DYNAMIC CAPABILITIES AND THEIR CHARACTERISTIC QUALITIES:

INSIGHTS FROM A LAB EXPERIMENT

Jutta Wollersheim
Technische Universität München
Lehrstuhl für Strategie und Organisation
Arcisstr. 21
80333 München
Germany
Email: wollersheim@tum.de

Koen Heimeriks
Tilburg University
TIAS School for Business and Society
Postbus 90153
5000 LE Tilburg
Netherlands
Email: k.h.heimeriks@tias.edu

PAPER FORTHCOMING IN ORGANIZATION SCIENCE

Keywords: Organizational capabilities, laboratory research, experimental designs, organizational routines

Acknowledgments: We dedicate the article to the late Michael D. Cohen, who contributed to strengthening our study from the very beginning onwards. Beyond providing personal and scholarly inspiration, we highly appreciate his many excellent suggestions and sound advice which were invaluable for the progress of this study.

We would like to thank our Editor, Daniel Levinthal, two anonymous reviewers and the attendants of several conferences (e.g., Organization Science Winter Conference 2014, Annual Meeting of the Academy of Management 2014) for their thoughtful guidance and constructive comments. Further thanks go to Linda Argote, Erich Barthel, Florian Bauer, Daniella Laureiro-Martínez, Patrick Oehler, Patrick Reinmoeller, Isabell M. Welpe, and Ralf Wilden for their valuable suggestions and support. Parts of the project were completed while Jutta Wollersheim was a Visiting Research Scholar in the Center for Organizational Learning, Innovation and Knowledge at the Tepper School of Business, Carnegie Mellon University. Jutta Wollersheim would like to thank the faculty in the Organizational Behavior and Theory area of the Carnegie Mellon University and Linda Argote in particular for their excellent support.

Last, we wish to thank the participants of our study and all persons involved in the project, such as the student assistants, who played a supporting role in conducting the experiment and the programmer, Sebastian Bendeich, who did an excellent job in programming the computer system that we used. The data for the study were collected at experimenTUM, laboratory for experimental economics, Technische Universität München, Germany.

Dynamic capabilities have become a central construct in the strategy and organization literatures (Teece et al. 1997). As a central source of change within organizations, dynamic capabilities relate to how (operational) routines are modified or adjusted through learning and form a key dimension of firm heterogeneity (Helfat and Winter 2011; Nelson and Winter 1982).

While there is consensus that dynamic capabilities govern adjustments in ordinary routines (Collis 1994; Winter 2003), extant work offers a plethora of conceptualizations (e.g., Barreto 2010; Di Stefano et al. 2010; Katkalo et al. 2010) and specifies different types of dynamic capabilities, e.g., "sensing", "seizing", "reconfiguring", "shaping", and "modifying" capabilities (Eisenhardt and Martin 2000; Teece et al. 1997; Zollo and Winter 2002). Moreover, the majority of scholarly work emphasizes only particular dimensions (Schreyögg and Kliesch-Eberl 2007) or studies the collective nature of the construct (Felin and Foss 2005; Salvato and Rerup 2011). Therefore, despite impressive studies on the topic, dynamic capabilities remain hard to observe and analyze. Some perceive the term to be "confusing" (Winter 2003) and "abstract" (Danneels 2008), leading others to call for an empirically grounded understanding of dynamic capabilities using experiments (Salvato and Rerup 2011). As a consequence, in contrast to the properties of routines (Becker 2004; Cohen and Bacdayan 1994), the characteristic qualities of dynamic capabilities are not well-documented (Giudici and Reinmoeller 2012).

The purpose of this study is to empirically identify the characteristic qualities associated with dynamic capabilities. Following prior work (e.g., Agarwal et al. 2012; Knez and Camerer 1994; Weber and Camerer 2003), we use an experimental design and induce dynamic capabilities in the laboratory. Given the consensus and emphasis on behavioral patterns, we follow Zollo and Winter's (2002) definition to induce dynamic capabilities in a laboratory setting. Specifically, we use an extended version of the Cohen and Bacdayan (1994) "Target the Two" card game to respond directly to recent calls emphasizing that "*extending the Cohen-Bacdayan line is a*

promising path forward" (Winter 2013: 127). To our knowledge, our study is the first to, instead of relying on aggregate proxies (Barreto 2010), examine the characteristic qualities by identifying dynamic capabilities in an empirically novel manner. The experiment aims to overcome the difficulty to grasp the empirical nature of dynamic capabilities so far (Di Stefano et al. 2010).

A total of 168 participants took part in the extended version of Cohen and Bacdayan's (1994) "Target the Two" card game that we used to develop an empirically grounded understanding of the characteristic qualities of dynamic capabilities. While our study does not aim to resolve all key debates on dynamic capabilities, we seek to shed light on the empirical reality of the construct. Our findings reveal that, in contrast to groups in the low dynamic capability condition, groups in the high dynamic capability condition: (a) make more efficient use of resources, (b) demonstrate an increasing efficiency of coordination, (c) rely on more appropriate action sequences, and (d) display greater deliberation in action.

THEORETICAL BACKGROUND

Dynamic Capabilities: Definitions and Extant Work

While a rich body of work offers numerous conceptualizations of dynamic capabilities, most work builds on one of the three most prolific definitions of the term. First of all, in their pioneering article, Teece et al. (1997: 516) build on the resource-based view of the firm (Acedo et al. 2006) to define dynamic capabilities as *"the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments"*. In this original definition, competencies relate to *"patterns of current practice and learning"* (Teece et al. 1997: 518), which enable a firm to alter how it operates through changes in its resource base (Helfat and Winter 2011). Second, Eisenhardt and Martin (2000: 1107) refine Teece et al.'s (1997) definition by relating dynamic capabilities to "*the firm's processes that use resources […] to match and even create market change"*. Beyond highlighting the notion of "market change",

their article directs attention to specific processes and routines, e.g., alliance or acquisition routines, that exhibit significant commonalities across firms and bring new resources into the organization as well as argues that dynamic capabilities look different in moderately vs. high-velocity contexts. Third, Zollo and Winter (2002: 340) propose a dynamic capability *"is a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in the pursuit of improved effectiveness"*. In their framework, Zollo and Winter (2002) build on evolutionary economics (Nelson and Winter 1982) to distinguish operational from dynamic capabilities—the latter involving adaptation of operating routines. In more recent work, Teece (2007) extends Teece et al.'s (1997) contribution by arguing that dynamic capabilities pertain not only to the firm's capacity to "reconfigure" the firm's resource base, but also to "sense", "seize", and potentially "shape" the environment. In this recent work, dynamic capabilities are disaggregated into *"distinct skills, processes, procedures, organizational structures, decision rules, and disciplines"* (Teece 2007: 1321) to explain how firms sustain superior performance.

With the literature providing many other definitions (see Barreto 2010), some scholars raise substantive, even existential, critiques (cf. Arend and Bromiley 2009). The construct is criticized for being "vague" (Kraatz and Zajac 2001), "fanciful" (Winter 2003), "confusing" (Winter 2003), "infant" (Helfat and Peteraf 2009), "black-boxed" (Pavlou and El Sawy 2011), "abstract" (Danneels 2008), and "self-destructive" (Giudici and Reinmoeller 2012). Despite others' attempts to reconcile the different understandings of the construct (Peteraf et al. 2013), extant work specifies different *types* of dynamic capabilities (Barreto 2010; Helfat et al. 2007; Zahra et al. 2006). First, following work by Teece and colleagues, "sensing", "seizing", "reconfiguring" capabilities that help to "address rapidly changing environments" form one type. Second, inspired by Eisenhardt and Martin's (2000) article, another type pertains to "shaping"

capabilities that "create market change" and "alter the firm's resource base" (Teece 2007: 1322). Third, Zollo and Winter's (2002) approach specifies a "modifying" capability as patterned behavior that adjusts operating routines through learning as a third type of dynamic capability.

Due to the different conceptualizations and types of dynamic capabilities we also *"do not have an empirically informed understanding of where dynamic capabilities are located in the organization"* (Salvato and Rerup 2011: 473). Others question the constructs' empirical grounding (Williamson 1999) as well as whether "*they exist"* (Winter 2003: 991) and "*where they come from"* (Zollo and Winter 2002: 340). Careful scrutiny of the three prolific definitions reveals each definition emphasizes different levels of analysis. Teece et al. (1997: 515) stress *firm-level* (i.e., capacity to renew competences to fit environment change), Eisenhardt and Martin (2000: 1107) address *process level* (i.e., processes that drive the creation, evolution, and recombination of other resources into new sources of competitive advantage), and Zollo and Winter (2002: 340) emphasize *patterns of collective activity* and *behavioral patterns* (i.e., modifying operating routines through learning to pursue improved effectiveness) as level of analysis (Helfat et al. 2007: 3). With the evolution of the construct, the level of analysis seems to gradually shift from collective to lower levels with recent work addressing individual or micro-foundational levels, recently emphasizing the role of "managerial choice" (Zahra et al. 2006: 925), "top management skills" (Teece 2012: 1398), "dynamic managerial capabilities" (Kor and Mesko 2013), and "managerial cognitive capabilities" (Helfat and Peteraf 2015: 832).

Comparable to the conceptual evolution of the construct, advances in empirical work follow a much similar path (for overviews of empirical works, see Barreto 2010; Wang and Ahmed 2007). The very dispersed body of empirical work initially studied a firm's adaptive capacity to fit environmental change; subsequent work emphasized specific internal processes that shape the firm's resource base; and more recent research started to examine micro-level

phenomena to stipulate how dynamic capabilities are structured (cf. Di Stefano et al. 2010). First, using a variety of methods, the numerous studies on dynamic capabilities analyze how firms *"address rapidly changing environments"* (Teece et al. 1997: 516). This early empirical work typically highlights a firm's adaptive capacity vis-à-vis industry changes and its role in capturing market opportunities. For example, in their study of the U.S. motion picture industry, Lampel and Shamsie (2003) use a sample of 400 films to demonstrate that two industry capabilities—i.e., mobilizing and transforming capabilities—crucially shape the assembly and transformation of resource bundles in the post-studio era. Similarly, without necessarily explicating the concept, D'Este (2002) analyzes manufacturing, R&D, and marketing capabilities of sixty-seven Spanish pharmaceutical firms and finds that those building product development capabilities outperform others.

Second, subsequent work analyzes specific, identifiable (and stable) internal processes e.g., product development and acquisitions, which may offer competitive advantage. For instance, Powell et al.'s (1996) analysis of biotech firms over the period 1990–1994 shows alliancing not only improves the network positioning of the focal firm but also critically influences firm growth. Studying 77 public manufacturing firms, Danneels (2008) demonstrates that willingness to cannibalize, constructive conflict, tolerance for failure, environmental scanning, and resource slack are antecedents of marketing and R&D capabilities, which determine a firm's propensity to change its resource base. In their single inductive case of a Fortune 100 firm, Galunic and Eisenhardt (2001) reveal how the use of a few simple rules enables the reconfiguration of resource divisions across business units, which critically shapes firm growth.

Last, recent work starts to assess behavioral patterns to study emergence and role of agency in capability development. For example, in her study of an anonymized high-tech firm,

Howard-Grenville (2005) uses ethnographic methods to succinctly note that the "roadmapping" routine within this firm is both persistent and flexible, which depends on agent and structural contingencies. Through an extended case method, Danneels's (2011) meticulous analysis of Smith Corona opens the black box of dynamic capabilities by advancing the notion of "resource cognition" to describe the role managers and their mental models play in identifying firm resources and their fungibility. Related studies on cognition and learning explore still other microfoundations of dynamic capabilities. For instance, in their study of 380 marketing executives, Slater et al. (2006) find that firm strategic orientation moderates the relationship between strategy formation capability and performance. In their study on cognitive processes involved in exploitation and exploration decisions, Laureiro-Martínez et al.'s (2015) experimental, neuroscientific fMRI design informs dynamic capability theory by showing that superior decision-making performance requires both an ability to sequence exploitation and exploration as well as recognizing when to switch to exploration. Thus, whereas initial empirical work assesses firm behavior in response to environmental dynamism, subsequent work examines processes and behavioral patterns to understand the nature of dynamic capabilities. Notwithstanding the contributions made by prior empirical studies, there is a lingering unclarity as to the empirical reality of the construct.

To develop an empirically grounded understanding of the characteristic qualities associated with dynamic capabilities, we follow Zollo and Winter (2002: 340) and define dynamic capability as *"a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness"*. Their definition explicitly acknowledges that routines are building blocks of dynamic capabilities (Salvato and Rerup 2011) implying that repetitive action patterns, rather than ad-hoc actions, are central to the construct (Winter 2003). Note that this definition contains

the elements of "learning" and "modification" that recur in prior work. Learning is a crucial element because it describes the insights generated from experience (e.g., Cohen 1991); modification relates to adjustments of the internal components of the firm (Dosi et al. 2000).

We adopt Zollo and Winter's (2002) definition for several reasons. First, despite the variety in operationalizations of the construct, there is broad consensus that dynamic capabilities govern the adjustment of ordinary or operating routines (Winter 2003). Conceptual work in this space separates "zero" or "operational" activities from "higher-order" or "dynamic routines" (e.g., Collis 1994; Helfat and Winter 2011; Winter 2003). This literature suggests that the term dynamic capabilities encompasses a repetitive or routine dimension (captured by patterned, collective activity) and an adaptive or flexibility dimension (captured by learning and modification) (cf. Katkalo et al. 2010). *"With routines being inputs to [dynamic] capabilities"* (Winter 2000: 983; 2003: 992), such repetitive action patterns form the basis for dynamic capabilities, which have to be adjusted or even abandoned in the presence of changing environmental conditions (Becker 2004). Schreyögg and Kliesch-Eberl (2007) offer a comparable conceptualization as they argue that the dynamic capability construct entails two countervailing processes: (1) routines or patterned problem-solving and (2) the ability to change or dynamization. Probably most akin to Zollo and Winter's (2002) definition, this consensus closely ties to the "modifying" capability type of dynamic capabilities. Central to this type of dynamic capability is that the term relates to the "*change of key internal components of the firm"* (Barreto 2010: 261) or, as Salvato and Rerup (2011: 473) emphasize, "*help[ing] a firm […] adapt lower-level entities—mainly routines and standard capabilities—to dynamic environments"*.[1] In other words, even though, as mentioned earlier, there are different sorts of dynamic capabilities some of which do not *"act upon operating routines"* (Helfat et al. 2007: 3), Zollo and Winter's (2002) definition fits well with the emerging consensus.

Next, in line with the purpose of our study, Zollo and Winter (2002) emphasize the role of behavioral patterns as well as the evolutionary nature of the construct. Aiming to improve our understanding of *"where they come from"* (Zollo and Winter 2002: 340), their evolutionary framework focuses on routines and learning which allows for an analysis of behavioral patterns and is particularly fitting for experimental designs (Winter 2013). Studying lower levels of analysis, i.e., behavioral patterns, in line with their definition, is proposed to help *"spell out some of the characteristics of the construct"* (Zollo and Winter 2002: 340). Last, their definition helps to avoid defining dynamic capabilities as a near-tautology as they reflect that "*an organization […] adapts [or modifies] its operating processes"* by being "*dedicated to process improvement"* (Zollo and Winter 2002: 340). This implies that dynamic capabilities do not necessarily improve firm performance (Helfat et al. 2007) and instead acknowledges both the existence of commonalities across firms as well as differential outcomes as a consequence of heterogeneous routines (Barreto 2010). Hence, instead of pursuing insights into "sensing", "seizing", "reconfiguring", or "shaping" capabilities, the next section details how our design focuses on changes in patterned behavior by agents following an environmental change.

Dynamic Capabilities: Our Experiment

We follow Salvato and Rerup's (2011) and Winter's (2003) recommendations and use an experimental design to capture the essence of the construct (Berkowitz and Donnerstein 1982). Experiments offer a number of important benefits. First, experimental research "*is an excellent way to address questions of causality"* (Bono and McNamara 2011: 658). Notwithstanding their inherent simplification, experiments represent a key and proven method to uncover basic processes underlying phenomena, such as knowledge transfer (Kane et al. 2005). Although the study of dynamic capabilities is expanding rapidly, experimental analyses of dynamic capabilities are, to our knowledge, non-existent. Therefore, the use of a laboratory experiment appears

promising. Second, laboratory experiments are well suited to addressing the limitations of studies based on field observations. Specifically, our design does not suffer from problems that are typical of studies based on real-world data. Such studies typically suffer from (1) the usage of weak measures of dynamic capability and (2) the problem that it is not possible to determine how the operating procedures would have evolved had the degree of dynamic capability been higher or lower. In contrast to studies relying on real-world data, our laboratory study allows us to exert control by exclusively manipulating the degree of dynamic capability while holding everything else constant. As a result, our experimental design allows us to make inferences concerning dynamic capabilities that complement existing field studies.

Our experiment included two sessions encompassing three phases. In Phase I, two participants jointly conducted a task intended to routinize the group's problem-solving behavior. During Phase I, the participants *"learned"* and, through repetition, developed *"a stable pattern of collective activity"* (Zollo and Winter 2002). In particular, the groups of two participants separately developed routines by playing a card game. In doing so, participants developed cognitive and behavioral regularities in action (Feldman and Pentland 2003). Subsequently, to create a situation in which dynamic capabilities are required and thus, to enable the assessment of groups' degrees of dynamic capability, in Phase II, we implemented the first novelty manipulation thereby creating an environmental change (Teece et al. 1997). Specifically, we instructed our participants, without prior warning, to change their roles and informed them of a change in the goal of the card game, which they subsequently had to play again (Cohen and Bacdayan 1994). This environmental change required that participants adjusted their operating routines through learning and modification (Zollo and Winter 2002). Then, in Phase III, we implemented the second novelty manipulation by merging the respective pairs into groups of four based on their degree of dynamic capability (our approach to identifying degrees of dynamic

capabilities is described in the "Data and Method" section). Playing the card game again, the four-person groups had to adjust their routinized behavior following the second novelty manipulation. Comparing low and high dynamic capability groups, we observed the characteristic qualities of dynamic capabilities by analyzing how behavioral patterns evolved (and thus, how routines were adjusted and new routines emerged) in Phase III. In total, more than 8,000 hands of the card game were played—more than 6,700 hands by 84 pairs in Phase I and Phase II and more than 1,600 hands by 42 four-player-groups in Phase III.

Although analyzing groups in a clearly defined routine-development task only captures some of the features of a real-world setting, our experiment serves as an important step towards generating an improved understanding of the characteristic qualities of dynamic capabilities following an environmental change. Weber and Camerer (2003: 404) correctly highlight that "*while experiments often seem to be overly simplified recreations of complicated real-world phenomena, using them can help get a handle on the basic processes underlying these phenomena.*" Our novel experimental design intends to make a fundamental contribution to the literature on dynamic capabilities in a field which has, thus far, widely neglected the use of experiments (cf. Croson et al. 2007).

DATA AND METHODS

Laboratory Experiment

Experimental design, data collection and analyses. Our experiment is based on the study of Cohen and Bacdayan (1994) who used a card game, "Target the Two", to analyze organizational routines in a laboratory setting. The card game is widely considered to be suitable for studying routines (e.g., Egidi and Narduzzo 1997), and thus appeared to be suitable for studying dynamic capabilities that govern adjustments in operating routines through learning and

modification (e.g., Zollo and Winter 2002), too. We designed an extended four-player design of the "Target the Two" game to explore the characteristic qualities of dynamic capabilities.

In the original version developed by Cohen and Bacdayan (1994), "Target the Two" is played by two participants and involves a total of six cards (2♥, 3♥, 4♥ and 2♣, 3♣, 4♣). The goal of the game is to place the 2♥ in the target position on the playing board. The less time and the fewer moves required to achieve this objective, the greater the reward for the pair of players who are awarded a fixed payoff per completed hand. As the relative pairs are rewarded as a team instead of on an individual basis, the participants have an incentive to cooperate. Each player is assigned a personal card, which cannot be observed by the other person. The remaining cards are on the board, with two lying face-down and two lying face-up. One of the face-up cards occupies the target position. For this position, a special rule applies, which differs according to the role the relative player represents: one of the players (called Numberkeeper) can only exchange his card with the one in the target position if his personal card has the same number as the one in the target position; the other player (Colorkeeper) is only allowed to exchange his personal card with that in the target position if the two cards are of the same suit. The players alternately exchange their personal card with one of the cards on the board until the hand is completed—i.e., until 2♥ is in the target position.

Our experimental design included two sessions encompassing three phases.

Insert Figure 1 about here

Because "Target the Two" is suitable for routinizing a group's problem-solving behavior (Cohen and Bacdayan 1994), we used Cohen and Bacdayan's (1994) card game for our study. In our first session, we instructed the participants to play two 40-minute sessions (Phase I and Phase

II). Specifically, in Phase I, we instructed our participants to play up to 40 hands of "Target the Two", and hence their problem-solving behavior became routinized. Thereafter, participants had a ten-minute break. Upon their return for Phase II, we then instructed our participants—without prior warning—to change their roles and informed them that the goal of the game was to put 2♣ in the target position (rather than 2♥) (this procedure corresponds to the novelty manipulation by Cohen and Bacdayan 1994). We implemented this novelty manipulation because we aimed at assessing groups' degrees of dynamic capability; we created a situation that challenged participants' understandings of the structure of the card game and, simultaneously, their capacity to identify appropriate procedures following a change in the environment. The treatment only occurred after Phase II, and hence all participants conducted the same task under identical circumstances in Phase I and Phase II. In the second session (Phase III), we implemented the second novelty manipulation to contrast the capacity of high vs. low dynamic capability groups to create new routines in response to an "environmental change". We merged the pairs, resulting in groups of four persons who were asked to play the card game once again. At this point, groups exhibiting a high degree of dynamic capability and groups exhibiting a low degree of dynamic capability were merged. Thus, whereas the first novelty manipulation was implemented to determine the dynamic capability degree, the second novelty manipulation included the actual formation of high vs. low dynamic capability groups to enable the observation of the characteristic qualities of dynamic capabilities.

From a more technical perspective, the novelty manipulations were not only characterized by differences, but also by some similarities. The two novelty manipulations that we used differed because, in the second novelty manipulation, we introduced a new game structure by merging the pairs of players to four-player groups and by extending the card game to a four-player version by introducing two additional cards (how we extended the card game will be

described in more detail below). However, the incentive scheme in both the second novelty manipulation and the first one were similar: in both experimental conditions, participants were urged to play quickly and, simultaneously, to avoid unnecessary moves in completing the hands they played. On a closely related note, similarities were present because the different rules for Colorkeeper and Numberkeeper were maintained for the second novelty manipulation in Phase III. However, the potential of dividing labor was enhanced by the second novelty manipulation because there were four (instead of two) players in the game, which, in turn, increased the importance of coordinating action between the multiple players. Accordingly, by implementing the second novelty manipulation, again, we disrupted the activity patterns of our participants who, in the first session, learned to jointly solve the task as a two-player group but subsequent to the second novelty manipulation had to modify their procedures to coordinate their actions in the four-player group (i.e., they had to create a new set of routines). Thus, similar to the changes that were implemented as part of the first novelty manipulation, the additional complexity introduced by the two additional cards in Phase III required that the groups of players had to identify appropriate procedures and to modify their joint operating routines to solve the task.

Participants' information and procedure. In both sessions, on their arrival in the computer room, participants were placed behind the computers. Passwords were then distributed to all participants, before they were instructed to log on to the computers. Thereafter, all participants completed a computerized training that consisted of reading the rules of the game and being led through an example hand of "Target the Two". To account for speed differences in learning, participants were instructed to control the speed themselves. After all participants had completed this part of the training, they were allowed to ask questions publicly. Pretests revealed that certain questions appeared regularly. Therefore, these aspects were always repeated irrespective of the questions asked by the participants. Consequently, information presented to

participants was identical in all sessions. During the first part of the training, participants were informed of their roles in "Target the Two" (i.e., being the Colorkeeper or Numberkeeper). Printed rules appearing on-screen reflected the respective roles, which had been assigned randomly by the experimenter beforehand. Participants were not informed about the research question underlying the experiments for the purpose of avoiding influences on their behavior.

Subsequent to the training, the experimenter distributed rule cards that reflected the respective role and summarized the rule of this role. Then, the experimenter centrally started the computer game. On each screen, cards were displayed in the same order—each participant could see his personal card at the bottom, whereas the partners' cards were displayed at the top.

Participants were strongly urged not to communicate when playing the card game; communication was only allowed during the break. In Phase II, after the break, our participants again played 40 hands of "Target the Two" with the same partner. Because the rules in general remained unchanged and participants only had to change their roles and follow a different, but similar goal, we implemented no training for Phase II. Instead, these changes appeared in a brief introductory text on screen.

In both sessions, the time required to finish the game varied from team to team depending on the speed of the respective players. Upon completion of Phase III, participants were debriefed and thanked. Participants were paid their winnings in cash (M = 29.45 Euro, SD = 1.33) shortly after Phase III. Because payment was partially variable, basic data analyses contributed to determining the amount to be paid.

Measures

Independent measure. Although few quantitative studies of dynamic capabilities exist in the literature (e.g., Drnevich and Kriauciunas 2011; Heimeriks et al. 2012), the measures these studies use are not suitable for laboratory data. For our experimental method, we assessed the

independent variable, *dynamic capability*, based on behavioral data rather than on self-assessments, thereby avoiding potential biases and acknowledging the tacit dimension of dynamic capabilities (Dosi et al. 2000). Specifically, we introduced the novelty manipulation during Phase II with the sole purpose of determining the dynamic capability degree.[2] Zollo and Winter (2002: 340) highlight that "*dynamic capabilities arise from learning [and that] they constitute the firm's systematic methods for modifying operating routines*." In line with this definition, due to the novelty of the task, participants needed to adjust their operating routines through learning and modifying procedures. For example, because players changed their roles from Colorkeeper to Numberkeeper or vice versa, each player had to individually learn to cope with the rules of the new role and to modify the operating routines accordingly. Additionally, because the ultimate object of the game changed from placing 2♥ to placing 2♣ in the target position, the pairs of players had to modify their joint operating routines to solve the task. Jointly, the number of hands completed and the number of moves per hand required to respond to the novel situation translated into winnings or "money gained". In other words, the lower the number of hands and moves per hand following the novelty manipulation, the greater "improved effectiveness" in Zollo and Winter's (2002) terminology. We used "money gained" during Phase II to reflect "improved effectivenes" and determine the degree of dynamic capability, thereby deducing the degree of dynamic capability from the presence of consequences that theory regularly attributes to dynamic capabilities.[3] We employed a median split (cf. Dijksterhuis et al. 2009) of money gained in Phase II to determine whether groups fell into the high or low dynamic capability condition for Phase III. The degree of dynamic capability was dummy coded (*0 = low degree of dynamic capability*; *1 = high degree of dynamic capability*). Participants did not receive feedback on how their group had performed relative to other groups.

One might wonder why our operationalization focuses on "money gained" following the (first) novelty manipulation. Ignoring the winnings prior to the novelty manipulation means that our measure cannot directly differentiate, for example, between groups that constantly behaved exceedingly well and groups that improved in terms of "money gained" (or suffered less) in the novel situation.[4] However, in line with the Cohen and Bacdayan (1994) design, Phase I aims to routinize groups' problem-solving behavior in the game. After having routinized participants' behavior, our design intendedly manipulates the game to identify the degree of dynamic capability. While involving winnings of Phase I might be valuable to see whether groups in the high dynamic capability condition showed a higher capacity to cope with the environmental change (Teece et al. 1997) induced by the first novelty manipulation (i.e., to see whether they suffered less in terms of "money gained"), we are confident that our operationalization is suitable because ex-post analyses show that our operationalization (indirectly) reflects the fact that high vs. low dynamic capability groups differed with respect to the degree to which their winnings suffered from the first novelty manipulation. Based on a repeated measures analysis of variance, confirming common understandings in the literature (e.g., Eisenhardt and Martin 2000; Teece et al. 1997), we found that groups in the high dynamic capability condition showed a higher capacity to cope with the novel situation than groups in the low dynamic capability condition.[5]

In our study, we did the following to address the tautology issue (e.g., Pavlou and El Sawy 2011; Williamson 1999; Zott 2003). First, as mentioned, following Zollo and Winter's (2002) conceptualization, our analyses focus on "process improvement" instead of "performance" (Helfat et al. 2007: 3). Second, we are sensitive to the notion of tautology per the design of the experiment in three ways. As we define dynamic capabilities to pertain to learning and modifying operating routines (Zollo and Winter 2002), our study relies on a *behavioral* instead of a subjective performance measure that focuses on the period subsequent to the novelty

manipulation to assess participants' responses to the novel situation. Operationalizing dynamic capabilities in terms of "money gained" in Phase II, our measure reflects the capacity to "*play quickly in order to increase the number of hands completed"* and "*to play carefully in order to avoid unnecessary moves in completing each hand"* (Cohen and Bacdayan 1994: 560) despite the novel situation. As such, our measure reflects a combination of the speed and sophistication of moves (i.e., efficiency and effectiveness) following an environmental change, thereby considering different aspects of the behavioral data that we collected. Moreover, the tautology issue is addressed by the fact that groups were identified as more or less capable by a different manipulation (Phase II) than the subsequent manipulation that we used as a basis for our analyses of the characteristic qualities of dynamic capabilities (Phase III). Third, "money gained"—which in Zollo and Winter's terminology is called "improved effectiveness"—has a very specific meaning (cf. Helfat and Winter 2011). Our experimental design ensures that any implication of "money gained" is merely a consequence of and representative for participants seeking improved efficiency and effectiveness in solving the card game. In other words, modifying operating routines for improved effectiveness may or may *not* have performance implications but does have cost and benefit implications. Fourth, while ex-post analyses showed that groups in the high dynamic capability condition demonstrated a higher capacity to cope with the novel situation, some groups in the low dynamic capability condition increased their winnings. These findings address Arend and Bromiley's (2009: 79) concern which stipulates that *"If poor performing firms cannot have dynamic capabilities, the dynamic capability view risks tautology"*.

Dependent measures. First, we measured money gained in the second session—i.e., subsequent to the second novelty manipulation in Phase III. In Phase III, each group of players was awarded one Euro per completed hand less five Cents per move needed to put the 2♥ in the target position. Consequently, the reward for each group of players depended on speed as well as

on the sophistication of moves. To shed light on the reasons why "money gained" varied between the experimental conditions, we additionally analyzed routineness in Phase III.

There is a broad consensus in the literature that organizational routines help to explain organizational behavior and particularly change (cf. Becker et al. 2005). Therefore, it is not surprising that dynamic capabilities research frequently relates to or even emphasizes the importance of routines (e.g., Di Stefano et al. 2010; Zollo and Winter 2002). As Zollo and Winter (2002: 340) define dynamic capability as "*a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness"*, they accompany the (joint) modification of operating routines. In our study, using the second novelty manipulation, we implemented an environmental change with which our participants jointly had to cope in the second session. Thus, in contrast to Cohen and Bacdayan (1994), we address the issue of coordinated behavior in a changing, not stable, environment. More specifically, we created a situation that challenged participants' capacity to identify appropriate procedures following a change in the environment and that required (joint) modification of operating routines. In both the two- and the four-player versions, there were several hundred "*legal ways to deal the cards in the game"* (Cohen and Bacdayan 1994: 559), and accordingly, there were innumerable possibilities for routine development and adjustments. We empirically identified the characteristic qualities of dynamic capabilities following the second novelty manipulation (i.e., in a situation where new routines had to be created by the four-player groups). To provide an extensive assessment of the adjustment of routines, we relied on the four indicators of organizational routinization suggested by Cohen and Bacdayan (1994): (1) reliability, (2) speed, (3) repeated action sequences and (4) occasional suboptimality.[6] The four indicators were analyzed as described in the study performed

by Cohen and Bacdayan (1994) such that we were able to observe in what way routine modification processes differ between high and low dynamic capability groups.

For the first part of our experiment, we used the original version of "Target the Two". For standardization and efficiency reasons, we switched to a computerized version of the game, which was programmed as a client-server-solution. For the second part of our study, a four-player-version had to be developed. For comparability reasons, we attempted to expand the game by making as few modifications as possible. By introducing two additional cards (A♥ and A♣), we avoided modifications of the rules and changes in the roles of the relative players. Only the terms under which a hand was regarded as completed had been amended proportionally. Specifically, the computer program considered a hand as failed and continued with the next hand when the number of moves made by a group of players exceeded 40 (instead of 20) or when the "pass" button was clicked more than eight times (instead of four times) in succession. Furthermore, we revised the initial card distributions for the second session. For comparability reasons, we based our initial card distributions for the four-player version on the original initial card distributions of the two-player version of the game (Cohen and Bacdayan 1994). Specifically, we rebuilt the low (high) difficulty hands (Egidi 1996) in the two-player version as low (high) difficulty hands in the four-player version (i.e., if a hand was a low difficulty hand in the two-player version, in general, it was also a low difficulty hand in the four-player version). The ace was occasionally placed in the target position instead of the 3 and 4. We ensured that the sub-goal logic (Egidi 1996) remained unchanged, i.e., A♣ only replaced 3♣ or 4♣ and A♥ only replaced 3♥ and 4♥. If the key cards for solving the game (2♥ or 2♣) were in the up or down positions in the two-player version, we left them in these positions for the four-player version. If these cards were in the hands of Colorkeeper or Numberkeeper in the two-player version, we left them in the hands of the Colorkeeper (1 or 2) or in the hands of the Numberkeeper (1 or 2),

respectively. In line with Cohen and Bacdayan (1994), we repeated some of the initial card distributions to enable comparisons of play between early and late hands in Phase III. Due to such replications, the general rules for determining the initial card distributions (e.g., leaving 2♥ or 2♣ in the same positions as in the two-player version) did not apply to hands 16 to 20 and to hands 36 to 40 (which were equivalent to hands 1 to 5 and hands 21 to 25).

Sample

Participants in our study were recruited using the software ORSEE (Greiner 2004). A total of 168 participants participated in both the first and the second session of our study. The sample consisted of 112 men (66.7%) and 56 women (33.3%), with age ranging from 18 to 35 and a mean age of 21.98 years (SD = 2.56). Participants were randomly assigned to groups in the first session, in which there were 101 groups consisting of two members each (some participants did not appear for the second session, and hence they and their group members were not included in the final sample of N = 168). In the second session, based on their degree of dynamic capability, groups were merged into groups of four members, resulting in 21 groups exhibiting a high degree of dynamic capability and 21 groups exhibiting a low degree of dynamic capability.

EXPERIMENTAL RESULTS

Evidence that Dynamic Capabilities Positively Influence "Money Gained"

We began by analyzing the relationship between dynamic capabilities and "money gained". Our findings showed that dynamic capability positively influenced "money gained" (ρ = .42, p < .01, one-tailed). The high dynamic capability groups (M = 2,201.43 cents, SD = 165.61) generated 4.16% higher profits on average than the low dynamic capability groups (M = 2,113.57 cents, SD = 112.39), $t(40) = -2.01$, p = .05. These findings suggest that, relative to the low dynamic capability groups, the high dynamic capability groups were better able to cope with

the novel situation; and thus, these findings illustrate that the differences with respect to "money gained" identified in the first manipulation are persistent after the second manipulation.

Characteristic Qualities of Dynamic Capabilities

Thereafter, to better understand the persistent differences in "money gained" and, thus, to empirically identify the characteristic qualities associated with dynamic capabilities, we analyzed differences in the number of moves required to solve the game in Phase III. To conduct these more fine-grained analyses, we used the four indicators of organizational routinization (Cohen and Bacdayan 1994) to compare high and low dynamic capability groups.[7] Our findings reveal the following four characteristic qualities of dynamic capabilities: (a) more efficient use of resources, (b) efficiency of coordination, (c) more appropriate use of action sequences, and (d) greater deliberation in action.

More efficient use of resources. To examine whether groups in the high vs. low dynamic capability conditions differed in the use of resources, we performed *t*-tests comparing the average number of moves required to complete the 40 hands of the card game in Phase III. The average number of moves represents the degree to which groups, in playing the card game, made efficient use of resources (Garapin and Hollard 1999). Groups in the high dynamic capability condition ($M = 354.00$, $SD = 20.18$) required fewer moves on average than groups in the low dynamic capability condition ($M = 376.33$, $SD = 21.42$), $t(40) = 3.48$, $p < .01$. This finding suggests that groups in the high dynamic capability condition used resources more efficiently than groups in the low dynamic capability condition.

Efficiency of coordination. To study potential differences between groups in the high vs. low dynamic capability conditions regarding the efficiency of coordination (Garapin and Hollard 1999), we began by assessing "reliability", or "*the increased ability of the [groups] to produce an acceptable result"* (Cohen and Bacdayan 1994: 558). In line with Cohen and

Bacdayan (1994), we analyzed the variation across groups in the number of moves required to complete a hand. Specifically, we analyzed whether the three-quartile range of moves-per-hand required decreased over the course of the game in Phase III by estimating regressions with hand number as the independent variable and the three-quartile range of moves per hand required as the dependent variable. In the high dynamic capability condition, we observed that, over the course of the 40 hands in Phase III, the number of moves per hand required by the best four-player group and by the seventeenth best group[8] became increasingly similar. The regression indicated a decrease of approximately 0.12 moves per hand, $t = -3.05$, $p < .01$, $R^2 = 0.20$. In contrast, in the low dynamic capability condition, we did not observe that the number of moves per hand required by the best four-player group and by the seventeenth best group became increasingly similar. Instead, the decrease of 0.04 moves per hand was not significant, $t = -0.49$, *ns*, $R^2 = 0.01$. To control for difficulty with respect to different initial card distributions, in line with Cohen and Bacdayan (1994), we compared the three-quartile-range of moves per hand required for five hands that occurred at the beginning of the game in Phase III and were replicated 25 hands later. In the high dynamic capability condition, we found that the mean of the range was 5.20 moves for the five hands that occurred at the beginning of the game and -1.00 moves when the identical initial card distributions recurred 25 hands later. In the low dynamic capability condition, we observed that the mean of the range was 4.20 moves for the early set of hands but 3.20 moves when the set of hands reoccurred. Thus, in the high dynamic capability condition, the three-quartile range of moves per hand required decreased substantially, indicating that groups in the high dynamic capability condition became more reliable in executing the task over the course of the game. The negative value for the range of moves per hand required for the second occurrence suggests that the seventeenth best group on average used slightly fewer moves than the best group when the set of hands reoccurred. Such strong increasing reliability was not

observed in the low dynamic capability condition, where the three-quartile range of moves per hand required only slightly decreased. These findings indicate that, in contrast to groups in the low dynamic capability condition, groups in the high dynamic capability condition displayed an increasing efficiency of coordination (Garapin and Hollard 1999).

More appropriate use of action sequences. To analyze the degree to which groups in the high vs. low dynamic capability condition rely on previously established action patterns, we analyzed "repeated action sequences". Cohen and Bacdayan (1994) argue that the formation of routines is reflected in the repeated use of action patterns over time. Similarly, Gersick and Hackman (1990: 69) note that a "*routine exists when a group repeatedly exhibits a functionally similar pattern of behavior"*. As dynamic capabilities represent the adjustment of ordinary routines, one would generally expect that high vs. low dynamic capability groups differ in the degree to which they rely on repeated action sequences. Analyzing repeated action sequences in high vs. low dynamic capability groups in Phase III of our experiment therefore sheds light on differences with respect to the behavioral patterns used in solving the card game following an environmental change.

Because our data were based on groups of four (rather than two) players and because there were more cards in the game, action patterns other than the "up-up-anything-target" sequence (Cohen and Bacdayan 1994) emerged. In our study, one such prevalent action pattern was a sequence to which we refer as "anything-up-pass-pass-pass-target" (*UPPPT). "Anything" indicates that this sequence was used to complete a hand and that any or no moves were made before UPPPT was used to complete a hand. The action pattern begins with one of the four players making an exchange with the (nontarget) face-up card on the board. The other three players then subsequently pass, thus consciously staying out of the game, before the hand is completed by an exchange with the target area. Thus, a player picks up a key card (i.e., 2♥ for

the Colorkeepers or 2♣ for the Numberkeepers) that is known and available in the up area of the board, the other players recognize that this player has the key card in his hand and they pass to allow the hand to be completed as quickly as possible.

There were a number of observations related to the use of specific sequences. First, the *UPPPT sequence occurred 618 times across the 1,675 hands, 288 times in the high dynamic capability condition and 330 times in the low dynamic capability condition. The average number of uses of this action sequence per group was significantly lower in the high ($M = 13.71$, $SD = 2.76$) than in the low dynamic capability condition ($M = 15.71$, $SD = 2.61$), $t(40) = 2.41$, $p < .05$. Second, when verifying whether groups in the high dynamic capability condition rely less on repeating action sequences multiple times, our data revealed that a total of 308 action sequences were only used once in the high dynamic capability condition vs. 416 action sequences in the low dynamic capability condition. Groups in the high dynamic capability condition ($M = 34.81$, $SD = 2.32$), on average, used significantly fewer sequences to solve the 40 hands than groups in the low dynamic capability condition ($M = 36.43$, $SD = 2.18$), $t(40) = 2.33$, $p < .05$. Thus, in contrast to groups in the low dynamic capability condition, groups in the high dynamic capability condition relied less on repeating the *UPPPT sequence and used a smaller set of action sequences only once.

This finding is notable because, at first glance and considered in isolation, using a smaller set of action sequences only once appears somewhat surprising: one might expect that, in the novel situation, dynamic capabilities would increase the likelihood that the groups can adapt their procedures, resulting in a greater variety of action sequences (Zollo and Winter 2002). However, having previously noted that groups in the high dynamic capability condition made more efficient use of resources, the reason that such groups also used smaller sets of action sequences, we deduce, is that they were more aware when relying on repeated action patterns was

appropriate (instead of implying a restricted capacity to modify operating routines). Thus, based on our findings, we suggest that groups in the high dynamic capability condition rely less on repeating action sequences, i.e., routinize less, but when they vary they tend to rely on more appropriate sequences.

Greater deliberation in action. To compare whether groups engage in action with full deliberation, we assessed the degree to which groups in the high vs. low dynamic capability condition are subject to "suboptimality". Occasional suboptimality refers to situations in which groups apply the behavior they have learned without considering alternative action sequences. Failing to recognize solutions that are superior to routinized behavior suggests that action occurs without full deliberation (Cohen and Bacdayan 1994; Gersick and Hackman 1990).

To analyze occasional suboptimality, we correlated the number of uses of the frequently observed action sequence with the average number of moves used in completing the 40 hands (Cohen and Bacdayan 1994). As repeated action sequences are expected to be related to occasional suboptimality, the number of *UPPPT uses should be positively related to the average number of moves used in completing the 40 hands. In the high dynamic capability condition, such a relationship was not observed: the number of *UPPPT uses was not significantly related to the average number of moves used to resolve the 40 hands ($\rho = .30$, *ns*, two-tailed). In contrast, in the low dynamic capability condition, we found a significant, positive relationship between the number of uses of *UPPPT and the average number of moves used to resolve the 40 hands ($\rho = .56$, $p < .01$, two-tailed), indicating suboptimality as expected.

To further examine occasional suboptimality, we analyzed the moves made in a specific situation. Specifically, we analyzed hand 32 in detail because hand 32 was a low-difficulty hand (Egidi 1996). Because 2♣ was in the target position, the remaining problem was for the Numberkeepers to obtain the 2♥ in their hands and place it in the target position. If the

Colorkeepers stayed out of the game and did not interfere, the Numberkeepers found the 2♥ either on the first search of a card lying face down (finishing in seven moves) or on the second search (finishing in eight moves). The best play was for the Colorkeepers to pass to ensure that they did not run the risk of receiving 2♥ in their hand, thereby requiring passing it to the Numberkeepers at the cost of several extra moves. In the low dynamic capability condition, in only one of the 21 four-player groups (i.e., 4.76%) did all four players make optimal initial moves—i.e., only in one of the 21 groups did both Colorkeepers pass and both Numberkeepers search for the key card 2♥. Furthermore, in only one of the 21 groups (i.e., 4.76%) did at least the Colorkeepers make the optimal initial moves. In contrast, in the high dynamic capability condition, in four of the 21 groups (i.e., 19.05%), all four players made the optimal initial moves, and in five of the 21 groups (i.e., 23.81%), at least the Colorkeepers made the optimal initial moves. Thus, the number of groups behaving in an optimal manner was clearly higher in the high than in the low dynamic capability condition. These findings indicate that, in contrast to low dynamic capability groups, groups in the high dynamic capability condition appear less prone to fall prey to "occasional suboptimality", i.e., the negative side of routine development. This implies that groups in the high dynamic capability condition exhibited greater deliberation in action (i.e., more mindful behavior) than groups in the low dynamic capability condition.

Additional Analyses: Alternative Mechanisms Potentially Influencing Observed Patterns

To verify whether the identified characteristic qualities of dynamic capabilities could possibly be explained by other factors, we performed additional analyses. First, we examined whether groups performed the task of playing 40 hands of the card game with increasing "speed". To do so, we followed Cohen and Bacdayan (1994) and estimated regressions with the hand number as the independent variable and the average move time per hand as the dependent variable. We found that, with each added hand of experience, the speed of the four-player groups

improved in both the high (b = -0.04 seconds per hand, t = -9.06, $p < .001$) and low dynamic capability conditions (b = -0.05 seconds per hand, t = -14.17, $p < .001$). Thus, our results suggest that dynamic capabilities do not manifest in speed differences.

Second, we performed various individual-level analyses. Specifically, we tested for mean differences in specific socio-demographic variables, work motivation, and the Big Five personality traits. These data were collected via questionnaire after the completion of the game in Phase III.[9, 10] *T*-tests revealed that participants in the high vs. low dynamic capability conditions did not differ in sex, $t(166) = 0.33$, *ns*, age, $t(166) = -0.39$, *ns*, or professional experience, $t(165) = 0.06$, *ns*. Similarly, we observed no differences in intrinsic work motivation (i.e., the mean of the challenge and enjoyment scales), $t(166) = 0.70$, *ns*. However, participants in the high dynamic capability condition were significantly less extrinsically motivated than groups in the low dynamic capability condition, $t(157.49) = 2.08$, $p < .05$.[11] As we operationalized dynamic capabilities in such a way that groups in the high dynamic capability condition were the groups that achieved higher levels of "money gained" in Phase II of the card game, one might argue that—if extrinsic work motivation influenced our results at all—it presumably attenuated the differences between the groups in the high vs. low dynamic capability conditions rather than inflating them. Additionally, one might argue that the observations based on the subscales for extrinsic work motivation (compensation: $t(160.47) = 1.08$, *ns*; outward: $t(166) = 1.92$, *ns*) that revealed no differences between participants in the low vs. high dynamic capability conditions are more precise. Finally, we observed no significant differences between the participants in the two experimental conditions on extraversion, $t(166) = 0.36$, *ns*, agreeableness, $t(166) = -1.29$, *ns*, conscientiousness, $t(166) = 1.29$, *ns,* and neuroticism, $t(166) = 0.83$, *ns*. However, we observed a significant difference on the openness to experience scale, $t(166) = 2.17$, $p < .05$, indicating that participants in the low dynamic capability condition were

more open than participants in the high dynamic capability condition.[12] As participants in the low dynamic capability condition presented a higher average value for openness to experience, one might again argue that—if openness to experience influenced our results at all—it presumably attenuated the differences rather than inflating them.

Moreover, we performed post-hoc analyses to examine to what degree groups that exhibited a strong financial payoff in terms of "money gained" in response to the first novelty manipulation exhibited a high level of routine driven behavior. To that end, we ex-post assigned the two-player groups to the high vs. low dynamic capability conditions and reran our analyses for the characteristic qualities of dynamic capabilities based on the data for Phase II. These post-hoc analyses generally tended to confirm our results except for "greater deliberation in action". That is, our post-hoc analyses indicate that high dynamic capability groups exhibited a high level of routine driven behavior in Phase II. Given this high level of routine driven behavior, one might argue that the necessity to "learn" and to "modify" procedures was even more pronounced for high than for low dynamic capability groups in Phase III (note that the new game structure introduced in Phase III required that our participants had to create a *new* set of routines).

DISCUSSION

Despite the prominence of the dynamic capabilities construct, we lack an empirically grounded understanding. We use an extended version of the Cohen and Bacdayan (1994) card game to induce dynamic capabilities in the laboratory. Relying on Zollo and Winter's (2002) conceptualization, which specifies a "modifying" type of dynamic capability that centers around behavioral patterns that adjust operating routines, our core contribution is to empirically identify characteristic qualities of dynamic capabilities.

Our study offers four key findings. First, our findings provide support for the notion that dynamic capabilities pertain to the use of resources (Amit and Schoemaker 1993; Makadok

2001). In our study, groups in the high dynamic capability condition make more efficient use of resources—i.e., they require fewer moves to solve the hands they play than groups in the low dynamic capability condition (Garapin and Hollard 1999). Also referred to as the "capability-building mechanism" (Makadok 2001), the use of resources is a key determinant of firm heterogeneity and growth (Penrose 1959). The use of resources is regarded as an instrument to generate isolating mechanisms (Rugman and Alain 2002). Thus, as the firm's resource base is an important element of the dynamic capabilities definition (Helfat et al. 2007), the efficient deployment of such resources is a characteristic quality of dynamic capabilities.

A second characteristic quality of dynamic capabilities is an improved capacity to efficiently coordinate action over time. In contrast to low dynamic capability groups, high dynamic capability groups increase their capacity to produce an acceptable result during the task (Cohen and Bacdayan 1994; Garapin and Hollard 1999). This finding seems to relate to what is referred to as the "coordination function" managers perform (Barnard 1938; Richardson 1960); through coordination assets can be more or less optimally orchestrated following environmental change (e.g., Burgelman 1994). Furthermore, this quality appears to demonstrate that action patterns internal to the organization help explain why firms evolve differently (cf. Helfat and Peteraf 2003): "random walks" critically shape evolution and adaptation such that sustained firm heterogeneity is likely even with no a priori differences (Denrell 2004). In general, "efficiency of coordination" relates to the principle that action patterns themselves can be drivers of both stability and change (Feldman and Pentland 2003).

Third, our findings suggest that dynamic capabilities are associated with relying on more appropriate action patterns. In our study, groups in the high dynamic capability condition not only rely on a smaller set of action sequences but also rely less on repeating parts of action sequences multiple times. Interestingly, while prior research notes that dynamic capabilities

increase the likelihood that actors can modify operating routines (e.g., Zollo and Winter 2002), our results appear to nuance this logic: groups in the high dynamic capability condition rely on a smaller set of repeated action sequences in the novel situation relative to groups in the low dynamic capability condition. This implies that the high dynamic capability groups are more selective in both repetition, i.e., the number of action patterns used, and variation, i.e., the alternative courses of action they explore. Selecting appropriate "component elements" to suit the environment following disruptive change could be one way in which high dynamic capability groups foster "positive transfer" (Singley and Anderson 1989). In other words, high dynamic capability groups rely on a small set of existing action patterns when appropriate and vary selectively to avoid negative transfer. Future research on dynamic capabilities could analyze component elements of organizational processes to uncover which facets of the organization are best kept stable and which can best be altered in the case of disruptive change. Moreover, what organizational mechanisms, akin to individual members (Cohen and Bacdayan 1994), are likely to yield suboptimal action patterns in light of disruptive change?

Fourth, greater deliberation in action, which is reflected in less repetition for repetition's sake, is the last characteristic quality of dynamic capabilities. Groups in the high dynamic capability condition avoid "suboptimality" as they are more cautious in applying learned behavior. Deliberateness pertains to purposeful and attentive action and is a characteristic quality of dynamic capabilities (cf. Dosi et al. 2000). This finding relates to the role of habit (Cohen 2007; Dewey 1922) and mindfulness in complex activities (Levinthal and Rerup 2006). Scholars vary in the degree to which they associate dynamic capabilities with deliberateness: some suggest that the adoption of resources occurs deliberately (e.g., Helfat et al. 2007), while others make no reference (e.g., López 2005) or emphasize environmental selection (e.g., Nelson and Winter 1982). Our finding suggests that dynamic capabilities relate to the capacity to overcome the

downsides of "habit". These insights shed important light on the balancing of habit and deliberation in complex decision making (Winter 2013). It would be interesting for future work to explore personal attributes that amplify or reduce the likelihood of selecting optimal action sequences in volatile contexts. Advancing our understanding of the role of "agency" in explaining firm heterogeneity (e.g., Augier and Teece 2009), such work could extend emerging neuro- and microfoundational work on ambidexterity (Laureiro-Martínez et al. 2015).

As our empirics help identify though not directly measure dynamic capabilities, our findings might inform future work which explores specific characteristic qualities of dynamic capabilities. More specifically, it would be interesting if future research could actually measure some of the stable characteristics of dynamic capabilities identified in our experiment. While we report certain characteristic qualities that enable groups to form new operating routines under changing circumstances, what do characteristic qualities of dynamic capabilities look like in specific empirical contexts? Do different types of dynamic capabilities exhibit similar characteristic qualities or do they display distinct characteristic qualities?

Because our study has important theoretical implications, establishing the extent to which our findings are generalizable requires further research. Specifically, it would be interesting to determine whether our results are robust when varying the experimental task. Conducting field experiments and using a variety of real-world business processes are fruitful avenues for future research. We believe such efforts will help to further advance our understanding of the degree to which the characteristic qualities of dynamic capabilities that are central to this study are influenced by other real-life contingencies.

Despite the important contributions of our study, our findings are logically bound by the methodological design. This study was designed to analyze the characteristic qualities of dynamic capabilities in a typical change situation. We merged high and low dynamic capability

groups to create a typical situation for an environmental change. In general, one might have imagined manipulations that retained the two-player version of the card game rather than implementing the merger of groups. For example, one could have changed the target card from 2♣ in Phase II to 3♥ and 3♣ (i.e., two target cards) in Phase III. This rule change could have been complemented, for instance, by extending the rules that apply for each player such that the Colorkeeper and Numberkeeper rules would not have been valid solely for the card in the target position but also for one of the other three cards on the desk. Although replicating our study using manipulations retaining the two-player version of the card game appears to be promising, the merger event that we chose represents an excellent example of a typical change situation.

We sought to contrast routine adjustments following a typical change situation for groups exhibiting a high vs. a low degree of dynamic capability. Accordingly, we merged groups with similar degrees of dynamic capability rather than merging groups with low and high degrees of dynamic capability. Merging groups with high and low degree of dynamic capability would be an interesting extension of the current study. Moreover, the modified version of "Target the Two" introduced in this study did not increase the complexity of the task in terms of the hierarchical structure of goals and sub-goals (Egidi 1996). To be able to draw causal conclusions concerning the characteristic qualities of dynamic capabilities, we had to identify an approach that allowed us to manipulate the degree of dynamic capability in a merger of groups (which is accompanied by an increase in the complexity of tasks in terms of coordination) while holding everything else constant. Changing other variables or characteristics of the task would have resulted in confounding effects, thereby diminishing the benefits of the high internal validity accompanying such a laboratory experiment. Further research is required to conduct experiments manipulating the complexity of tasks to additionally analyze this typical characteristic of mergers. Furthermore, our experimental design implicitly relies on relatively high levels of

discretion. In reality, dynamic capabilities do not occur in a vacuum but are instead subject to executive intervention from high authority levels in the organization (Barreto 2010). Thus, although our experimental paradigm is consistent with much of the work in the dynamic capabilities domain (Helfat et al. 2007), future work could expand on the influence of individuals at higher levels in the organization on the plasticity of dynamic capabilities at lower levels of the organization, only the last of which was studied in this experiment.

CONCLUSION

With dynamic capabilities emerging as a central construct in strategic management, the literature offers a flurry of conceptualizations of dynamic capabilities. Despite a rapidly growing body of work on the topic, debates persist regarding the empirical nature of the construct. We employed an extended version of the Cohen and Bacdayan (1994) card game to study the characteristic qualities of dynamic capabilities. Building on Zollo and Winter's (2002) conceptualization, our laboratory experiment enables us to replicate the need to adjust routines among pairs of participants, recreating a typical change situation. Our findings reveal that, compared to low dynamic capability groups, high dynamic capability groups: (a) make more efficient use of resources, (b) demonstrate higher increasing efficiency of coordination, (c) demonstrate greater awareness of when relying on repeated action patterns is appropriate, and (d) display greater deliberation in action by not falling prey to the negative side of routine development. By empirically identifying the characteristic qualities that facilitate forming new operating routines in changing circumstances, we hope our findings foster conceptual and theoretical progress in this important domain.

REFERENCES

Acedo, F.J., C. Barroso, J.L. Galan. 2006. The resource-based theory: Dissemination and main trends. *Strategic Management Journal* **27**(7) 621-636.

Agarwal, R., J. Anand, J. Bercovitz, R. Croson. 2012. Spillovers across organizational architectures: The role of prior resource allocation and communication in post-acquisition coordination outcomes. *Strategic Management Journal* **33**(6) 710-733.

Amabile, T.M., K.G. Hill, B.A. Hennessey, E.M. Tighe. 1994. The work preference inventory: Assessing intrinsic and extrinsic motivational orientations. *Journal of Personality and Social Psychology* **66**(5) 950-967.

Amit, R., P.J.H. Schoemaker. 1993. Strategic assets and organizational rent. *Strategic Management Journal* **14**(1) 33-46.

Arend, R.J., P. Bromiley. 2009. Assessing the dynamic capabilities view: Spare change, everyone? *Strategic Organization* **7**(1) 75-90.

Augier, M., D.J. Teece. 2009. Dynamic capabilities and the role of managers in business strategy and economic performance. *Organization Science* **20**(2) 410-421.

Barnard, C.I. 1938. *The functions of the executive*. Harvard University Press, Cambridge.

Barreto, I. 2010. Dynamic capabilities: A review of past research and an agenda for the future. *Journal of Management* **36**(1) 256-280.

Becker, M.C. 2004. Organizational routines: A review of the literature. *Industrial and Corporate Change* **13**(4) 643-678.

Becker, M.C., N. Lazaric, R.R. Nelson, S.G. Winter. 2005. Applying organizational routines in understanding organizational change. *Industrial and Corporate Change* **14**(5) 775-791.

Berkowitz, L., E. Donnerstein. 1982. External validity is more than skin deep: Some answers to criticism of laboratory experiments. *American Psychologist* **37**(3) 245-257.

Bono, J.E., G. McNamara. 2011. Publishing in AMJ—Part 2: Research design. *Academy of Management Journal* **54**(4) 657-660.

Burgelman, R.A. 1994. Fading memories: A process theory of strategic business exit in dynamic environments. *Administrative Science Quarterly* **39**(1) 24-56.

Cohen, M.D. 1991. Individual learning and organizational routine: Emerging connections. *Organization Science* **2**(1) 135-139.

Cohen, M.D. 2007. Reading Dewey: Reflections on the study of routine. *Organization Studies* **28**(5) 773-786.

Cohen, M.D., P. Bacdayan. 1994. Organizational routines are stored as procedural memory: Evidence from a laboratory study. *Organization Science* **5**(4) 554-568.

Collis, D.J. 1994. How valuable are organizational capabilities? *Strategic Management Journal* **15**(S1) 143-152.

Croson, R., J. Anand, R. Agarwal. 2007. Using experiments in corporate strategy research. *European Management Review* **4**(3) 173-181.

D'Este, P. 2002. The distinctive patterns of capabilities accumulation and inter-firm heterogeneity: The case of the Spanish pharmaceutical industry. *Industrial and Corporate Change* **11**(4) 847-874.

Danneels, E. 2008. Organizational antecedents of second-order competences. *Strategic Management Journal* **29**(5) 519-543.

Danneels, E. 2011. Trying to become a different type of company: Dynamic capability at Smith Corona. *Strategic Management Journal* **32**(1) 1-31.

Denrell, J. 2004. Random walks and sustained competitive advantage. *Management Science* **50**(7) 922-934.

Dewey, J. 1922. *Human nature and conduct: An introduction to social psychology*. Modern Library, New York.

Di Stefano, G., M. Peteraf, G. Verona. 2010. Dynamic capabilities deconstructed: A bibliographic investigation into the origins, development, and future directions of the research domain. *Industrial and Corporate Change* **19**(4) 1187-1204.

Dijksterhuis, A., M.W. Bos, A. van der Leij, R.B. van Baaren. 2009. Predicting soccer matches after unconscious and conscious thought as a function of expertise. *Psychological Science* **20**(11) 1381-1387.

Dosi, G., R.R. Nelson, S.G. Winter. 2000. Introduction: The nature and dynamics of organizational capabilities. G. Dosi, R.R. Nelson, S.G. Winter, eds. *The nature and dynamics of organizational capabilities*. Oxford University Press, New York, 1-22.

Drnevich, P.L., A.P. Kriauciunas. 2011. Clarifying the conditions and limits of the contributions of ordinary and dynamic capabilities to relative firm performance. *Strategic Management Journal* **32**(3) 254-279.

Egidi, M. 1996. Routines, hierarchies of problems, procedural behaviour: Some evidence from experiments. K.J. Arrow, M. Perlman, C. Schmidt, eds. *The rational foundations of economic behaviour*. Palgrave Macmillan, Houndmills et al., 303-333.

Egidi, M., A. Narduzzo. 1997. The emergence of path-dependent behaviors in cooperative contexts. *International Journal of Industrial Organization* **15**(6) 677-709.

Eisenhardt, K.M., J.A. Martin. 2000. Dynamic capabilities: What are they? *Strategic Management Journal* **21**(10-11) 1105-1121.

Feldman, M.S., B.T. Pentland. 2003. Reconceptualizing organizational routines as a source of flexibility and change. *Administrative Science Quarterly* **48**(1) 94-118.

Felin, T., N.J. Foss. 2005. Strategic organization: A field in search of micro-foundations. *Strategic Organization* **3**(4) 441-455.

Galunic, D.C., K.M. Eisenhardt. 2001. Architectural innovation and modular corporate forms. *Academy of Management Journal* **44**(6) 1229-1249.

Garapin, A., M. Hollard. 1999. Routines and incentives in group tasks. *J Evol Econ* **9**(4) 465-486.

Gersick, C.J.G., J.R. Hackman. 1990. Habitual routines in task-performing groups. *Organizational Behavior and Human Decision Processes* **47**(1) 65-97.

Giudici, A., P. Reinmoeller. 2012. Dynamic capabilities in the dock: A case of reification? *Strategic Organization* **10**(4) 436-449.

Greiner, B. 2004. An online recruitment system for economic experiments. K. Kremer, V. Macho, eds. *Forschung und wissenschaftliches Rechnen 2003. GWDG Bericht 63*. Ges. für Wiss. Datenverarbeitung, Göttingen, 79-93.

Heimeriks, K.H., M. Schijven, S. Gates. 2012. Manifestations of higher-order routines: The underlying mechanisms of deliberate learning in the context of post-acquisition integration. *Academy of Management Journal* **55**(3) 703-726.

Helfat, C.E., S. Finkelstein, W. Mitchell, M.A. Peteraf, H. Singh, D.J. Teece, S.G. Winter, eds. 2007. *Dynamic capabilities: Understanding strategic change in organizations*. Blackwell Publishing, Malden et al.

Helfat, C.E., M.A. Peteraf. 2003. The dynamic resource-based view: Capability lifecycles. *Strategic Management Journal* **24**(10) 997-1010.

Helfat, C.E., M.A. Peteraf. 2009. Understanding dynamic capabilities: Progress along a developmental path. *Strategic Organization* **7**(1) 91-102.

Helfat, C.E., M.A. Peteraf. 2015. Managerial cognitive capabilities and the microfoundations of dynamic capabilities. *Strategic Management Journal* **36**(6) 831-850.

Helfat, C.E., S.G. Winter. 2011. Untangling dynamic and operational capabilities: Strategy for the (n)ever-changing world. *Strategic Management Journal* **32**(11) 1243-1250.

Howard-Grenville, J.A. 2005. The persistence of flexible organizational routines: The role of agency and organizational context. *Organization Science* **16**(6) 618-636.

Kane, A., L. Argote, L.J. M. 2005. Knowledge transfer between groups via personnel rotation: Effects of social identity and knowledge quality. *Organizational Behavior and Human Decision Processes* **96**(1) 56-71.

Katkalo, V.S., C.N. Pitelis, D.J. Teece. 2010. Introduction: On the nature and scope of dynamic capabilities. *Industrial and Corporate Change* **19**(4) 1175-1186.

Knez, M., C.F. Camerer. 1994. Creating expectational assets in the laboratory: Coordination in weakest-link games. *Strategic Management Journal* **15**(S1) 101-119.

Kor, Y.Y., A. Mesko. 2013. Dynamic managerial capabilities: Configuration and orchestration of top executives' capabilities and the firm's dominant logic. *Strategic Management Journal* **34**(2) 233-244.

Kraatz, M.S., E.J. Zajac. 2001. How organizational resources affect strategic change and performance in turbulent environments: Theory and evidence. *Organization Science* **12**(5) 632-657.

Lampel, J., J. Shamsie. 2003. Capabilities in motion: New organizational forms and the reshaping of the Hollywood movie industry. *Journal of Management Studies* **40**(8) 2189-2210.

Laureiro-Martínez, D., S. Brusoni, N. Canessa, M. Zollo. 2015. Understanding the exploration–exploitation dilemma: An fMRI study of attention control and decision-making performance. *Strategic Management Journal* **36**(3) 319-338.

Levinthal, D., C. Rerup. 2006. Crossing an apparent chasm: Bridging mindful and less-mindful perspectives on organizational learning. *Organization Science* **17**(4) 502-513.

López, S.V. 2005. Competitive advantage and strategy formulation: The key role of dynamic capabilities. *Management Decision* **43**(5) 661-669.

Makadok, R. 2001. Toward a synthesis of the resource-based and dynamic-capability views of rent creation. *Strategic Management Journal* **22**(5) 387-401.

Nelson, R.R., S.G. Winter. 1982. *An evolutionary theory of economic change*. Belknap Press of Harvard University Press, Cambridge.

Pavlou, P.A., O.A. El Sawy. 2011. Understanding the elusive black box of dynamic capabilities. *Decision Sciences* **42**(1) 239-273.

Penrose, E.T. 1959. *The theory of the growth of the firm*. Oxford University Press, Oxford.

Peteraf, M., G. Di Stefano, G. Verona. 2013. The elephant in the room of dynamic capabilities: Bringing two diverging conversations together. *Strategic Management Journal* **34**(12) 1389-1410.

Powell, W.W., K.W. Koput, L. Smith-Doerr. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly* **41**(1) 116-145.

Rammstedt, B., O.P. John. 2007. Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality* **41**(1) 203-212.

Richardson, G.B. 1960. *Information and investment: A study in the working of the competitive economy*. Oxford University Press, Oxford.

Ringelhan, S., J. Wollersheim, I.M. Welpe, M. Fiedler, M. Spörrle. 2013. Work motivation and job satisfaction as antecedents of research performance: Investigation of different mediation models. *J Bus Econ* **3**(Special Issue) 7-38.

Rugman, A.M., V. Alain. 2002. Edith Penrose's contribution to the resource-based view of strategic management. *Strategic Management Journal* **23**(8) 769-780.

Salvato, C., C. Rerup. 2011. Beyond collective entities: Multilevel research on organizational routines and capabilities. *Journal of Management* **37**(2) 468-490.

Schreyögg, G., M. Kliesch-Eberl. 2007. How dynamic can organizational capabilities be? Towards a dual-process model of capability dynamization. *Strategic Management Journal* **28**(9) 913-933.

Singley, M.K., J.R. Anderson. 1989. *The transfer of cognitive skill*. Harvard University Press, Cambridge, MA.

Slater, S.F., E.M. Olson, G.T.M. Hult. 2006. The moderating influence of strategic orientation on the strategy formation capability–performance relationship. *Strategic Management Journal* **27**(12) 1221-1231.

Teece, D.J. 2007. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal* **28**(13) 1319-1350.

Teece, D.J. 2012. Dynamic Capabilities: Routines versus Entrepreneurial Action. *Journal of Management Studies* **49**(8) 1395-1401.

Teece, D.J., G. Pisano, A. Shuen. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* **18**(7) 509-533.

Wang, C.L., P.K. Ahmed. 2007. Dynamic capabilities: A review and research agenda. *International Journal of Management Reviews* **9**(1) 31-51.

Weber, R.A., C.F. Camerer. 2003. Cultural conflict and merger failure: An experimental approach. *Management Science* **49**(4) 400-415.

Williamson, O.E. 1999. Strategy research: Governance and competence perspectives. *Strategic Management Journal* **20**(12) 1087-1108.

Winter, S.G. 2000. The satisficing principle in capability learning. *Strategic Management Journal* **21**(10-11) 981-996.

Winter, S.G. 2003. Understanding dynamic capabilities. *Strategic Management Journal* **24**(10) 991-995.

Winter, S.G. 2013. Habit, deliberation, and action: Strengthening the microfoundations of routines and capabilities. *Academy of Management Perspectives* **27**(2) 120-137.

Wollersheim, J., A. Lenz, I.M. Welpe, M. Spörrle. 2015. Me, myself, and my university: A multilevel analysis of individual and institutional determinants of academic performance. *J Bus Econ* **85**(3) 263-291.

Zahra, S.A., H.J. Sapienza, P. Davidsson. 2006. Entrepreneurship and dynamic capabilities: A review, model and research agenda. *Journal of Management Studies* **43**(4) 917-955.

Zollo, M., S.G. Winter. 2002. Deliberate learning and the evolution of dynamic capabilities. *Organization Science* **13**(3) 339-351.

Zott, C. 2003. Dynamic capabilities and the emergence of intraindustry differential firm performance: Insights from a simulation study. *Strategic Management Journal* **24**(2) 97-125.

FIGURE 1

Experimental Design and Procedure

First session
(Replication of Cohen & Bacdayan (1994))

Phase I	Break	Phase II
- Objective: Routinization of the groups' problem-solving behaviors - Means: Two-player version of the card game	10 minutes	- Objective: Assessment of the degree of dynamic capability - Means: First novelty manipulation (role switch and adjusted objective of the game)

Second session – Phase III
(New game structure, i.e., larger groups and associated game changes)

- Objective: Investigation of the characteristic qualities of dynamic capabilities
- Means: Second novelty manipulation (new groups created based on "money gained" in Phase II)

ENDNOTES

[1] Note that our study is neither tailored to address in detail how characteristic qualities of dynamic capabilities trigger strategic innovation or shift in the firm's resource base (Teece 2007) nor to how individual managerial cognitive skills translate into dynamic capabilities (e.g., Laureiro-Martinez, Brusoni, Canessa, Zollo 2015; Helfat and Peteraf 2015). We designed our study to conceptualize "capabilities" as event sequences and trace their evolution to

individual actions (Cohen and Bacdayan 1994; Helfat et al. 2007). Therefore, in line with Cohen and Bacdayan's (1994) design and in keeping with Zollo and Winter's (2002) framework, we assume bounded rational actors.

[2] We thank an anonymous reviewer for this excellent suggestion.

[3] This implies that we can empirically identify the degree of dynamic capabilities without a direct measurement.

[4] Note that the groups in the high vs. low dynamic capability conditions might have followed different learning curves: they might have (1) benefited from the novelty manipulation (i.e., an increase in "money gained" subsequent to the novelty manipulation in Phase II); (2) behaved exceedingly well (or poor) in both Phase I and Phase II (i.e., "money gained" was stable over time); (3) suffered from the novelty manipulation (i.e., a decrease in "money gained"). In general, we follow established approaches that implicitly assume that dynamic capabilities lead to sustained or improved performance (e.g., Eisenhardt and Martin 2000; Teece et al. 1997), and thus focus on the first two learning curves. However, additionally, we do not neglect that groups showing a high degree of dynamic capability follow the third learning curve. We focus on a relative rather than on an absolute measure. For example, one might imagine that although a group followed the third learning curve, it suffered less from the novelty manipulation than other groups, and thus, responded to change more successfully. According to our understanding, the relatively higher amount of "money gained" subsequent to the novelty manipulation would indicate a higher capacity to adjust routines through learning and modification, and thus, a high degree of dynamic capability.

[5] To get deeper insights into the specific learning curves, we additionally compared how many groups per experimental condition showed increased / decreased / stable winnings. To do so, we subtracted the average winnings (in terms of money gained) in hands 1 to 5 of the Phase II from the average winnings for hands 26 to 30 of Phase I and observed the frequencies of negative values, positive values, and zeros. In the high dynamic capability condition, 14 groups showed an increase in their winnings, 23 showed a decrease, and 5 showed stable winnings. In the low dynamic capability condition, 7 groups showed an increase in their winnings, 32 showed a decrease, and 3 showed stable winnings. These frequencies again suggest that, overall, groups in the high dynamic capability condition suffered less from the novelty manipulation than groups in the low dynamic capability condition did.

[6] Note that we chose these specific four indicators because our experimental design is based on Cohen and Bacdayan (1994). For an overview of alternative suggestions, see Becker (2005).

[7] Note that our findings regarding "speed" are reported in our "Additional Analyses" section.

[8] Either of two groups that required the same number of moves could have been regarded as the seventeenth best group in the high dynamic capabiliy condition. Therefore, one of them was randomly selected.

[9] Work motivation was assessed based on items from the Work Preference Inventory (Amabile et al. 1994). For each subscale of intrinsic and extrinsic work motivation, we selected the two items that loaded highest on the primary factor (for details concerning the scale that we used, see Ringelhan et al. 2013; Wollersheim et al. 2015).

[10] The Big Five personality traits were assessed using the German version of the BFI-10 (Rammstedt and John 2007).

[11] Note that after the application of Bonferroni alpha correction, this difference is not significant.

[12] Note that after the application of Bonferroni alpha correction, this difference is not significant.