that continuous switching between different requirements and different activities is not organized sequentially, but rather complex and unpredictably. The example demonstrates that the leader has to show both opening and closing leader behaviors, but even more importantly, it illustrates that the leader has to be very sensitive to the situation that requires the temporal flexibility to switch from one kind of behavior to the other one. If the leader switches from opening to closing too early, the team may not have come up with good ideas or solutions yet. If the leader switches from opening to closing too late, the team members may have lost track of their best ideas and get overwhelmed by too many ideas. Therefore, the leader needs to be sensitive to know which leader behavior is situationally appropriate.

Routes to ambidextrous leadership. This leads us to the next question: How might a leader pursue these two very different opening and closing leader behaviors and switch between them? Behavioral as well as cognitive complexity may be important prerequisites for leaders to be ambidextrous. Although we do not suggest that opening and closing leader behaviors are mutually exclusive, they are still very different behaviors. To be an ambidextrous leader one has to be capable of showing these different behaviors and, therefore, have a wide behavioral repertoire. Behavioral complexity, as defined by Hooijberg (1996), includes the dimensions of repertoire and differentiation. The behavioral repertoire refers to the range of behaviors that a leader is capable of performing while behavioral differentiation denotes the degree of variation between different behaviors according to situational requirements (Hooijberg, 1996). Thus, in terms of ambidextrous leadership, behavioral complexity refers to the capability of having a repertoire of both opening and closing leader behaviors as well as the temporal flexibility to switch between them (differentiation). Empirical support for these assumptions comes from Lubatkin, Simsek, Ling, and Veiga (2006) who found that top management team behavioral integration – a concept closely related to behavioral complexity – was positively related to firm performance, and this relationship was mediated by an ambidexterity orientation.

In addition, the leader must know that exploration and exploitation are not mutually exclusive. Martin (2007) called this "integrative thinking", that is, "the ability to face constructively the tension of opposing ideas" (p. 15). Integrative thinking refers to refraining from making a decision between two ideas, but to integrate both into one superior idea. Ambidextrous leaders need to hold simultaneously in mind exploration and exploitation as well as opening and closing leader behaviors and integrate them into a coherent overall strategy. Similar to the cognitive integrative capacity needed for creativity (Mumford & Gustafson, 1988), cognitive complexity may help ambidextrous leaders to lead creative and innovative teams and individuals.

Zhou and George (2003) proposed emotional intelligence as a leader characteristic that enables the leader to understand and channel the emotions of followers connected to the innovation process. They suggest that leaders with high emotional intelligence are better able to "help their followers be flexible in their information processing" (p. 564). Thus, emotional intelligence may be helpful with respect to a leader's sensitivity in recognizing what kind of leader behaviors are called for in a given situation and sensibly adjusting the leadership behavior to the requirements of the innovation tasks.

Another activity that might help leaders to decide when to utilize opening and closing leader behaviors is forecasting and planning (Mumford, et al., 2002). Although we assume innovation processes to be highly unpredictable, at least some steps can often be anticipated. Scanning the environment, being highly informed about the current activities in the team, and a high level of alertness will help to anticipate some steps ahead and thereby to predict when opening and closing leader behaviors are going to be necessary.

Proposition 6. Behavioral and cognitive complexity, integrative thinking, emotional intelligence, and forecasting skills are antecedents of ambidextrous leadership.

Alternative routes to ambidextrous leadership. In addition to just a single leader switching between opening and closing leader behaviors, different possibilities of how to achieve ambidextrous leadership are conceivable. First, multiple leaders within a team might be responsible for supporting exploration or exploitation. Possibly, several designated leaders or team members that adopt opening or closing leadership functions may exist. However, dispensing ambidextrous leadership behaviors by different people requires a high level of coordination between these individuals (e.g., a high quality transactive memory system, K. Lewis, 2003). As we discussed above, the timing of opening and closing leadership behaviors is of crucial relevance; this is even more so in the case of several leaders performing these behaviors. Thus, when sharing leadership functions in a team, leaders need to know very well when it is appropriate to take the lead, and when to step back to let the others take over. At the organizational level, a recent article similarly suggested that the behavioral complexity of the top management team is crucial for organizational ambidexterity (Carmeli & Halevi, 2009). Second, leadership behaviors may be complemented by team attributes, such as the team culture or climate. We already took note of this possibility when discussing the study by Eisenbeiss et al. (2008) that found a positive correlation between transformational leadership and innovation only for teams with high climate for excellence. In these teams, team members make sure that high standards of performance are maintained and goal attainment is controlled. Thus, one could argue that the team climate takes over closing leadership functions. In combination with the more opening nature of transformational leadership, this climate leads to high innovative performance. Several different combinations of leadership behavior and team climate or culture are conceivable. In any case, the coordination and timing of leadership behaviors are critical.

2.5 Discussion

Leadership in the innovation process has been studied frequently. Unfortunately, the results of these studies do not add up to a simple conclusion. Instead, our literature review suggests that studies arrive at different results. Different leadership styles are positively related to innovation, but most of them show a broad range of correlations that depend on moderating conditions. We developed a theory of ambidextrous leadership to explain this variation. Ambidextrous leadership consists of two complementary sets of leadership behaviors that specifically match the requirements of exploration and exploitation. The most important characteristic of this ambidextrous leadership, however, is the temporal flexibility that leaders need to have in order to switch between the leadership behaviors as the innovation tasks require. We will now discuss the similarities and differences of our theory to several leadership and innovation theories to answer the question of what is distinct about our theoretical model.

First, our theory makes use of the geneplore model of creativity (Ward, Smith, & Finke, 1999), which differentiates two cognitive processes in creativity, namely, the generation of preinventive structures and the exploration and interpretation of these structures. The generation of preinventive structures has some overlap with exploitation, as it includes the retrieval of information from memory, drawing analogies, and combining information from memory (Ward, et al., 1999). Likewise, the exploration and interpretation of the preinventive structures has some similarity with explorative activities. It includes looking for new attributes in the structures or looking at the structures from different angles (Ward, et al., 1999). The geneplore model, therefore, is in line with our reasoning that both exploration and exploitation are required for the generation of new and useful ideas. Ward et al. (1999) also explicitly state that both processes included in their model are passed through alternately throughout the creative process, that is, the idea of nonlinearity is also included in their model. However, the geneplore model does not include implementation of ideas and is therefore restricted to creativity. In addition, as it is a model of general creativity and has not been developed for the organizational context, it does not make any assumptions about the leadership for creativity or innovation.

Second, our theory of ambidextrous leadership shares some assumptions with the competing values approach of leadership by Quinn (1988). This model differentiates eight leadership roles that are arranged in a spatial model that is made up by the two orthogonal value dimensions of control–flexibility and internal–external focus (for a detailed description of the leadership roles cf. Quinn, 1988). The idea of this model is that leaders have to meet all of the opposing and contradictory values along the two dimensions. The different leadership roles are matched to these values. For example, the role of the coordinator matches the values of stability and control. The challenge of each leader is to bridge the contradictions implied by the spatial arrangement of values in this model and to reconcile opposing leadership roles (Denison, et al., 1995; Quinn, 1988). Our theory of ambidextrous leadership shares the assumption with Quinn’s (1988) model that leaders need to unite contradictory leadership behaviors or roles. In addition, both theories suppose that these leadership behaviors or roles need to be incorporated into one integrated whole. However, our theory adds the idea of temporal flexibility to these assumptions. We suggested that it is not enough to show more of each of the opposing leadership behaviors, but it is the temporal flexibility to switch between these leadership behaviors according to the current requirements of the innovation tasks that is crucial. Although Quinn (1988) states that the leader needs to be sensitive to environmental cues in deciding which leadership role is necessary in a given situation, he does not include the idea that the innovation task itself and its changing requirements demand a leader to flexibly switch between leadership behaviors, which is the core of temporal flexibility within a single innovation process as defined by us. In this sense, we build upon and extend Quinn's concept of the competing values approach to leadership.

Third, our approach builds upon and extends leadership theories that take situational contingencies into account. Most importantly, path-goal theory of leadership assumes that leadership behavior must match the situation of the followers to be effective (House, 1996). To be more explicit, leadership should be directive and clarify path-goal relationships in case the followers lack the necessary knowledge or abilities to reach these goals. On the other hand, supportive leadership may be more effective when the subordinates' tasks are stressful or dangerous (House, 1971). Although we share the assumption that leader behavior has to be contingent on the situation, there are several differences between our approach and the path-goal theory of leadership. Most importantly, in contrast to path-goal theory, we assume that the flexibility of the leader and the adjustment of leadership behaviors must not only be matched to the overall (and quite stable) situation, but has to be temporally appropriate for the innovation tasks that change quickly over time. That is, time and timing are explicit components of the theory of ambidextrous leadership, but not in path-goal theory. Furthermore, the path-goal theory concentrates on followers' motivation and makes use of expectancy theories of motivation (House, 1996). We acknowledge that motivation is an important antecedent not only of general performance but also of innovative performance. However, our theory concentrates on specific behavioral activities of followers, that is, exploration and exploitation, and not on motivation. Finally, in path-goal theory, an important function of the leader is to complement followers' behaviors and their environment to enhance satisfaction and general performance, whereas our theory focuses on how leaders may be able to foster specific behaviors to boost innovative performance. To conclude, although the general mechanisms of our theory and path-goal theory are similar – that is, the leader adjusts his or her behavior to the situation – the specifics of the two theories differ in the above-mentioned ways.

Fourth, a more specific approach to leadership in the innovation process has been taken by Van de Ven et al. (1999). On the organizational level, they distinguish four top management leadership roles that they find important in the “innovation journey”: the sponsors who champion an innovation, the mentors who coach and supervise the innovation team leader, the critics who test the innovation against hard business criteria, and the institutional leaders who balance the power of the other three leadership roles (Van de Ven, et al., 1999). In the innovation projects that Van de Ven et al. (1999) studied, these roles were – contrary to their expectations – not accomplished by different persons, but individual members of the top management carried out several of these roles. Thus, managers need to be able to carry out more than one leadership role and must be able to switch between them. Paradoxical use of very different leadership styles or roles (e.g., as a sponsor and critic), therefore, seems to be necessary for innovation success (Cameron & Quinn, 1988). Van de Ven et al. (1999) claim that “the odds of organizational learning and adaptability increase when a balance is maintained among dialectical leadership roles throughout the innovation development” (p. 118). Taking this reasoning to the next level, we propose that the balance of different leadership behaviors is not only important for the top management, but also for leaders of innovative teams and individuals. However, we do not propose distinct leadership roles that need to be balanced within the innovation process, but rather specific leadership behaviors that foster exploration and exploitation – namely, opening and closing leader behaviors as defined above. The advantage of this approach is that these leader behaviors are more specific on the one hand and more flexible to be used on the other hand. Roles generally include a broader cluster of behaviors and are rather stable and less flexible. Therefore, we suggest concentrating on leadership behaviors rather than on leadership roles.

Finally, one has to ask the question of how the specific leadership behaviors proposed in our theoretical model of ambidextrous leadership differ from established leadership styles. The uniqueness of opening and closing leader behaviors lies in their sole focus on increasing and reducing variance in followers’ behavior. Other leadership styles have very different foci or goals that might or might not include the increase or reduction of variance. That is, one single leadership style may increase or reduce variance in behavior depending on the specific leadership behaviors used. For example, in the “vision” subfacet of transformational leadership, communicating an inspiring vision might increase variance in followers’ behavior if it motivates them to think independently, thus, it would be an opening leader behavior. On the other hand, an inspiring vision might also reduce the variance in behavior, in case the vision incorporates an explicitly stated goal that followers are motivated to follow as closely as possible. In the latter case, communicating a vision would be closing behavior. In Table 2.4 we give some more examples to show that both transformational leadership behaviors and transactional leadership behaviors can be both opening and closing leadership behaviors. Similar matrixes could be developed for other leadership styles, for example, initiating structure and consideration. However, for the sake of brevity, we limit this comparison to transformational and transactional leadership. Our point is that although individual opening and closing leader behaviors might also be subsumed under traditional leader concepts (of course, none of these behaviors are in themselves totally "new"), it is the different categorization according to the specific function of opening and closing leader behaviors to increase or reduce variance in follower behavior that makes them distinct.

Table 2.4

Categorization of Transformational and Transactional Leadership Behaviors as Opening and Closing Leadership Behaviors

	Opening Leader Behaviors	**Closing Leader Behaviors**
Transformational Leadership	◆ A vision that motivates exploratory behavior ◆ Stimulation of thoughts in very new directions ◆ Communication of the values of openness and tolerance	◆ A vision that motivates confirmatory behavior ◆ Stimulation of small improvements and enhancement of efficiency ◆ Communication of the values of conscientiousness and rules adherence
Transactional Leadership	◆ Rewarding experimentation ◆ Focus on errors to learn from errors ◆ Setting and monitoring exploration goals	◆ Rewarding efficiency ◆ Focus on errors to avoid errors ◆ Setting and monitoring exploitation goals

Limitations

Some limitations of our approach need to be mentioned. First, in our literature review, we could not use meta-analytic tools to integrate findings for every leadership style due to the limited number of studies available for some leadership styles. In these cases we had to rely on a narrative review of findings which always bears the risk of subjective biases. More studies on these leadership styles and innovation are needed to more objectively summarize the findings. Second, the variation we found in the relationship between leadership and innovation may not only be due to systematic variance that is caused by moderating conditions, but could also be due to methodological or statistical reasons. For some methodological moderators, such as the level of analysis or the type of dependent variable, we could do moderator analyses (for the relationship of transformational leadership and innovation) that showed that these moderators do explain some of the variation. However, a wide range of variation still needs to be explained by further moderators. In addition, by using meta-analytic tools, we could rule out sampling error by correcting for it. Nevertheless, range restriction might still play a role as some samples of the reviewed studies are more homogeneous (e.g., R&D teams) than others (e.g., college students). However, we do not see strong reasons why the range of leadership styles should vary dramatically across different samples.

Future Research

Taking into account both our literature review and our theoretical line of reasoning, we make several suggestions for future research in addition to the propositions explicated throughout the article. Most importantly, future research on leadership in innovation contexts needs to systematically consider the complexity of the innovative process. We suggest that we need more studies that take situational contingencies into account. This may be done, for example, by using diary studies that examine daily fluctuations of situational requirements, leadership behaviors, follower behaviors, as well as creativity and innovation. Moreover, as the timing of leadership behaviors plays an important role in our theory, time needs to be considered in the methods used to study the proposed relationships (Mitchell & James, 2001). Another possibility is situation-dependent measurement of leadership behaviors, for example, by using situational judgment tests or similar instruments that utilize situationally anchored items (McDaniel, Morgeson, Finnegan, Campion, & Braverman, 2001; Motowidlo, Dunnette, & Carter, 1990). Both methods allow for the measurement of leadership variability and temporal flexibility which are the heart of our ambidextrous leadership theory.

In addition, we suggest multilevel research to be done on leadership and innovation. Although we did not explicitly focus on level issues in our literature review, differences between relationships at the team level and at the individual level emerged. For example, the correlation between transformational leadership and innovation was higher at the team level (.28) than at the individual level (.17), although this difference was not significant. The only consistent relationship with innovation was shown for LMX, a leadership style that concentrates on leader-follower dyads. We further suggest that studies should look at both individual and team processes simultaneously to identify crucial individual behaviors and group culture in context. In addition, it might be helpful to take the team and the organizational context into account when studying the effect of leadership on individual and team innovation. For example, the overall organizational strategy may tend to either more exploration or exploitation which could impact the frequency of requirements of explorative and exploitative activities at the team level and, therefore, may have consequences for the leadership behaviors needed. Alternatively, the organizational approach on managing the conflict between exploration and exploitation – that is, for example, whether the organization separates R&D strictly from production (Tushman & O'Reilly, 1996) or tries to make use of synergies of both departments – is likely to influence how exploration and exploitation need to be handled at lower levels of the organization. Finally, on an even higher level on analysis, the national culture that provides a context for an innovating organization may play a role in what way ambidextrous leadership is performed (Bledow, Frese, & Müller, in press).

Conclusion

In this article we propose that research on innovation needs to take the specifics of the innovation process into account in order to make reliable predictions about the influence of leadership in the innovation context. The complex nature of the innovation process that leads to a complex sequence of events is probably its most important characteristic. Complex explorative activities may be more important in the beginning and periodic exploitative activities may be more central at the end of an innovation process (Cheng & Van de Ven, 1996); similarly, creativity may be more prevalent in the first part of the innovation process and implementation activities may be more frequent in the later part (West, 2002). However, both exploration and exploitation are vital throughout the whole innovation process, and the need for these activities alternates. Indeed, exploration and exploitation are sometimes interwoven activities that cannot be separated (Bledow, et al., 2009). For leaders, this means that, on the one hand, they need to foster exploration by opening leader behaviors and to foster exploitation by closing leader behaviors. On the other hand, leaders need to have the knowledge or intuition of when and how to act and – even more importantly – they need to flexibly switch between behaviors according to situational requirements. This threefold competency – opening leader behaviors, closing leader behaviors, and the temporal flexibility to switch – is what we call ambidextrous leadership.

Leading a creative and innovative workforce is a complex matter. Therefore, leaders need to take the complexity of the innovation process into account. The same is true for the innovation research and literature: Only complex and comprehensive models of leader influence in the innovation process are able to embrace this complexity (Mumford & Licuanan, 2004). Breaking down the innovation process into two (or more) separate phases, and looking for what needs to be done in those phases, creates a simplistic view of innovations. This view misses a lot of what is inherent to innovation – the creative tension of opposites. When considering the complexity of the innovation process, both the theory and practice of innovation promise to be more successful.

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CHAPTER 3

Dynamic self-regulation in innovation projects

Innovation processes are complex and dynamic and they require self-regulatory competencies from individuals. In this paper we develop an intraindividual perspective of self-regulation in innovative contexts. As innovation is inherently oriented towards the future, we focus on cognitions about the future as a means of self-regulation. In a sample of 323 individuals we examine the relationships between thinking about the future and both actively pursuing a project along established lines and exploring new directions. Results confirm the hypothesis that in situations when individuals focus on the positive outcome of a project they tend to push the project according to previously made plans, whereas in situations when individuals think about potential hindrances and barriers they are more likely to change the course of the project. In addition, we show that use of these future-related cognitions is related to individual differences in promotion and prevention focus.

3.1 Introduction

A central topic in the literature on innovation is the assumption that innovation is characterized by dilemmas, tensions, or paradoxes (Andriopoulos & Lewis, 2009; Benner & Tushman, 2003; Cameron & Quinn, 1988; Lewis, Welsh, Dehler, & Green, 2002). Innovation projects are challenging and often difficult to handle because the innovation process is complex (Anderson, De Dreu, & Nijstad, 2004). In addition, innovation projects are highly dynamic (Bledow, Frese, Anderson, Erez, & Farr, 2009) and future steps can only be planned to a limited extent as the final outcome of the project is never completely determined (Brun & Sætre, 2009). For example, when a research and development (R&D) team develops a new product, the exact nature of this product is not known in the beginning of the process and it is going through changes and adjustments in the course of the process. Therefore, R&D teams need to make decisions about the direction of a project. In other words, they have to decide whether they proceed as before or whether they take a path into a new direction. In this paper, we are going to examine how self-regulatory processes are related to these decisions.

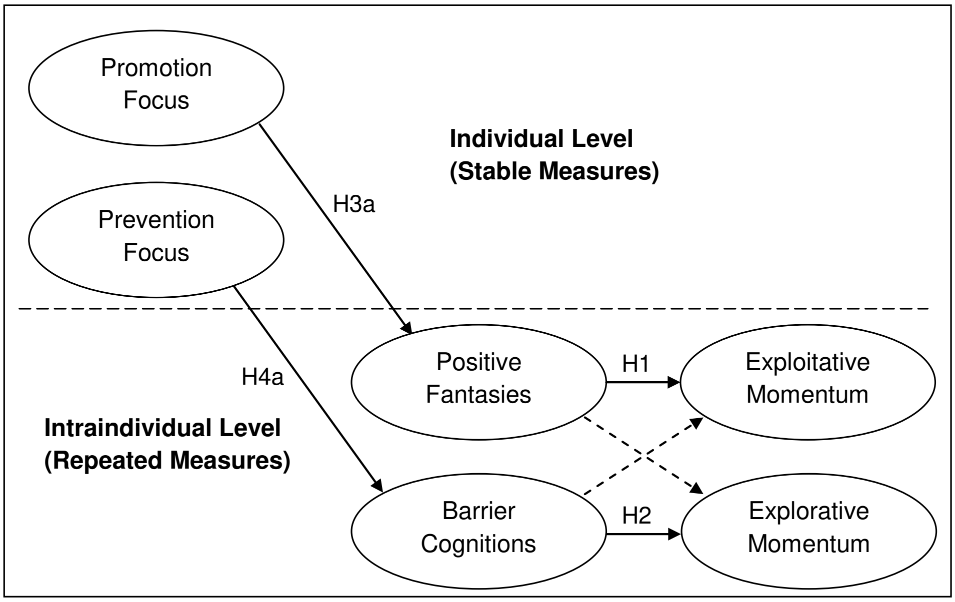

Figure 3.1. *Theoretical model*
Note. Dotted paths are hypothesized to be zero.

To handle the complexity of the innovation process, individuals need well-developed self-regulatory competencies (Van de Ven, 1986). However, research on self-regulation and the regulation of affect is missing within the innovation literature. This is surprising because there already is quite a bit of research on the influence of affect in innovation contexts (e.g., Amabile, Barsade, Mueller, & Staw, 2005; De Dreu, Baas, & Nijstad, 2008; George & Zhou, 2002, 2007). In order to address this gap, we will develop a dynamic perspective on self-regulation in innovative contexts. Figure 3.1 gives an overview of our theoretical model. We assume that it is important to study the dynamics of self-regulation over time. We are interested in when individuals tend to go into new directions and when they stay with previously chosen goals dependent on self-regulatory processes at that moment. This is important because as outlined before goals cannot be just set once in the beginning of an innovation project, but need to be reconfirmed or adjusted throughout the innovation process. Therefore, we need an intraindividual perspective on self-regulation (Seo & Ilies, 2009) in innovation contexts to adequately map the dynamics of innovation.

Future-related cognitions and innovation

In innovation projects, future orientation is crucial as innovation is inherently directed towards the future. Therefore, we focus on future-related cognitions (Oettingen & Mayer, 2002) as a means of self-regulation in innovative contexts. Future-related cognitions can be defined as affectively toned thoughts about the future (Oettingen, 1996). We assume that thinking about the future of an innovation project (i.e., future orientation) implies actively working on the project (Frese, 2009) and signals strong commitment to the project (Klinger, Barta, & Maxeiner, 1980). We distinguish positive fantasies and barrier cognitions. Positive fantasies are imaginations of achieving a goal or successfully completing a project. In contrast, barrier cognitions are thoughts about hindrances or difficulties that might arise in the course of a project or when working on a task. We propose that the nature of the future-related cognitions decides about the direction of a project.

In a dynamic environment such as an innovation project, individuals need to decide whether they want to further pursue the track they have chosen before or whether they need to make adjustments to that track and explore different routes to project success. In dynamic and complex environments it is not possible to just set one goal at the beginning of a task or project, but individuals need to "continuously engage in goal choice processes" (Seo & Ilies, 2009, p. 130). That is, in addition to the general goal of completing a project with a good and innovative product, individuals need to decide on how they will pursue this general goal, that is, they need to decide on how the product will look like. We use the concept of momentum to describe the goal choices people make concerning the direction of a project (Jansen, 2004). Two forms of momentum can be distinguished that differ in the direction of this force or energy (Jansen, 2004). Exploitative momentum is "the energy associated with persisting with or extending the current trajectory" (Jansen, 2004, p. 277), whereas explorative momentum is "the energy associated with pursuing a new trajectory" (Jansen, 2004, p. 277). At the individual level, both exploitative and explorative momentum may be conceptualized as facets of active performance (Frese, 2009), that is, as actively pursuing and promoting a project or task. The two dimensions of momentum provide the direction or orientation of this active performance. In other words, exploitative momentum is promoting the project along established lines (i.e., exploiting a chosen path) and represents the decision to proceed as before. On the other hand, explorative momentum is pushing the project in new directions (i.e., exploring new alternatives) and thus constitutes the assessment that modifications are called for. In this context, we postulate that positive fantasies signal that at the moment everything is going well and the chosen path is likely to be successful, whereas barrier cognitions inform about potential difficulties that make adjustments to the route towards the project success necessary. We will elaborate on these assumptions in the following.

We expect that imagining the future success of a project will foster exploitative momentum as positive fantasies reinforce both the chosen goal and the chosen track towards this goal. Positive fantasies about future success "activate incentives" (Job & Brandstätter, 2009, p. 1532). That is, positive fantasies provide a vivid image of what can be achieved by attaining a goal, which might be external rewards, reputation in the eyes of important other persons, or the fulfillment of implicit need structures. For example, when an individual in an R&D team imagines that he successfully completed a product development, and imagines the pride and happiness he will feel and the appreciation from colleagues and superiors he will gain, he gets a better picture of what the incentives of this specific goal are (Job & Brandstätter, 2009). The expectancy of those incentives in turn motivates active pursuit of that goal. Positive fantasies give a sense of direction because they "pull" towards the positive future (Oettingen, Pak, & Schnetter, 2001). In addition, the positive affect attached to the positive fantasies leads to higher attractiveness evaluations of the anticipated outcome (Seo, Bartunek, & Barrett, 2010). Finally, mood-as-information theory claims that positive affect signals that it is going well towards project success (Schwarz, 1990; Schwarz & Clore, 1983). Therefore, positive fantasies represent a reinforcement that the chosen track towards project success is the right one and is worth pursuing.

In contrast to the research that shows a positive link between positive affect and explorative behavior (i.e., creativity; Amabile, et al., 2005; Isen, 1999), we do not expect that positive fantasies are related to explorative momentum. The positive affect activated by the positive fantasies broadens the available cognitive and motivational resources of the individual (Fredrickson, 2001). However, as the positive affect is attached to the previously chosen goal and is activated only in connection to this goal, these additional resources will not be utilized to search for alternative goals, but will be rather invested into the chosen goal. It is the previously established goal that is reinforced by the positive fantasies; therefore a search for alternative goals is obsolete. Moreover, positive fantasies do not prepare for future difficulties (Oettingen & Mayer, 2002) and therefore they make adjustments of the track towards the goal unlikely.

Thus, for positive fantasies we hypothesize:

Hypothesis 1: Positive fantasies are positively related to exploitative momentum.

We expect that thinking about barriers and hindrances will foster explorative momentum. We propose that these cognitions have an informing function that tells individuals what is likely to go wrong about a task or what might be flaws in the current path towards task completion. For example, an engineer in an R&D team might contemplate what kinds of difficulties some technical detail of a new product may create in future production processes. Or she may consider what kinds of objections decision makers may have about certain product features. Thus, barrier cognitions alert individuals about potential future difficulties (George & Zhou, 2007). That is, we assume that barrier cognitions represent a critical analysis of reality that is focused on detecting important difficulties and barriers. To overcome these barriers, individuals cannot just do "more of the same", but instead need to modify and adjust their trajectories towards project success. Therefore, we do not expect barrier cognitions to be related to exploitative momentum. Instead, the negative affect connected to barrier cognitions signals that successful goal attainment is not likely (Martin, Ward, Achee, & Wyer, 1993). Thus, adjustments to the chosen track towards project success are necessary and the barrier cognitions provide the required information to decide on the nature of these adjustments. This assumption is supported by research on action rumination that shows that thinking about (past) difficulties and about how to improve performance is related to creativity (Ciarocco, Vohs, & Baumeister, 2010). In line with this reasoning, negative affect has been related to careful re-analyzing of information (George & Zhou, 2002, 2007; Kaufmann & Vosburg, 1997) and to seeking and utilizing new information in problem-solving (Spering, Wagener, & Funke, 2005). Therefore, we hypothesize that the more individuals think about barriers and hindrances the more they will search for alternative paths towards project success and adapt the nature of the project outcome.

Hypothesis 2: Barrier cognitions are positively related to explorative momentum.

Individual differences in future-related cognitions

We assume that the engagement in future-related cognitions does not only vary over time, but propose that future-related cognitions also differ between individuals. In other words, although we suggest that everyone engages in both positive fantasies and barrier cognitions to some extent, some individuals are more likely to use positive fantasies, whereas other individuals engage frequently in barrier cognitions. We utilize regulatory focus theory to explain these individual differences in self-regulation. Regulatory focus theory posits that individuals regulate their goals and actions by either trying to achieve success or to avoid failure (Higgins, 1997, 1998). The promotion system is responsible for the regulation of aspired end states (i.e., success), whereas the prevention system concerns the regulation of negative outcomes (i.e., failure). We assume that imagining success of a project is a direct expression of a promotion focus. In contrast, imagining barriers that might lead to project failure is a cognitive expression of a prevention focus.

Individuals who have a promotion focus are oriented towards success and positive outcomes (Higgins, 1997, 1998). We assume that positive fantasies about completing tasks successfully are an active cognitive expression of a promotion focus. Regulatory fit theory postulates that imagining positive outcomes fits a promotion focus as “it maintains the eagerness that sustains their focus” (Idson, Liberman, & Higgins, 2004, p. 928). Imagining the anticipated positive outcome of a task is a means of promotion-focused individuals to stay on target and to self-motivate active pursuit of a goal. Individuals with a promotion focus are sensitive to information that signals whether success of goal-pursuit is likely or not (Higgins et al., 2001). Therefore, promotion-focused individuals should be likely to engage in positive fantasies of project success.

Hypothesis 3a: Promotion focus is positively related to positive fantasies.

Moreover, we expect that promotion focus is indirectly related to exploitative momentum via positive fantasies. As just outlined, promotion-focused individuals are likely to engage in fantasies about the success of the project (Hypothesis 3a). These positive fantasies are in turn proposed to be positively related to exploitative momentum (Hypothesis

1). Combining these two assumptions suggests that promotion focus has an indirect effect on exploitative momentum because of its relation to positive fantasies.

Hypothesis 3b: There is a positive indirect effect from promotion focus via positive fantasies to exploitative momentum.

In contrast, individuals who have a prevention focus are oriented towards avoiding failure and negative outcomes (Higgins, 1997, 1998). We assume that thinking about barriers and difficulties that might arise when pursuing a goal is a direct cognitive expression of a prevention focus. For prevention-focused individuals, regulatory focus theory predicts a high frequency of barrier cognitions as these “maintain the vigilance that sustains their focus” (Idson, et al., 2004, p. 928). Individuals with a prevention focus are susceptible to information that signals what could go wrong with a task (Higgins, et al., 2001). Therefore, prevention-focused individuals are likely to attend to any kind of information that is related to project failure, that is, hindrances and barriers. Thus, we expect prevention-focused individuals to regularly engage in barrier cognitions while working on a project.

Hypothesis 4a: Prevention focus is positively related to barrier cognitions.

In addition, we propose an indirect effect of prevention focus on explorative momentum. As just discussed, we assume that individuals high on prevention focus regularly engage in barrier cognitions (Hypothesis 4a). Additionally, we postulate that barrier cognitions are positively related to explorative momentum (Hypothesis 2). Combining these two assumptions suggests an indirect effect of prevention focus on explorative momentum. This effect needs some further elaboration. At first sight it seems to be implausible to assume an (indirect) relationship between prevention focus and explorative momentum, as the literature rather suggests no or a negative relationship. For example, prevention (compared to promotion focus) has been negatively related to creativity (Friedman & Förster, 2001). However, recent evidence supports the proposition that prevention focus may also be positively related to creativity under certain circumstances (Baas, De Dreu, & Nijstad, in press). That is, when a goal is not yet fulfilled (as it is the case in an ongoing innovation project), a prevention focus is activating and leads to original and new insights and therefore may be related to explorative momentum.

Hypothesis 4b: There is a positive indirect effect from prevention focus via barrier cognitions to explorative momentum.

3.2 Method

Sample and procedure

We tested our hypotheses using a sample of 323 students working on applied innovation projects throughout one semester[4]. We used a longitudinal multi-wave design with three to six observations (depending on the length of projects) to measure momentum and future-related cognitions. The number of days between observations was held constant. In most cases, the time span between two observations was two weeks. The total number of observations is 1197 (mean number of observations per person: 3.7). In addition, stable individual differences in regulatory focus were measured once at the beginning of the projects. Mean age of the students was 20.4 years (SD 3.7; range 16 to 47 years); 21.7 % of the students were female. Most students in the sample were engineering majors (83.3%), but some students also came from business (8.7%), science (5.6%), and media (2.2%) departments. About two thirds of the students (68.1%) were from one US university, whereas the other third of the teams (31.9%) were from five German universities (two universities in northern Germany, two universities in central Germany, and one university in southern Germany).

Our sampling strategy was twofold. First, we contacted the engineering college of one public US university and deans of several German universities and asked about applied student projects. We were then referred to professors teaching such projects who were asked to participate. However, as the prevalence of such student projects was much lower in Germany than in the US, we could locate only a few projects in Germany by this strategy. Therefore, we additionally searched German university websites for applied student projects and contacted the supervising professors directly. In case the professors agreed to participate, we introduced our study in class. Students who were willing to participate provided us with their e-mail addresses. All questionnaires were administered online and students were invited to participate by e-mail reminders. At the beginning of their projects, students answered a questionnaire concerning stable individual differences and sociodemographic information. In the course of the projects, students repeatedly answered a questionnaire that covered the variables relating to the work in the project for the last two weeks.

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[4] The same sample was used in study of the first chapter. However, there is no overlap in the variables analyzed in the two studies. Moreover, study of the first chapter concerned only team level constructs, whereas the current study applies to the individual level of analysis.

Measures

Regulatory focus. Regulatory focus was measured using 9 items per dimension (Lockwood, Jordan, & Kunda, 2002). Sample items are “I typically focus on the success I hope to achieve in the future” for promotion focus and “I frequently think about how I can prevent failures in my life” for prevention focus. Participants responded on a 7-point scale ranging from 1 = “strongly disagree” to 7 = “strongly agree”. Cronbach’s alphas were .82 for promotion focus and .75 for prevention focus.

Repeated measures. Items in the repeated questionnaire referred to the time span since the last questionnaire (i.e., mostly the last two weeks). Participants responded on a 5-point scale ranging from 1 = “very false” to 5 = “very true”. As we had to adapt and develop items we pilot-tested the repeated questionnaire in a sample of 40 students.

Future-related cognitions. For positive fantasies and barrier cognitions, we developed three items per scale based on the literature on future-related cognitions (Oettingen & Mayer, 2002). A sample item for positive fantasies is “I envisioned the future success of this project”; a sample item for barrier cognitions is “I concerned myself with difficulties that might occur in the course of this project”. Cronbach’s alphas were .87 for positive fantasies and .87 for barrier cognitions.

Momentum. The two momentum dimensions were also measured in the repeated questionnaire with three items per dimension. Items were adapted from Jansen (2004). Sample items are “There was quite a bit of momentum to continue the project in the same manner as in previous weeks” for exploitative momentum and “There was quite a bit of momentum to handle the project in a very different manner than before” for explorative momentum. Cronbach’s alphas were .87 for exploitative momentum and .92 for explorative momentum.

We analyzed the structure of the four scales used in the repeated questionnaire by a multilevel confirmatory factor analysis. The four factor model [X^2 = 274.0, df = 99; CFI = .98; RMSEA = .04; SRMR(within) = 0.04; SRMR(between) = 0.04] fitted the data better than models with fewer factors, confirming that the four scales are distinct but interrelated factors.

Data Analysis

With this design, we had multilevel indirect effects models (see Figure 3.1) with the predictors (prevention and promotion focus) at the individual level and the intervening variables (positive fantasies and barrier cognitions) as well as dependent variables (exploitative and explorative momentum) at the intraindividual level. Due to this nested nature of our data, we used multilevel structural equation modeling (MSEM) as recommended by Preacher and colleagues (Preacher, Zhang, & Zyphur, in press; Preacher, Zyphur, & Zhang, 2010) in Mplus (Muthén & Muthén, 1998-2009) to test our hypotheses in one model.

3.3 Results

Means, standard deviations, and intercorrelations of all variables in the model are reported in Table 3.1. As most of the variables in our model correlate with age, gender, and country, we used these three variables as controls in all our analyses. In addition, Table 3.1 reports the percentage of variance that resides at the intraindividual level. For all of the repeated measures, the proportion of variance that is due to variation within individuals is between 43.7 % and 58.8 %. This is a substantial proportion of the overall variance; thus, an intraindividual perspective is justified.

Table 3.1

Means, standard deviations, and intercorrelations of variables in the model

		Mean	SD	% Var within	1	2	3	4	5	6	7	8
	Repeated Measures											
1	Positive Fantasies	3.58	.99	43.7 %	-	.44**	.26**	.42**				
2	Barrier Cognitions	3.22	.98	56.0 %	.47**	-	.30**	.17**				
3	Explorative Momentum	2.71	1.07	54.2 %	.36**	.38**	-	.17**				
4	Exploitative Momentum	3.68	.82	58.8 %	.49**	.21**	.20**	-				
	Stable Measures											
5	Promotion Focus	5.34	.84	-	.32**	.19**	.19**	.22**	-			
6	Prevention Focus	4.11	.93	-	.10	.23**	.10	.05	.32**	-		
7	Age	20.42	3.70	-	-.19**	-.14*	-.34**	-.17**	-.27**	-.15**	-	
8	Gender[a]	1.78	.41	-	-.02	.11*	.21**	.05	.08	-.03	-.09	-
9	Country[b]	1.68	.47	-	.35**	.29**	.49**	.23**	.35**	.10	-.61**	.22**

Note. Correlations below the diagonal refer to the individual level (N = 323). In order to calculate correlations between stable and repeated measures, repeated measures were aggregated to individual level. Correlations above the diagonal refer to the intraindividual level (N = 1197).
* p < .05, ** p < .01.
[a] Gender was coded 1 = female and 2 = male.
[b] Country was coded 1 = Germany and 2 = US.

The path model with our results is displayed in Figure 3.2. It is important to note that the results need to be separated into the individual level and intraindividual level of analysis (the upper and lower parts in Figure 3.2). As our predictors reside at the individual level (i.e., the values for promotion and prevention focus vary only between, but not within individuals) the hypothesized indirect effects can only occur at the individual level (Bauer, Preacher, & Gil, 2006; Preacher, et al., 2010). In other words, the predictors cannot account for any intraindividual variation of the intervening or dependent variables. However, the effects of the intervening variables on the dependent variables can be estimated both at the intraindividual level and the individual level, and those effects are orthogonal to each other (Preacher, et al., 2010). Thus, hypotheses 1 and 2 can be tested both within and between individuals.

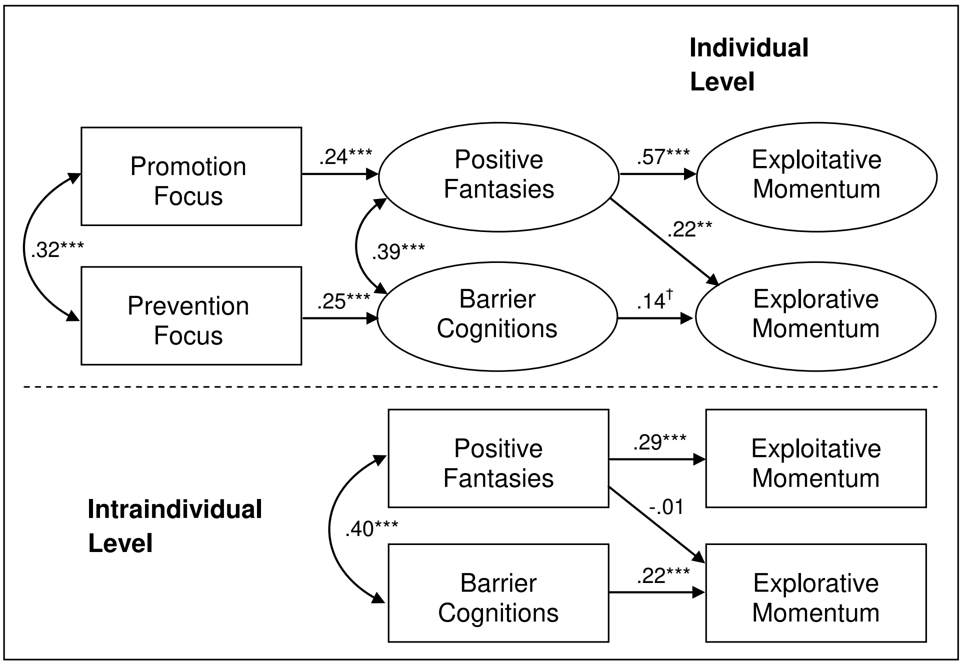

Figure 3.2. *Path-model of the hypothesized effects*

Note. N = 323 at the individual level, N = 1197 at the observation level.
Standardized path coefficients are reported.
† p < .10, ** p < .01, *** p < .001 (two-tailed).

In the base model to test our hypotheses, we also estimated the paths from positive fantasies to explorative momentum and from barrier cognitions to exploitative momentum to test whether these paths are zero as hypothesized (dotted paths in Figure 3.1). As expected, the path from barrier cognitions was close to zero and non-significant at both the intraindividual level (β = -.03, p = .49) and the individual level (β = -.03, p = .77). We therefore constrained these paths to zero, which did not reduce model fit (Table 3.2). However, constraining the paths from positive fantasies to explorative momentum to zero reduced the model fit significantly (the chi-square difference test was significant, p < .05; see Table 3.2). Therefore, these paths remained in our final model. Fit indices of the final model

(model 2 in Table 3.2) are as follows: $X^2 = 44.68$, df = 16; CFI = .95; RMSEA = .04; SRMR(within) = .004; SRMR(between) = .088.

Table 3.2

Fit indices of path model

Model	X^2 (df)	CFI	RMSEA	SRMR within	SRMR between	X^2 Difference Test[a]
(1) All effects	46.25 (14)	.942	.044	.003	.088	-
(2) Without path barrier cognitions to exploitative m.	44.68 (16)	.949	.039	.004	.088	.619 (df = 2) p = .73
(3) Without path positive fantasies to explorative m.	52.40 (16)	.935	.044	.003	.097	6.231 (df = 2) p = .04

Note. N = 323 at the individual level, N = 1197 at the intraindividual level.
CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.
[a] Satorra-Bentler scaled chi-square test, testing the respective model against the "all effects" model (1).

Figure 3.2 shows a positive relationship between positive fantasies and exploitative momentum both at the intraindividual level (β = .22, $p < .001$) and at the individual level (β = .57, $p < .001$), supporting hypothesis 1. That is, when individuals engaged in positive fantasies, they were likely to actively pursue their project along established lines (intraindividual level relationship). In addition, those individuals who in general engaged in positive fantasies were also in general likely to actively continue their projects in the established direction (individual level relationship). In partial support of hypothesis 2, barrier cognitions were significantly positively related to explorative momentum within individuals (β = .29, $p < .001$); however this effect was only marginally significant at the individual level (β = .14, $p < .10$). That is, although individuals changed the course of their projects at times when they thought about barriers and hindrances, individuals that often engaged in barrier cognitions were only marginally more likely to give the project a new direction. At the individual level, positive fantasies were also related to explorative momentum (β = .22, $p < .01$). However, this relationship was close to zero and nonsignificant at the intraindividual level (β = -.03, p = .77). That is, although individuals who in general engaged in positive fantasies tended to push their projects in new directions, this behavior was not dependent on those situations when they imagined the success of their projects.

The hypotheses concerning the relationships between regulatory focus and future-related cognitions can only be tested at the individual level as regulatory focus variables only vary between individuals and not over time. Hypothesis 3a that promotion focus is positively related to positive fantasies was supported ($\beta = .24$, $p < .001$). In addition, promotion focus was positively related to exploitative momentum via positive fantasies (indirect effect = .09, S.E. = .025; $p < .01$), supporting hypothesis 3b. Furthermore, our data showed an indirect effect of promotion focus on explorative momentum via positive fantasies (indirect effect = .05, S.E. = .018; $p < .05$) that was not hypothesized. Hypothesis 4a that prevention focus is positively related to barrier cognitions was supported ($\beta = .25$, $p < .001$). However, the small positive indirect effect of prevention focus on explorative momentum via barrier cognitions did not reach statistical significance (indirect effect = .03, S.E. = .020; $p = .13$). Thus, hypothesis 4b could not be confirmed.

3.4 Discussion

Our results shed light on the role of self-regulation in innovation contexts. Innovation projects are highly complex and dynamic (Anderson, et al., 2004; Bledow, et al., 2009). Individuals working in innovation projects need to decide whether they want to pursue their project along the trajectory they established before or whether adaptations and modifications of that trajectory are necessary. Self-regulation is an important influencing factor in making these decisions (Rothman, Baldwin, Hertel, & Fuglestad, 2011). In this study, we chose an intraindividual focus to appropriately cover the dynamics of an innovation project (Bolger, Davis, & Rafaeli, 2003). Our results confirmed that positive imaginations of the project outcome help individuals to stay on target and actively pursue a project as planned before. In contrast, thinking about potential difficulties and hindrances supports making adjustments to the project track and the search of alternative outcomes. In addition, at the individual level future-related cognitions were related to regulatory focus (Higgins, 1997, 1998). Promotion-focused individuals who are oriented towards success often engaged in fantasies about completing a project, whereas prevention-focused individuals regularly thought about potential hindrances and difficulties. Thus, our study adds to the literature on regulatory focus by identifying affective-cognitive consequences of both promotion and prevention focus.

An important outcome of our study is the divergence of the relationships between the individual and intraindividual level. Whereas we could clearly show the hypothesized effects at the intraindividual level, at the individual level a different picture emerged. This finding confirms the importance of studying both kinds of relationships as they cannot be easily transferred between levels (Seo & Ilies, 2009).

First, positive fantasies were unexpectedly related to exploration momentum at the individual level. That is, individuals that tended to engage in positive fantasies were in general likely to explore new directions of a project. We assume that is less an effect of the positive fantasies per se, but can be explained by the influence of positive affectivity. A high dispositional positive affectivity is probably related to regularly anticipating and fantasizing about positive events in general (Lyubomirsky, Tkach, & DiMatteo, 2006) and therefore also about positive outcomes of tasks and projects. In addition, a whole stream of research shows that positive affectivity is also related to explorative behavior and creativity (e.g., Amabile, et al., 2005; Fredrickson, 2001; Isen, 1999; Lyubomirsky, King, & Diener, 2005). However, at the intraindividual level, a specific positive fantasy is always related to a specific goal or outcome, such that this fantasy will not lead to explorative search for alternative goals; therefore, there is no relationship between positive fantasies and exploration momentum at the intraindividual level.

Second, barrier cognitions only had a marginally significant relationship with exploration momentum at the individual level, which also led to a nonsignificant indirect effect of prevention focus on exploration momentum. Individuals who regularly thought about hindrances were only little more likely to explore alternative routes to project success. We assume that this small effect is due to opposing effects that are operating at the individual level. Analogous to the hypothesized effect at the intraindividual level, barrier cognitions in general inform about flaws and difficulties in the chosen track towards the goal and therefore make adjustments and search for alternative routes likely (Ciarocco, et al., 2010). However, individuals who tend to engage in barrier cognitions might also be prone to dysfunctional rumination. Prevention focus has previously been related to rumination (Keller, Hurst, & Uskul, 2008). Whereas the cognitions that are related to tangible hindrances of a project or task support explorative behavior, task-irrelevant ruminative thoughts in contrast block exploration (Ciarocco, et al., 2010). Taken together, the informing effect of barrier cognitions and the blocking effect of rumination yield only a slightly positive effect on exploration momentum when considered as a between individuals effect. Thus, future research may need to incorporate additional forms of cognitions (such as rumination) to more precisely delineate the effects of future-related cognitions.

Beyond the findings concerning self-regulation, our results add to the innovation literature in an additional way. Previous research implies that both explorative and exploitative behaviors are essential for innovation (Bledow, et al., 2009; Gibson & Birkinshaw, 2004). In this study, we conceptualized and operationalized exploration and exploitation at the individual level of analysis. To date, exploration and exploitation have been mainly used as organizational level concepts (e.g., Benner & Tushman, 2003; He & Wong, 2004). However, recently an increasing number of innovation researchers assume that the interplay of exploration and exploitation is valid at multiple levels of organizations (Andriopoulos & Lewis, 2009; Bledow, et al., 2009; Raisch & Birkinshaw, 2008). In line with the idea of contextual ambidexterity that individuals within organizations have to decide when to use explorative and exploitative behaviors (Gibson & Birkinshaw, 2004), we introduced explorative and exploitative momentum as facets of individual active performance (Frese, 2009). Contextual ambidexterity necessitates switching between explorative and exploitative behavior. Our research shows how explorative and exploitative behaviors can be fostered through different self-regulatory strategies. Thus, future-related cognitions may be helpful in switching between those behaviors. That is, we suggest that future research on the integration of exploration and exploitation at the individual level (i.e., individual ambidexterity) considers the interplay of positive fantasies and barrier cognitions over time.

Limitations and future research directions

A first limitation of our study concerns the use of a student sample that might constrain the generalizability of our conclusions. However, we took precautions to maximize the similarity to professional R&D teams. In discussions with the supervising professors we made sure that student teams worked on applied innovation projects that have validity in the "real world". For example, some teams worked on developing new kinds of wind turbines with increased efficiency, others redesigned electrical toothbrushes. Importantly, the teams' tasks were not artificially imposed by us, but were assigned by the professors and were part of the respective university's curriculum. This framework made sure that the tasks and requirements of the students were highly similar to professional R&D work. Nevertheless, even with a great resemblance in the task, other factors still differ between student teams and professional teams, such as the length of the projects or the professional experience of the individuals. Thus, future research needs to replicate our findings in professional R&D teams to further ensure the external validity of our findings.

Second, the correlational nature of our data does not allow for a causal interpretation of the demonstrated relationships, which the path model might imply (Bullock, Harlow, & Mulaik, 1994). Experimental designs that manipulate future-related cognitions are necessary to determine the causal order of events. Nevertheless, we assume that is plausible that self-regulation precedes behavior rather than the reversed order. However, as the dynamic and complex nature of innovation suggests, the relationship between future-related cognitions and momentum is probably not unidirectional but to a certain extent reciprocal. For example, explorative momentum may not only be a consequence of thinking about potential future difficulties, but it might also to some degree lead to further barrier cognitions as a new and unexplored avenue is most likely connected to other potential hindrances (i.e., radical innovation has a high probability to fail; Hill & Rothaermel, 2003). Future research needs to further disentangle these processes in carefully designed experiments.

Third, we used broad time spans between the repeated measures (mostly about two weeks). The selection of a time frame has important implications for the examined relationships (Roe, 2008). We decided for this time frame because we wanted to cover the whole innovation process, and not only parts of it. In addition, we wanted to capture the major fluctuations in the trajectories of innovation projects that were crucial for the overall project outcomes as compared to minor variations that might occur on a daily base or even within days. However, future research might also examine shorter time intervals to find out whether our results generalize to smaller adjustments within the innovation path.

Practical implications

Individuals in innovation work contexts such as R&D teams need to make decisions on the direction they want to go. Our study gives suggestions on how self-regulation may support and guide these decisions. First of all, individuals in innovation contexts need an explicit awareness of their cognitions in the course of a project. Furthermore, whenever the momentum of a project is going in the same direction for a while, it might be worthwhile to pause for a moment and consider potential barriers and, likewise, when the direction of a project frequently changes, it might be helpful to engage in fantasies about the success of the project. Moreover, supervisors of innovative teams may steer the direction of a project by activating either positive fantasies or barrier cognitions.

In addition, we found that individual differences play a role in future-related cognitions. Individuals high on promotion focus are likely to engage in positive fantasies, whereas individuals high on prevention focus are more likely to focus on barrier cognitions. That is, those kinds of cognitions come easily and effortlessly to these individuals. However, both kinds of cognitions are necessary in innovation projects to deal with the dynamics of innovation (Bledow, et al., 2009). Thus, promotion-focused individuals need to explicitly attend to potential barriers that might arise in the course of their project. In contrast, prevention-focused individuals need to regularly imagine the future success of the project. This may be achieved for example by staffing a project with individuals that differ along the dimensions of prevention and promotion focus. Promotion-focused persons may trigger positive fantasies in their prevention-focused colleagues and vice versa. Alternatively, supervisors may actively initiative discussions about both the positive aspects of future success and potential hindrances that lie on the way to success.

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