OPENING THE BLACK BOX OF HETEROGENEOUS VALUE CREATION: COGNITIVE MICROFOUNDATIONS OF NOVEL AND VALUABLE SOLUTION GENERATION

by

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ABSTRACT

The field of strategic management comprises the scientific exploration of organizational heterogeneity, scope, and performance. Subsequently, the large majority of extant theory builds predictions of organization and industry level outcomes from aggregate constructs (e.g., organizational structure, resources, routines, capabilities, institutions). Emerging interest surrounding the microfoundations of strategy, however, has begun to refocus attention on important antecedent events, specifically individual psychological and cognitive processes driving firm heterogeneity, scope, and performance. Building on the problem-finding problem-solving perspective, this dissertation adopts methodologies from both psychology and neuroscience to examine cognitive processes underlying the generation of novel and valuable solutions.

Three studies exploring sources of heterogeneity in solution development are presented. The first investigates how comprehensive problem formulation and time constraints interact to determine the degree of novelty and value of complex and ill-defined strategic problems. The second study, leveraging NK landscape logic, develops a theoretical model of how affect operates to enhance the generation of value-creating solutions. Specifically, two separate cognitive mechanisms and their neurological correlates are identified, producing systematic differences in both how knowledge search and recombination unfold and the types of solutions developed. The third and final study develops and tests a set of organizational routines posited to enhance the neurological

processes of novel and valuable solution generation by overcoming the constraining effects of mental maps and heuristics.

Microfoundational research investigating the cognitive processes of value creation effectively repositions the strategist at the center of strategic management. While early research within the field directly acknowledged and explored the psychological and cognitive foundations of firm performance and competitive advantage, continued focus on aggregate constructs and phenomena has obscured important sources of heterogeneity arising from lower levels of analysis. Building on the problem-finding problem-solving framework, this dissertation increases understanding of the cognitive processes underlying novel and valuable solution generation and lays the foundation for future research investigating models of cognition within the field of strategy.

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CHAPTER 1

INTRODUCTION

The field of strategic management comprises the scientific exploration of organization- and industry-level phenomena. Subsequently, the large majority of extant theory builds predictions of organization and industry outcomes from aggregate constructs (e.g., organizational structure, resources, routines, capabilities, institutions) (Felin & Foss, 2005). While strategic management theory addresses important questions of firm behavior, heterogeneity, scope, and performance (Rumelt, Schendel, & Teece, 1994), most theories within the field are built upon a foundation of individual, psychological, and cognitive arguments. For example, in developing mobility barriers, Porter (1979) identifies risk preferences of the manager as a key determinant in the formation of strategic groups and industry structure. The resource-based view (Barney, 1986; 1991; Wernerfelt, 1984), while explicitly linking competitive advantage with underlying resource attributes, accounts for the origins of asymmetries in strategic factor markets through two mechanisms, luck and/or superior managerial expectations. Penrose (1959) explicitly highlights the importance of individual perception. Productive opportunity frontiers are posited to result from the combination/interaction of available resources and the manager's image of how those resources might be reconfigured and redeployed. Similar arguments are found in the entrepreneurship (e.g., opportunity discovery, bricolage) (Baron, 2006; Kirzner, 1997; Phillips & Tracey, 2007; Shane, 2000) and dynamic capabilities literatures. Dynamic capabilities (Teece, Pisano, & Shuen, 1997) shift the locus of competitive advantage from the isolating mechanisms of the resource-based view (RBV) to an organization's ability to dynamically integrate, build, and reconfigure existing routines. In answering the question of how value-creating capabilities are developed and selected, Teece (2007) points to organizational routines aiding individuals in the scanning and creative processes underlying capability development. Moreover, several theories within strategic management explicitly build on individual cognition and psychology, including behavioral theory (Gavetti, 2012), dominant logics (Prahalad & Bettis, 1986), attention-based view of the firm (Ocasio, 1997), and organizational learning, (e.g., Kogut & Zander, 1992; Nonaka, 1994; Zahra & George, 2002).

Despite the centrality of individual cognition within extant theory, the field of strategic management has largely failed to open the black box of the various psychological and cognitive mechanisms posited (Powell, Lovallo, & Fox, 2011). Asymmetries in risk preferences, expectations, perceptions, creativity, and knowledge creation are identified as critical predictors of strategic outcomes. Theoretical and empirical research within strategic management, however, largely provides an ex-post account of readily observed organizational-level variables providing few insights into the upstream cognitive antecedents driving firm behavior, heterogeneity, scope, and performance. The importance of disentangling the origins of heterogeneity from the subsequent outcomes cannot be overstated. Theoretical models accurately predicting empirical realties in firm- or industry-level data, by definition, fail to capture and test the underlying individual cognitive and psychological processes argued to produce the observed heterogeneity in the aggregate data. If indeed the goal of strategic management is to accurately describe organization- and industry-level phenomena and the majority of extant theory presents individual-level cognitive mechanisms as the source of heterogeneity, an explicit examination of individual psychological and cognitive mechanisms is needed.

A cogent explication of individual cognitive and psychological processes is of particular relevance in answering questions of value creation. Value is created as individuals within organizations find, frame, and formulate problems, develop novel and valuable solutions, and implement the newly developed solutions (Baer, Dirks, & Nickerson, 2013; Nickerson, Yen, & Mahoney, 2011; Teece, 2007; Volkema, 1983). As dynamic and complex environments have become more ubiquitous, processes of value creation have received increased attention among strategic management scholars (Brown & Eisenhardt, 1997; Teece, 2007). Organizations able to continuously create value (i.e., problem formulation, solution development, implementation) often enjoy superior performance and competitive advantage (Brown & Eisenhardt, 1997; Roberts, 1999). Indeed, the importance of perpetual value creation frequently outweighs that of value protection.

Developing models of value creation presents a unique challenge to scholars of strategic management. Theories of value protection, while identifying individual cognitive mechanisms central in value creation, build primarily on arguments of isolation and appropriation, allowing strategic management scholars to leverage aggregate constructs and methodologies. Nevertheless, a focus on the protection and appropriation of value conceptualizes the value-creation process as a discrete event involving loosely developed cognitive mechanisms occurring at an earlier point in time. Shifting the focal question from value protection to continuous value creation, however, necessitates a fundamental shift in both constructs and methodologies implemented. For example, individual cognitive mechanisms of preferences, expectations, perception, and creativity become increasingly salient as value creation moves from isolated past events to a perpetual and ongoing process central in determining organizational outcomes. Subsequently, individual-level theories are needed to adequately model variance arising from these distinct cognitive processes.

Recognizing the need for additional theoretical development, several scholars have begun to explore relevant microfoundations within problem-finding problem-solving (Baer et al., 2013), entrepreneurship (Felin & Zenger, 2009), dynamic capabilities (Abell, Felin, & Foss, 2008; Gavetti, 2005; Teece, 2007), and organizational learning (Felin & Hesterly, 2007) literatures. For example, highlighting the various degrees of knowledge complexity required to address a given problem, Nickerson and Zenger (2004) present a knowledge-based theory of the firm specifying "…how a manager should organize individuals to generate knowledge that the firm seeks" (p. 618). Addressing the microfoundations of the dynamic capability perspective, Teece (2007) highlights the importance of sensing and shaping opportunities and threats through organizational routines enhancing individual creativity, and learning mechanisms. Similarly, investigating the origins of novel entrepreneurial strategies, Felin and Zenger (2009) posit that experiential fragments, perception, and imagination of alternative possibilities form the upstream antecedents of value creation. Taken as a whole, this literature has advanced current understanding by highlighting the cognitive microfoundations underlying value creation. Nevertheless, the current microfoundation literature stops short of exploring and testing the actual psychological and cognitive mechanisms (i.e., experiential fragments, scanning processes, imagination, creativity), providing instead a theoretical account of their relevance and posited operation. A new set of research questions and designs emerges as focus shifts from the identification and positioning of cognitive mechanisms underlying value creation to the salient mechanisms influencing heterogeneity in the cognitive and neurological processes themselves.[1] Indeed it is surprising, given the interdisciplinary nature of strategic management, that the field has lagged behind economics, finance, and law in exploring the cognitive and neurological foundations of its central theories (Powell, 2011). As such, "until theories of firm heterogeneity fully incorporate psychology, the empirical facts will continue to frustrate our attempts to explain them, and researchers will find it impossible to integrate theory with practice" (Powell et al., 2011, p. 1377).

The following dissertation addresses this gap by directly exploring the cognitive and neurological mechanisms underlying value creation. All three papers build from a problem-finding problem-solving framework with insights from psychology and neuroscience to provide a better understanding of salient variables influencing heterogeneity in novel and valuable solution generation, a critical step in value creation and subsequent competitive advantage. While alternative theoretical lenses are available (e.g., entrepreneurship, dynamic capabilities, organizational learning), the problem-

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[1] It merits note that the focus of the strategic management literature is on explaining relationships among firms and industries. In short, the level of analysis is clearly on the organization, industry, or in some cases transaction. It is not the intent of the current work to challenge this position. It is however, the goal of this dissertation to explore the important psychological and cognitive arguments upon which these theoretical relationships are built.

finding problem-solving perspective demonstrates three distinct advantages. First, by adopting the problem as the unit of analysis, the problem-finding problem-solving approach presents a theoretical apparatus integrating individual, group, and organizational mechanisms (Nickerson & Zenger, 2004). Second, the problem-finding problem-solving approach theoretically disentangles the various stages involved in the value-creation process (Baer et al., 2013). Specifically, value is created as individuals embedded in groups and organizations find, frame, and formulate problems, develop unique and valuable solutions, and subsequently implement the newly developed solutions. The distinction between the various stages provides needed precision within the value-creation literature. Lastly, the identification of the problem as the unit of analysis allows for a more robust conversation of important cognitive mechanisms influencing the topography and search of solution landscapes (Nickerson & Zenger, 2004). In summary, the problem-finding problem-solving approach provides theoretical space for growth within microfoundational research by integrating several levels of analysis, identifying the various stages involved in value creation, and elucidating a conceptual tool (i.e., solution landscapes) to explore the important cognitive and neurological mechanisms underlying value creation.

Powell (2011) poses an important question, “whether strategy should be asking questions about the brain” (p. 1489). Indeed, the use of psychological and neuroscientific methodologies may appear to be misaligned with the aggregate focus of strategic management. Detractors of neurostrategy provide several arguments, including theory construct misalignment, reductionist methodologies, reverse inference, and the frequent critique that few insights are gained with the addition of nueroscientific methodologies.

In contrast, proponents highlight the ability of neuroscience to link unobserved cognitive mechanisms to neuro-physiological outcomes, thereby increasing construct validity and theory refinement (Powell, 2011). Building on a large body of neuro-economic research (Camerer, Loewenstein, & Prelec, 2004; 2005; Fehr & Rangel, 2011), proponents of neurostrategy frequently cite important insights gained through the neurological exploration of key elements of competitive games, including, among others, decision-making, loss aversion, willingness to pay, and cooperation. "If neuroscience gives genuine insight into the mechanisms of strategic choice, then it has a direct relevance to strategy research" (Powell, 2011, p. 1489).

A focus on the neuro-economic foundations of strategic management, however, ultimately obscures the centrality of psychological and cognitive mechanisms underlying most of extant strategic management theory. For example, Powell (2011) states that industrial organization, institutional theory, resource-based view, and evolutionary view make few or no assumptions about individual psychology. As explained above, this argumentation does not accurately reflect the literature, while focusing on the firm or industry, individual psychological mechanisms are explicitly identified in theories of IO economics, the resource-based view, dynamic capabilities, and organizational learning. Indeed, although frequently left undeveloped, the genesis of organizational heterogeneity is often ascribed to variance in underlying individual psychological and cognitive processes (e.g., risk preferences, expectations, perceptions, attention, scanning, creativity, imagination of possibilities). Subsequently, critiques of a misalignment between strategic management theory and individual cognitive processes are unwarranted. Moreover, a reductionist approach becomes necessary if individual mechanisms (e.g., expectations, perceptions, attention, imagination) producing the heterogeneity are to be adequately identified and explored. Concerns of reverse inference and value added are also frequently proffered with respect to neuroscientific methodologies. Indeed, with few exceptions, the observation of neuro-physiological activity within the brain cannot be identified as the causal mechanism of a behavioral outcome. Nevertheless, leveraging both the extant neuroscience literature and careful experimental design, conditions giving rise to neurological correlates associated with behavioral outcomes can be theorized and tested. Elucidating the neurological correlates enhancing expectations, imagination of possibilities, or knowledge recombination is of particular relevance to questions of value creation. For example, organizations aligning problem formulation, incentives, or organizational routines, with those conditions giving rise to the neurological correlates of enhanced expectations, imagination of possibilities, or knowledge recombination, are more likely to perpetually create value. In the following section, I briefly highlight the three papers comprising this dissertation, identifying relevant research questions, empirical design, and contributions. I conclude by reviewing the contributions of cognitive/neurological research within the broader conversation of strategic management and the opportunity for additional research.

Panacea or Paralysis, Comprehensiveness in Wicked Problem Formulation, empirically examines the role of comprehensive problem formulation (i.e., the number of relevant and alternative problem formulations) in enhancing the generation of novel and valuable solutions to complex and ill-defined strategic problems (i.e., wicked problems). The development of solutions to wicked problems represents an important step in the value-creation process (Nickerson & Zenger, 2004). Indeed, solutions to wicked problems are more likely to generate value and competitive advantage given the causal ambiguity, and complexity inherent in wicked problems (Barney, 1991; Lippman & Rumelt, 1982). The problem-finding problem-solving perspective posits that comprehensive problem formulation serves to enhance the novelty and value of solutions by reducing the likelihood of selecting narrow or inappropriate formulations and producing a wider spectrum of possible solutions (Baer et al., 2013).

Cognitive constraints, however, often result in bounded rationality or satisficing behavior, suggesting several limitations of comprehensive problem formulation. As documented in bounded rationality (Kahneman, 2003; Simon, 1955), paradox of choice (Iyengar & Lepper, 2000; Oulasvirta, Hukkinen, & Schwartz, 2009; Schwartz et al., 2002), and information overload literatures (Edmunds & Morris, 2000; Eppler & Mengis, 2004; O'Reilly, 1980), increased informational demands become particularly restrictive under conditions of limited time and/or rapid change, causing individuals to rely on established mental maps or heuristics.

In an effort to disentangle the effects of comprehensive problem formulation, a theoretical model exploring novel and valuable solution generation is proposed and empirically tested. Two research questions are examined: how does comprehensive problem formulation impact the generation of novel and valuable solutions to strategic problems and how do time constraints moderate this effect? The proposed model is evaluated through an experimental design manipulating both the degree of comprehensiveness in the formulation of the wicked problem (low, medium, high), and time allowed to develop a solution (time constraint, no-time constraint). Participants are presented with a short strategic vignette (i.e., mini-case) describing a complex and ill-defined strategic problem facing an organization. At the conclusion of each vignette, various alternative problem formulations are presented. Participants in the low comprehensiveness condition are presented with one problem formulation, while participants in the medium are presented with three formulations and those in the high with five formulations. In addition, participants are assigned to one of two time conditions. Participants are then asked to propose a solution. The degree of novelty and value of the proposed solution is subsequently evaluated by a panel of experts.

Theoretical elucidation of, and empirical support for the value-creating mechanisms of comprehensive problem formulation contributes to the strategic management literature in two ways. First, by elucidating the microfoundations of problem formulation on the generation of value-creating solutions, an important and frequently overlooked source of value creation and competitive advantage is identified. Second, theoretical tension within the extant literature is resolved. While the deleterious effects of bounded rationality are well known, the relative importance of comprehensiveness with respect to novel and valuable solution generation is less established. Comprehensive problem formulation represents a significant departure from simplification approaches currently employed in strategic management theory and practice.

Effective Affect: Elucidating Micromechanisms of Value-Creating Solutions to Strategic Problems explores the affective, cognitive, and neurological processes underlying novel and valuable solution generation. As mentioned, antecedents of novel and valuable solution generation include, among others, perception, creativity, and the imagination of possibilities. Subsequently, mechanisms enhancing or directly inhibiting these processes have a direct impact on both value creation and competitive advantage. One of the most widely documented moderators of perception, scanning, creativity, and imagination of possibilities is affect. Indeed, affect has demonstrated a direct impact on the storage, search, and recombination of knowledge elements (Amabile, Barsade, Mueller, & Staw, 2005; Dreisbach & Goschke, 2004; Fredrickson & Branigan, 2005; Gasper & Clore, 2002; Isen, 2002; Rowe, Hirsh, & Anderson, 2007), fundamental processes underlying value creation. Interestingly however, the field of strategic management has largely ignored the moderating cognitive and neurological conditions produced by affect. As such, a relevant research question emerges: how do positive and negative affect, and their neurological correlates, impact both the formulation and type of novel and valuable solutions to strategic problems.

Building from NK landscapes within the problem-finding problem-solving framework (Nickerson & Zenger, 2004), the enhancing mechanisms of both positive and negative affect are explored. Specifically, positive affect resulting in alpha synchronization (neurological correlate) is posited to enhance value-creating solutions by defocusing attention, increasing relevant cognitive elements and overall cognitive flexibility (e.g., Amabile et al., 2005; Dolan, 2002; Dreisbach & Goschke, 2004; Fredrickson, 2001; Fredrickson & Branigan, 2005; Gasper & Clore, 2002; Isen, 2002; Rowe et al., 2007). Defocused and broad attentional processes are argued to expand the individual's perception of the solution landscape and enhance the likelihood of identifying the global optimum. Negative affect resulting in alpha de-synchronization is also predicted to enhance novel and valuable solution generation by increasing perseverance and optimization (e.g., De Dreu, Baas, & Nijstad, 2008; Kaufmann &

Vosburg, 1997; Vosburg, 1998). Increased perseverance and optimization is posited to narrow the solution landscape and enhance the likelihood of identifying the local optimum. Moreover, the type of solution produced is also predicted to vary according to the form of affect. Solutions developed through positive affect are posited to draw upon more diverse and unrelated knowledge sets while solutions developed through negative affect are predicted to demonstrate a more narrow and focused knowledge set.

Elucidating the influential role of affect on the central value-creating processes of perception, scanning, and imagination of possibilities meaningfully refines microfoundational theories of value creation and provides important insights into the practice of strategic management. Specifically, building on the creativity and neuroscience literatures, two separate cognitive mechanisms are identified and posited to produce systematic differences in how knowledge search and recombination unfold. Mechanisms influencing heterogeneity in knowledge search and recombination directly inform the problem-finding problem-solving perspective (Baer et al., 2013; Nickerson & Zenger, 2004), microfoundational frameworks of dynamic capabilities (Gavetti, 2005; Teece, 2007), and entrepreneurial cognition (Alvarez & Barney, 2007; Mitchell et al., 2002). Several implications for organizational practice are also revealed. Organizations pursuing exploitation or exploration may be better able to create value by structuring the organization and incentivizing individuals in such a way as to enhance the likelihood of developing appropriate solutions. Moreover, dynamic organizations developing routines or capabilities leveraging both mechanisms may be better able to respond to changing conditions by continuously creating value.

The final paper*, Routines, Creativity and Competitive Advantage: Elucidating Neurological Microfoundations of Value Creation* develops and empirically explores an organizational routine enhancing the neurological processes underlying the generation of novel and valuable solutions. A robust body of literature examines the role of organizational routines in the acquisition, reconfiguration, and application of knowledge (e.g., Cohen & Levinthal, 1990; Helfat & Peteraf, 2003; Helfat & Winter, 2011; Levitt & March, 1988; Zahra & George, 2002; Zollo & Winter, 2002). In contrast, how organizational routines might impact *neurological activity* to enhance value-creating solutions remains largely undeveloped. If strategic management research is to enhance value creation, then understanding in detail how specific organizational routines spark underlying neurological processes (e.g., perception, scanning, creativity, imagination of possibilities) to generate value-creating solutions is a necessary step (Teece, 2007). Indeed, understanding the interaction between routines and neurological activity that generates solutions offers the potential for designing better routines in support of value creation.

A set of design goals is first identified, which when met, overcomes the impediments of novel and valuable solution generation (e.g., bounded rationality, mental maps, heuristics). Subsequently leveraging NK landscapes within the problem-finding problem-solving approach, an organizational routine incorporating first, contradiction mechanisms and second, incubation mechanisms is theoretically developed and empirically tested. Contradiction mechanisms are posited to activate a wider range of knowledge sets, thus expanding the solution landscape, while incubation mechanisms are predicted to release deliberate cognitive resources, thus enhancing the combinatorial search of the newly expanded landscape.

In an experimental design involving 120 students, the posited effects of the proposed routine are explored. Participants are randomly assigned to one of four routines: (1) problem presentation – solution generation – solution finalization, (2) problem presentation – contradiction mechanisms – solution finalization, (3) problem presentation – incubation mechanisms – solution finalization and, (4) the posited routine, problem presentation – contradiction mechanisms – incubation mechanisms – solution finalization. Neurological activity of a subset of the participants is monitored throughout the process using electroencephalography (i.e., EEG) techniques, providing an initial insight into the specific cognitive processes underlying solution development. Lastly, the degree of novelty and value of the proposed solutions is evaluated by a panel of experts.

Several contributions of this study merit comment. First, by elucidating the underlying neurological processes of novel and valuable solution generation, key mechanisms within the black box of value creation are identified. As mentioned, microfoundational research within dynamic capabilities, entrepreneurship, and organizational learning highlight the role of perception, creativity, and imagination of possibilities in creating value. By identifying the neurological correlates involved in knowledge search and recombination, organizational routines enhancing these mechanisms can be theorized and tested. Second, the adoption of neuro-experimental methodologies represents an important first step in enhancing the precision and causal attribution of the underlying cognitive processes. Finally, a specific routine enhancing the generation of novel and valuable solutions is presented, providing important insights into the perpetual creation of value and competitive advantage.

Tracing its historical trajectory, Cynthia Montgomery (2012) succinctly identifies the shortcomings of extant strategic management theory and practice.

> "As a field, we had hoisted ourselves on our own petard. We had demoted strategy from the top of the organization to a specialist function. Chasing a new idea, we had lost sight of the value of what we had—the richness of judgment, the continuity of purpose, the will to commit an organization to a particular path. With all good intentions, we had backed strategy into a narrow corner and reduced it to a left-brain exercise..." (p. 3).

Indeed, by focusing on theoretical frameworks of a given industry, resource, knowledge attribute, and/or dynamic capability, strategic management scholars have largely abandoned the cognitive and psychological processes of the individual strategist, a prominent consideration in early strategic management research. The three papers comprising this dissertation theoretically develop and empirically test models of both "left and right brain" processing, clearly identifying the role of the individual in value creation and competitive advantage. Specifically, this dissertation addresses how comprehensive problem formulation, affective states, and organizational routines influence the type, novelty, and value of solutions generated to complex strategic problems.

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CHAPTER 2

PANACEA OR PARALYSIS: COMPREHENSIVENESS IN WICKED PROBLEM FORMULATION

Abstract

Wicked problems present an ongoing challenge for organizations. Indeed, many of the important strategic problems facing organizations demonstrate complexity, interdependence, and are ill-defined. Comprehensive problem formulation has been suggested as one way to enhance the generation of value-creating solutions to wicked problems. While proponents of this perspective highlight the value-creating advantages of increasing the number of problem formulations, few studies have empirically demonstrated its effect. Moreover, the bounded rationality, paradox of choice, and information overload literatures suggest a negative effect of increased comprehensiveness in the solution-generation process, particularly under conditions of limited time. This study examines how comprehensive problem formulation and time constraints influence the degree of novelty and value of solutions to wicked problems. Findings suggest an inverted-U-shape relationship between the level of comprehensiveness and the value of the solution generated. Time constraints are also shown to reduce both the novelty and value of the solution. The identification of how comprehensiveness operates to enhance the generation of value-creating solutions clarifies theoretical predictions and provides important insights into microfoundational theories of value creation.

"The mere formulation of a problem is far more often essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle requires creative imagination and marks real advances in science."

- Albert Einstein

Introduction

Many of the critical strategic problems organizations encounter are complex, interdependent and ill-defined (Baer, Dirks, & Nickerson, 2013; Camillus, 2008; Nickerson, Silverman, & Zenger, 2007). Subsequently, an organization's ability to define the problem and develop novel and valuable solutions directly influences the organization's effectiveness in creating value and competitive advantage. The microfoundational literature has begun to explore the role of individuals in finding, framing, and formulating strategic problems, generating novel and valuable solutions, and implementing the newly developed solutions (Baer et al., 2013; Felin & Zenger, 2009; Gavetti, Levinthal, & Rivkin, 2005; Teece, 2007). Microfoundational arguments within the problem-finding problem-solving perspective emphasize the role of comprehensiveness in enhancing the development of valuable solutions to complex, ill-defined problems (i.e., wicked problems) (Baer et al., 2013; Boland, 1978; Lyles, 1981; Volkema, 1983). Comprehensiveness is defined as the number of relevant and alternative problem formulations. Problem-finding problem-solving scholars suggest increased comprehensiveness mitigates the complexity and ill-defined nature of wicked problems by reducing the likelihood of narrow and/or inappropriate formulations. As such, comprehensive problem formulation generates a wider spectrum of solutions, increasing the probability of solving a better problem and improving the value-creating potential of the solution.

Several literatures, however, suggest higher levels of comprehensiveness decrease the novelty and value of the solution, especially when time constraints are present. Simon (1955; 1972) posits incomplete information, cognitive limitations, and limited time serve to bind the rationality of the actor resulting in satisficing behavior. Theoretical and empirical work across numerous disciplines has established the veracity of this claim (see Conlisk, 1996). Building on notions of bounded rationality, Oulasvirta, Hukkinen, and Schwartz (2009) identify the paradox of choice, suggesting increased comprehensiveness or number of options may "lead to paralysis, poor choice, and decreased satisfaction with the choice…" (p. 516). Similarly, scholars investigating information overload highlight the negative effects of increased information – effectively obscuring valuable details, and reducing overall decision-making performance (e.g., Eppler & Mengis, 2004; Grise & Gallupe, 2000). In short, the bounded rationality, paradox of choice, and information overload literatures suggest a negative impact of comprehensive problem formulation on value-creating solutions, particularly in conditions of limited time. The apparent tension between the problem-finding problem-solving and bounded rationality literatures therefore merits additional investigation.

Building on the problem-finding problem-solving literature, this study directly examines how comprehensive problem formulation and time constraints impact the degree of novelty and value of solutions to wicked problems. In an experiment involving 306 students, we test the proposed model by manipulating both the degree of comprehensiveness in the formulation of the wicked problem (i.e., low, medium, high), and the amount of time provided to develop a solution. We find comprehensive problem formulation increases the value of the proposed solutions. Specifically, we observe a significant increase in the value of the solution developed when transitioning from a low level of comprehensive problem formulation to a medium level of comprehensive problem formulation. A decrease in the value of the solution, however, was also observed when moving from medium levels of comprehensiveness to high levels of comprehensiveness, suggesting a boundary condition of comprehensive problem formulation. Lastly, results indicate time constraints reduce both the novelty and value of the solutions.

This study addresses the important question of how organizations can enhance the generation of novel and valuable solutions to wicked problems. First, by elucidating the micro-level dynamics of problem formulation on the generation of value-creating solutions, we answer the recent call to establish the microfoundations of value creation and competitive advantage (see Baer et al., 2013; Felin & Hesterly, 2007; Teece, 2007). Second, we resolve the theoretical tension within the extant literature by empirically examining the effects of both comprehensiveness and time-constraints on the development of novel and valuable solutions. Medium levels of comprehensive problem formulation were found to enhance the value of the solution. This finding represents a departure from the bounded rationality, paradox of choice and information overload literatures. Specifically, rather than a systematic narrowing of the relevant problem to its essential features, we find the expansion and explicit consideration of multiple problem formulations increases the value of the solution generated (i.e., low to medium levels of comprehensiveness). The effectiveness of comprehensive problem formulation informs microfoundational explanations of value creation. By elucidating the influence of comprehensiveness on the generation of value-creating solutions, this study indentifies an important source of heterogeneity in the value-creation process.

The remainder of the study proceeds as follows. We begin with a brief review of the relevant literature in dynamic capabilities, problem-finding problem-solving, bounded rationality, and paradox of choice, highlighting inherent tensions and the need for a more complete understanding of how organizations can enhance the generation of novel and valuable solutions to wicked problems. Second, through formal hypotheses, we build a model of how comprehensive problem formulation and time constraints influence the generation of value-creating solutions. Third, we test the proposed model in an experiment involving 306 students in a 3X2 factorial design. We conclude by explicating results, research implications, and issuing a call for additional scholarly investigation in this area.

Problem Formulation and Value Creation

Organizations often confront wicked problems. Wicked problems are characterized by an inability to adequately model and address the problem due to the number of complex, interdependent, and ill-defined variables under consideration (Baer et al., 2013; Camillus, 2008; Rittel & Webber, 1973). Mitroff (1979) highlights three salient features of wicked problems: no consensus by those who are assigned to address the problem as to an appropriate solution or strategy, disagreement on how to proceed, and no clear formulation of the problem itself. Given the abundant amount of information available to organizations and the increasingly dynamic business environment, wicked problems have indeed become commonplace. Simple problems, in contrast, are characterized by limited complexity and interaction of problem elements. Unlike wicked problems, simple problems are often successfully addressed through a combination of relevant frameworks and careful rational thought (Jonassen, 1997; Kitchener, 1983; Schraw, Dunkle, & Bendixen, 2004). Despite the ubiquitous nature of wicked problems, much of strategic management focuses on the superimposition of wicked problems onto simple problem frameworks to aid in formulation and solution generation. "In essence, strategy research has moved away from the field's foundational questions to focus on tactical decisions to be made under definable circumstances" (Nickerson et al., 2007, p. 1). Although providing useful cognitive and pedagogical frameworks, the simplification of wicked problems to strategic frameworks prescribed by prominent theory fails to capture the reality of strategic decision-making and unnecessarily obscures meaningful variance arising from the formulation of the problem itself.

Value is created as individuals in organizations find, frame, and formulate problems, generate solutions, and implement those solutions to lower costs and/or create greater perceived benefits (Nickerson, Yen, & Mahoney, 2011; Volkema, 1983). Significant scholarly attention has been given to the second stage in the value-creation process - generation, evaluation, and selection of the potential solutions - while variance arising from the initial task of problem formulation remains less developed (Baer et al., 2013; Lyles & Mitroff, 1980). Wicked problem formulation represents an important source of value creation. Unlike simple problems, the causal ambiguity and complex nature of wicked problems are more likely to generate value and competitive advantages

(Barney, 1991; Lippman & Rumelt, 1982) as organizations asymmetrically define core elements of a problem and develop unique value-creating solutions.

Wicked problems, by definition, can be formulated in numerous ways. Although not amenable to clear consensus, formulation of the wicked problem must be established prior to the development of a solution. As a result, problem formulation is the central determinant of which problem is solved and directly influences the nature and value of the solution (Baer et al., 2013). Wicked problem formulations failing to capture the root causes of the problem result in formulations that are either too narrow or inappropriate. Subsequently, solutions generated under narrow or inappropriate problem formulations emerge as less valuable, failing to adequately address the underlying causal mechanisms of the problem.

Scholars investigating the problem-finding process suggest comprehensiveness in wicked problem formulation serves as an effective tool for overcoming the complex interdependencies of wicked problems (Baer et al., 2013; Boland, 1978; Lyles, 1981; Volkema, 1988; Volkema & Gorman, 1998). Specifically, by increasing the number of alternative and relevant formulations, the likelihood of selecting a formulation, or set of formulations, capturing the underlying causal mechanisms of the problem is enhanced. In addition, exposure to multiple perspectives through increased comprehensiveness expands unitary representations of the problem, enhancing the novelty of the solution. As such, comprehensive problem formulation plays a central role in overcoming the complex challenge of wicked problems and extracting their significant value-creating potential.

When examining the value of comprehensive problem formulation, it is important to distinguish between the type of problem, simple or wicked. Comprehensiveness in the formulation of simple problems ultimately decreases value as critical organizational resources and time are expended unnecessarily. By definition, the underlying causal mechanisms of simple problems are readily identified, suggesting the development of numerous alternative formulations at best expends organizational resources and at worst serves to obfuscate and confuse solution development. The role of comprehensive problem formulation in the development of simple and wicked problems can be seen in Figure 2.1.

Despite the posited benefits of comprehensive wicked problem formulation, a substantial body of literature suggests important limitations (e.g., Kahneman, 2003; Simon, 1955; 1972). Cognitive constraints of simultaneous processing result in bounded rationality and satisficing behavior, indicating a deleterious effect and/or possible boundary condition to the beneficial mechanisms of comprehensive problem formulation. Moreover, cognitive constraints appear to be particularly restrictive under conditions of limited time and rapid change, causing individuals to rely on established mental maps or heuristics to quickly categorize vast amounts of information and act accordingly. Several literatures document these cognitive constraints, including bounded rationality (Kahneman, 2003; Simon, 1955), paradox of choice (Iyengar & Lepper, 2000; Oulasvirta et al., 2009; Schwartz et al., 2002), and information overload (Edmunds & Morris, 2000; Eppler & Mengis, 2004; O'Reilly, 1980). Perhaps as a result of this evidence, the majority of strategic management training is designed to aid individuals in narrowing the wicked problem from its idiosyncratic and interdependent attributes to a simplified or stylized representation of the problem. In short, comprehensive problem formulation explicitly incorporates and expands the multiple facets of the wicked problem while stylized problem formulations, suggested by the bounded rationality, paradox of choice, and information overload literatures, simplify and reduce the wicked problem to its core elements. Given the apparent tension, it is unclear whether processes of expansion or reduction in wicked problem formulation are more effective in the development of novel and valuable solutions. The extant literature provides few insights into the important question of comprehensive vs. stylized wicked problem formulation or how comprehensiveness might interact with time constraints to determine the optimal degree of comprehensiveness. In the following sections, we develop and test a series of hypotheses elucidating the role of comprehensive problem formulation and time constraints in the generation of value-creating solutions.

Hypotheses

Strategic problem formulation is defined as a formalized causal representation of a given symptom or web of symptoms (Baer et al., 2013). Organizations often become aware of a potential "problem" through the observation of its symptoms. The distinction between a problem and its symptom is worth noting. For example, a loss in market share represents a symptom while possible problem formulations range from new technologies, incoming competitors, governance misalignment, or supply chain inefficiencies. The ill-defined, complex, and interdependent nature of wicked problems result in a wide range of possible problem formulations, effectively obscuring the emergence of a clear choice. Subsequently, wicked problems often result in disagreement and confusion within the top management as to the appropriate course of action (Mitroff & Emshoff, 1979).

Scholars investigating the problem-formulation process identify comprehensiveness as a desired outcome of wicked problem formulation (e.g., Baer et al., 2013; Lyles, 1981; Volkema, 1988). As the number of alternative and relevant formulations increases, novel and valuable solutions are more likely to be reached. The probabilistic arguments presented by this group of scholars are clear. Wicked problems are characterized by a relatively limitless set of possible problem formulations (Rittel & Webber, 1973; Smith, 1989). Each formulation has an accompanying set of solutions resulting in a given economic value when implemented. Solutions developed for wicked problem formulations capturing the root causes of the problem are more likely to create value by directly addressing the operating causal mechanisms. In contrast, solutions developed for narrow and inappropriate formulations are less likely to produce value. By maintaining a broad and inclusive set of relevant formulations, comprehensive problem formulation increases the probability of capturing core causal mechanisms, thereby increasing the value of proposed solutions. Comprehensive problem formulation is also predicted to enhance the novelty of the solution. As additional causal mechanisms are considered, solutions sets across problem formulations are more able to mix and integrate. As documented by creativity scholars, exposure to alternative information enhances the generation of novel and unique ideas (e.g., Kray & Galinsky, 2003; Nemeth, Brown, & Rogers, 2001; Nemeth, Personnaz, Personnaz, & Goncalo, 2004). Comprehensive problem formulation expands unitary mental representations of problem–solution relationships, resulting in a cullying and expansion of information available in the development of the solution.

The underlying mechanisms of comprehensive problem formulation are built on assumptions of rational decision-making and probability. As alternative relevant formulations are established, the likelihood of identifying core causal mechanisms is enhanced. Although problem-finding problem-solving scholars present a clear theoretical argument for the expansion of problem formulations, several bodies of literature identify an important limitation of the rational actor model—the processing capabilities of the human mind. "If one were to imagine the vast collection of decision problems…as a sea or ocean, with easier problems on top and more complicated ones at increasing depth, then deductive rationality would describe human behavior accurately only within a few feet of the surface" (Arthur, 1994, p. 406).

Wicked problems, by definition, lie deep within the ocean of possible decision problems, rendering them maladapted for rational cognitive processes. Indeed, systematic deductive reasoning breaks down under increasing complexity due to the cognitive limitations or bounded rationality of the actor (Simon, 1955). The cognitive load of simultaneously examining multiple problem formulations (i.e., comprehensiveness) as well as their complex interactions is argued to become overwhelming, resulting in satisficing behavior, the selection of "good enough," as opposed to optimal alternatives. An additional constraint to rational actor models, particularly salient to strategic management, is the assumption that all relevant actors also act in a logical manner. Even if computational constraints of the focal strategic actor are relaxed, the complex adaptive system in which the actor and organization are embedded requires that all economic actors correctly identify and pursue purely logical strategies (Arthur, 1994).

Several bodies of literature across various disciplines document the breaking down of rational thought process under increasing loads of complexity, including, among others, bounded rationality (Kahneman, 2003; Simon, 1955), paradox of choice (Iyengar & Lepper, 2000; Oulasvirta et al., 2009; Schwartz et al., 2002), and information overload (Edmunds & Morris, 2000; Eppler & Mengis, 2004; O'Reilly, 1980). In contrast to the expansion and recombination benefits of increased comprehensiveness, this body of work suggests that as complexity increases, arising from additional problem formulations, the computational limits of the actor are reached. As such, high levels of comprehensive problem formulation likely lead to an overwhelming of the strategic actor, resulting in paralysis and abandonment of the solution search or a rapid retreat to established mental maps and existing heuristics. An increased reliance on previously established mental maps and heuristics is less likely to result in novel and valuable solutions. Given that mental maps are formed through problem-solution relationships experienced in the past, the likelihood of generating novel and valuable solutions is diminished.

Taken together, the problem-finding problem-solving and bounded rationality literatures suggest an inverted-U shaped relationship between the level of comprehensiveness and the novelty and value of the solutions. As comprehensiveness increases, the likelihood of identifying problem formulations that capture the root causes of the problem is enhanced. However, as the level of comprehensiveness surpasses the computational facility of the strategic actor, a retreat to established mental maps and heuristics is likely to occur, resulting in a decrease of novelty and value. As such, H1: Medium levels of comprehensive problem formulation result in (a) more novel and (b) more valuable solutions than low levels of comprehensive problem formulation

H2: High levels of comprehensive problem formulation result in (a) less novel and (b) less valuable solutions than medium levels of comprehensive problem formulation

Business environments are becoming increasingly dynamic and volatile. Subsequently, rapid problem identification and resolution has begun to play a central role in determining organizational performance and sustained competitive advantage (Eisenhardt, 1989; Nickerson et al., 2007). Wicked complex problems when combined with time constraints represent a particularly difficult, yet salient challenge for strategic decision makers. Organizations are not only required to formulate and solve complex wicked problems, but are often obligated to do so under conditions of limited time. Time constraints have been shown to speed up the execution of the decision-making process, disproportionately increase the salience of negative information, and increase the likelihood of switching to previously implemented decision strategies (Benson & Beach, 1996; Edland & Svenson, 1993; Wright, 1974). For example, Ordonez and Benson (1997) find time constraints result in an increased reliance on past decision strategies when evaluating the attractiveness of economic gambles. The increased cognitive demands posed by time constraints are suggested to result in a less deliberate cognitive strategy and an adoption of simplifying heuristics. As such, similar to the effects of high levels of comprehensive problem formulation, time constraints often result in an increased reliance on established mental maps and heuristics, limiting the novelty and value of the solution.

H3: Solutions developed with time constraints are (a) less novel and (b) less valuable than solutions developed without time constraints

Time constraints are also likely to interact with the level of comprehensiveness in determining the novelty and value of the solution. Higher levels of comprehensiveness are more effectively processed with increased time as problem-relevant information can be stored, categorized, and referenced (Schick, Lawrence, & Haka, 1990). A greater number of problem formulations and their interdependencies can be deliberately considered with the addition of time, arguably enhancing the overall novelty and value of the solution. In contrast, time constraints lower the level of problem comprehensiveness able to be processed, resulting in a greater reliance on established cognitive maps and mental representations. Early problem-finding scholars suggest time constraints limit the posited beneficial effects of comprehensiveness (Fredrickson & Mitchell, 1984; Janis, 1972; Mintzberg, 1973; Nutt, 1976), as such time constraints will have less of an impact on the novelty and value of solutions when combined with low levels of comprehensiveness, and an increasingly negative effect with increasing levels of comprehensiveness. Subsequently,

H4: Time constraints moderate the relationship between comprehensive problem formulation and novel and valuable solutions such that time constraints weaken the positive effect of comprehensiveness (low to medium) on (a) novelty and (b) value

H5: Time constraints moderate the relationship between comprehensive problem formulation and novel and valuable solutions such that time constraints strengthen the negative effect of comprehensiveness (medium to high) on (a) novelty and (b) value

Methods

Experimental Designs

An experimental design was used to test the hypothesized model. Experimental designs offer the unique advantage of isolating variables of interest providing, increased confidence in the causal mechanisms posited (Shadish, Cook, & Campbell, 2001). By controlling for extraneous factors, focal theoretical relationships can be cleanly examined. Experiments are also reliably replicated, effectively establishing the validity of the findings and clarifying theoretical relationships (Falk & Heckman, 2009). Subsequently, experiments are often beneficial when competing theories intersect around a given phenomenon (Agarwal, Anand, Bercovitz, & Croson, 2012). In addition, experimental designs side step the pitfalls of selection and endogeneity, common problems in strategic management research.

The fields of psychology, sociology, and economics have enjoyed a long history of experimental research. More recently, strategic management scholars have begun to utilize experiments to explore: spillovers of organizational routines (Agarwal et al., 2012), incentive alignment and partner selection within strategic alliances (Agarwal, Croson, & Mahoney, 2010; Shah & Swaminathan, 2008), and cultural effects on merger performance (Weber & Camerer, 2003). Strategic management scholars investigating the cognitive microfoundations of the field have largely relied on experimental methodologies. For example, Gary and Wood (2011) find managerial cognition significantly influences strategy selection and subsequent performance. Shapira and Shaver (2013) experimentally demonstrate the deleterious effects of anchoring in strategic investments. Song, Calantone, and Di Benedetto (2002) explore the role of simplifying heuristics in the analysis of the competitive environment while Gary, Wood, and Pillinger (2012) unpack the mechanisms of knowledge transfer between strategic contexts.

The primary objective of this study is to explore how comprehensive problem formulation and time constraints influence the development of novel and valuable solutions to strategic management problems. The central operating mechanisms of comprehensiveness and bounded rationality are argued to operate within the cognitive processes of strategic actors, thereby lending themselves to an experimental design. Wicked problems, by definition, are idiosyncratic and characterized by complexity and interdependence. As such, an experimental design cleanly isolating the individual effects of both comprehensiveness and time is necessary to reliably test the proposed model (Falk & Heckman, 2009).

While highlighting the benefits of experimental methodologies, a brief discussion of their limitations merits comment. The central objection to experimental research is its abstraction from reality. Critics of experimental research argue important attributes of both the context and the actors are absent in a laboratory setting, limiting the generalizablity of the findings (Brinberg & McGrath, 1985). We address these possible limitations by (1) adopting a strategic problem facing an actual firm of which participants have familiarity, (2) incentivizing participants with merit-based rewards, and (3) selecting participants with a working knowledge of strategic management theory and practice. It is worth noting, however, that while research design efforts to bridge the gap between the laboratory and the field are useful, they may be misleading. Specifically, failures in generalizability may not be directly attributed to the design, rather to an omission in the theory being tested (see Agarwal et al., 2012; Plott, 1991; Zelditch, 1969).

Sample and Research Design

Hypothesized effects were evaluated in an experiment involving 306 participants, of which 22 were excluded due to missing data, nonsensical responses, and evidence of limited effort,[2] resulting in a total of 284 participants. Participants consisted of senior-level undergraduate and MBA business students at a large research institution in the United States. Participants completed the assignment online as part of their coursework. Strategic and international management students were selected due to their familiarity with case-based methodologies and their knowledge and ability to critically evaluate strategic problems. Participants were randomly assigned to one of six conditions, resulting in a 3X2 factorial design with three levels of comprehensiveness (low, medium, high) and two levels of time (no-time constraints, time constraints). The novelty and value of the solutions were assessed by a panel of experts. In addition, four prizes valuing $50 dollars each were awarded for the four most novel and valuable solutions.

Problem Development and Procedures

Several design goals in the development of the strategic problem were present. First, comprehensiveness and time constraints are predicted to impact solution development when dealing with wicked problems. Subsequently, the strategic problem should demonstrate complexity and interdependency of relevant variables. Second,

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[2] Limited effort was determined by the response times of the participants. Reading time was estimated for each condition using a 300 word-per-minute rate. Any participant taking less than 2 minutes to answer the 5 solution development questions, in addition to the time required to read the problem, was excluded.

problem formulations should reflect a realistic strategic problem with numerous and varied building blocks (i.e., resources, capabilities, routines) with which to develop a solution. Lastly, problem formulations must be appropriately designed to ensure internal validity (e.g., eliminate the possibility of additional covariates, wording biases to a particular solution, variance between problem formulations).

To achieve these goals, we first identified real organizations facing wicked problems. Six problem descriptions across various industries were reviewed. Upon evaluation for appropriateness and complexity, a wicked problem facing a large consumer electronics retail firm was selected. A review of the information surrounding the problem indicated competing views among stakeholders regarding how to proceed, as well as the presence of multiple interrelated problem formulations. Subsequently, we adopted the underlying framework of the company to serve as a baseline in developing a wicked problem that would be appropriate in an experimental setting. Details regarding the focal company's salient resources and capabilities were collected as well as information regarding the firm's history. Relevant problem formulations were also categorized and labeled. When necessary, the complexity and approximate length of the problem formulations were increased or decreased to ensure equivalency across formulations.

The end result placed participants in the role of a turn-around specialist at "Bordet Electronics," a fictitious consumer electronics firm facing declining sales and falling stock prices. Participants were first given a brief history of the company and were told that their task was to develop a unique and creative solution that would provide economic value and help the company compete. According to the level of comprehensiveness assigned, participants next received one, three, or five formulations of the problem. Problem formulations included competition from internet retailers, customer experience, product offering, firm boundaries, and brand. Moreover, each problem formulation included an additional level comprised of three subformulations. For example, the problem (i.e., symptom) of declining sales could be formulated as internet competition. As a result a manager might develop a solution to address the rise in internet competition. Internet competition, however, could also be conceptualized as the symptom with possible formulations being: lower prices, increased access to information, and the convenience of internet shopping. For the purposes of illustration a hierarchical representation of the problem can be seen in the appendix. However, many of the formulations and sub-formulations are inter-related across levels, a likely outcome of wicked problems, suggesting a more accurate conceptualization of a web or network. Participants were also given a list of the company's resources and capabilities and were presented with five questions to aid in the development of the solution: what is your idea for your new strategy, how do you intend to use the company's resources and capabilities to support your plan, what, if any, new resources or capabilities need to be developed or acquired, does your strategy involve expansion into other businesses or partnering with other companies, and how would your strategy position the company within the industry? Lastly, participants were asked to complete a brief demographic questionnaire.

Manipulations

Problem comprehensiveness. Three levels of problem comprehensiveness were used. Participants in the low condition were given one problem formulation (3 sub-formulations), while participants in the medium condition were given three problem formulations (9 subformulations) and participants in the high condition were given five problem formulations (15 subformulations). Random assignment was again implemented within each of the conditions to determine which formulation was received. Participants in the low condition were randomly assigned one of the five formulations. Participants in the medium condition were randomly assigned to 1 of 10 possible combinations of the three problem formulations. Participants in the high condition received all five problem formulations. Formulations were designed to minimize potential differences (e.g., length, complexity, likelihood of developing a novel and valuable answer).

Time. Participants were assigned to a condition of no time constraints or time constraints. Participants in the no time constraint condition had as long as desired to read and develop a solution. For the time constraint condition, a pretest was used to calculate an appropriate time for each level of comprehensiveness. The pretest indicated no significant differences in the time taken to develop a solution between the levels of comprehensiveness. Subsequently, the overall median time was used as the time constraint for medium level of comprehensiveness. To address the differences in the amount of time required to read the problem, we adjusted the time constraint based on the word count of the low and high conditions and a 300 word-per-minute reading rate.

Dependent Variables

A panel of experts (*n*=3) was used to rate the novelty and value of the proposed solutions. Expert panels have been used to evaluate the value of strategic alliances (Lavie, Haunschild, & Khanna, 2012), the novelty and usefulness of entrepreneurial ideas (Chua, 2013), the innovativeness of solutions (Shepherd & DeTienne, 2005), and are frequently employed in the creativity literature (Amabile, 1990). Expert raters were selected based on education, managerial experience, and working knowledge of strategic management theory and practice.

Novelty. Raters evaluated the degree of novelty of the proposed solutions on a 7-point Likert-type scale, where 1 represents a common and or frequently proposed idea and 7 represents an uncommon and or infrequently proposed idea. The greatest discrepancies among raters were resolved through discussion. Cronbach's Alpha demonstrated high interrater reliability ($\alpha = .88$); subsequently, the three novelty scores were averaged for each participant.

Value. Raters were first asked to consider how the proposed solutions would lower the overall economic costs and/or increase the perceived benefits of the products or services. Solutions were then rated on a 7-point Likert-type scale in response to the question: How much economic value is the proposed solution likely to generate, where 1 represents no value and 7 represents significant value? The greatest discrepancies among raters were again resolved through discussion. Cronbach's Alpha demonstrated inter-rater reliability ($\alpha = .88$); subsequently, the three value scores were averaged for each participant.

Covariates

In order to isolate the effects of interest and reduce within group variance, several covariates were included in the analyses.

Age. Age has been shown to systematically influence creative productivity (see Simonton, 1988) and captures meaningful differences in work and life experience.

Non-native English speaker. Problem comprehensiveness (i.e., complexity) and time constraints are likely to interact with a participant's familiarity with the English language. Subsequently, participants were dummy coded for English as a native language.

Grade point average (GPA). GPA captures differences in a participant's basic ability and willingness to critically evaluate problems and formulate answers.

Results

Hypothesized effects were evaluated through a series of ANCOVAs, crossing three levels of comprehensiveness (low, medium, high) with two levels of time (no-time constraints, time constraints). Means for each variable are shown by condition in Table 2.2. ANCOVA results examining both novelty and value are shown in Table 2.3.

ANCOVA results evaluating novelty indicated no significant main effect for comprehensiveness on the novelty of the solution ($F_{2, 275} = .33$, $p > .05$, $\eta_p^2 = .00$). A significant main effect, however, was observed for time on the novelty of the solution ($F_{1, 275} = 4.56$, $p < .05$, $\eta_p^2 = .02$). In addition, no significant interaction between comprehensiveness and time was found ($F_{2, 275} = .85$, $p > .05$, $\eta_p^2 = .01$). The absence of a significant interaction allows for interpretation of the main effects. Taken together, these findings indicate no support for hypothesis 1a, medium levels of comprehensive problem formulation result in more novel solutions than low levels of comprehensive problem formulation, or hypothesis 2a, high levels of comprehensive problem formulation result in less novel solutions than medium levels of comprehensive problem formulation. The significant main effect of time, however, supports hypothesis 3a, solutions developed with time constraints are less novel than solutions developed without time constraints. Lastly, the absence of a significant interaction indicated time did not moderate the effects of comprehensiveness on novelty. Subsequently additional tests investigating the patterns of moderation were not warranted. As such, no support was found for hypotheses 4a or 5a.

ANCOVA results examining value revealed a significant main effect for comprehensiveness on the value of the solution ($F_{2, 275} = 3.44$, $p < .05$, $\eta_p^2 = .02$). A significant main effect was also observed for time on the value of the solution ($F_{1, 275} = 4.26$, $p < .05$, $\eta_p^2 = .02$). However, no significant interaction was observed between comprehensiveness and time ($F_{2,275} = 1.17$, $p > .05$, $\eta_p^2 = .01$). Subsequently, planned contrasts of the main effects of comprehensiveness were conducted to test the hypothesized effects. A planned contrast between the low and medium levels of comprehensiveness revealed a significant main effect ($F_{1, 275} = 6.02$, $p < .05$, $\eta_p^2 = .02$), indicating support for hypothesis 1b, medium levels of comprehensive problem formulation result in more valuable solutions than low levels of comprehensive problem formulation. A planned contrast between the medium and high levels of comprehensiveness also revealed a significant main effect ($F_{1, 275} = 3.97$, $p < .05$, $\eta_p^2 = .01$), supporting hypothesis 2b, high levels of comprehensive problem formulation result in less valuable solutions than medium levels of comprehensive problem formulation. Support for hypothesis 3b, solutions developed with time constraints are less valuable than solutions developed without time constraints, was also found as indicated by the significant main effect of time. Finally, the lack of a significant interaction indicated time did not moderate the impact of comprehensiveness on the value of the solution. As such, additional tests investigating the patterns of moderation were not warranted.

Subsequently, no support was found for hypotheses 4b or 5b. A figure depicting the observed relationships can be seen in Figure 2.2.

Discussion

Wicked problems present an ongoing challenge for organizations. Indeed, many of the important strategic problems facing organizations demonstrate complexity, interdependence, and are ill-defined (Baer et al., 2013; Camillus, 2008; Nickerson et al., 2007). Dynamic and volatile business environments introduce an additional obstacle as organizations must often confront and address the complexities of wicked problems in a timely manner. A proposed method for overcoming the complexities presented by wicked problems is increased problem comprehensiveness (Baer et al., 2013; Boland, 1978; Lyles & Mitroff, 1980; Volkema, 1988). While proponents of this perspective effectively argue the value-creating advantages of increasing the number of problem formulations, few studies have empirically demonstrated its effect. Moreover, a large body of research suggests negative effects of increased comprehensiveness, particularly under conditions of limited time (e.g., Conlisk, 1996; O'Reilly, 1980; Simon, 1955). Subsequently, the important question of how comprehensiveness operates to enhance the novelty and value of solutions to strategic management problems remains unanswered.

This study directly addresses this tension by theoretically developing and empirically testing the role of both comprehensiveness and time in the development of value-creating solutions. Taken together, our findings indicate that comprehensiveness in the formulation of a wicked problem plays a central role in determining the value of the solution generated. Specifically, we observe a 12% increase in the value of the solution as a result of a more comprehensive formulation. This finding suggests that the expansion and explicit consideration of multiple problem formulations does in fact serve as an effective tool for overcoming the complexities and interdependencies of wicked problems. A limitation of comprehensive problem formulation, however, was also observed. As hypothesized, cognitive constraints served to limit the value of the solution as problem complexity increased beyond a given point, suggesting an inverted-U-shape relationship between problem comprehensiveness and the value of the solution. The observed 9% decrease in value highlights the potential danger of over formulation, and corresponds with the bounded rationality and information overload literatures.

It is worth noting that while the value of the solution varied with respect to the level of comprehensiveness, the novelty of the solution did not. In fact, no differences were observed across any level of comprehensiveness. Two potential explanations could explain the absence of this effect. Comprehensiveness is argued to increase novelty by expanding the mental representation of the problem through the introduction of new and previously overlooked information. However, comprehensiveness is also posited to increase value through a largely rational and systematic consideration of the multiple problem formulations. It is possible that the analytical processes engaged by increased comprehensiveness counterbalance the creativity enhancements gained through the exposure of alternative information. An additional explanation may be the underlying techniques implemented when analyzing a strategic management case. Although participants were explicitly instructed to develop a unique and creative solution, the majority of strategic management training relies on a deliberate and analytical examination of relevant frameworks to evaluate potential opportunities. The failure to observe any effect with respect to novelty is insightful, suggesting a potential shortcoming of strategic management training. Indeed, developing both an economically viable solution as well as one that is novel has important competitive implications.

An additional goal of the study was to investigate how the effects of comprehensive problem formulation were impacted when strategic actors were given limited time to respond. Time constraints resulted in an overall reduction in both the novelty and value of the solutions. Specifically, solutions developed with a time constraint demonstrated an 11% decrease in novelty and an 8% decrease in value compared to solutions developed in the absence of a time constraint. Interestingly, no significant interactions were observed, suggesting time constraints did not moderate the effects of comprehensiveness on both novelty and value. These findings are surprising given that a strategic actor's ability to effectively process increasing levels of comprehensiveness likely requires time. One potential explanation may be the relatively small effect size of time. Additional research introducing more restrictive time constraints may prove helpful in unpacking whether or not moderating effects are present.

This study contributes to the extant literature by answering the call to more clearly establish and test the microfoundations of strategic management (Baer et al., 2013; Felin & Hesterly, 2007; Powell, Lovallo, & Fox, 2011; Teece, 2007). The central operating mechanisms of comprehensive problem formulation were both identified and tested providing important insights into a frequently overlooked source of heterogeneity in the value-creation process. Theoretical tension within the literature was explored and resolved resulting in a more complete picture of how comprehensiveness operates to enhance the value of solutions. In addition, this study highlights the relevance of wicked problems in strategic management and demonstrates the limitations of stylized problem formulations as well as the importance of expanding problem formulation.

Limitations

Given our reliance on experimental methodologies, the most salient limitation is the generalizability of the results. One potential concern centers on the appropriateness of the sample. While we acknowledge the participants in our sample may differ from strategic decision makers in a business setting, several steps were implemented to mitigate this limitation (see methods). An additional concern may be the specification of the problem formulations, namely the degree to which the problem formulations map to a strategic challenge in the business environment. While care was also taken to address this concern, wicked problems are inherently complex, interdependent, and ill-defined. Subsequently, any formulation will result in a degree of abstraction from the focal phenomenon. Moreover, to successfully and reliably isolate the effects of comprehensiveness, a deliberate design of comparable formulations is required. Indeed, the study of comprehensiveness in wicked problem formulation utilizing alternative methodologies would prove difficult, if not impossible, given the many confounding variables. The imposition of time constraints may also represent a limitation of the design. A central goal of the study was to examine the effects of comprehensive problem formulation when the strategic actor was subjected to time-sensitive pressures. We acknowledge that solutions to strategic management problems are rarely developed in the amount of time provided in this study. The requirements of a laboratory setting, however, necessitated a “best” approximation of a time pressure. Additional investigation would be valuable in specifying further the potential effects of time constraints.

Future Research and Conclusions

Several promising avenues for future research emerge as a result of this study. The primary objective of this research was to elucidate and test the role of comprehensive problem formulation. As such, participants were given predefined problem formulations and asked to develop a solution. Future research might explore the upstream antecedent processes involved in the finding, framing, and formulating of the wicked problems. Strategy scholars have alluded to several mechanisms likely involved in this process, including, among others, attention (Ocasio, 1997; Ocasio & Joseph, 2005), scanning, and sense-making (Hodgkinson & Healey, 2011; Teece, 2007; Zahra & George, 2002). Microfoundational research unpacking how these cognitive mechanisms operate to predict the emergence of comprehensive problem formulations would provide valuable insights. Alternatively, future research could explore concomitant processes inherent in solution development and value creation. This study focuses on individual cognitive mechanisms, effectively isolating the role of comprehensiveness and providing a foundation for future research. Nevertheless, individuals are embedded in groups, organizations, and institutional environments. Research exploring how wicked problem formulation and solution development operate across these various levels would provide additional insight (Ocasio & Joseph, 2005). Lastly, while we controlled for individual differences through random assignment and covariates, future research explicitly integrating individual differences, or as mentioned, group and organizational differences, could account for additional heterogeneity in solution development. For example, accumulated experiences, knowledge, and expertise are likely to interact with both comprehensive problem formulation and time constraints in predicting novelty and value.

The findings of this study have several implications for practice. Despite the importance of problem formulation, managers frequently overlook or inaccurately formulate strategic problems, resulting in a loss of value and time (Baer et al., 2013; Lyles, 1981; Mintzberg, 1973). We find problem formulation significantly impacts the value of the solution. Subsequently, a refocusing of managerial attention from solution development to problem formulation is warranted. The explicit consideration of problem formulation becomes increasingly relevant given the ubiquitous nature and competitive implications of wicked problems. In addition to refocusing attention on problem formulation, this study highlights a potential tool for overcoming the complexities of wicked problems. In contrast to processes of problem simplification and reduction, we identify the importance of broadening and maintaining problem comprehensiveness. Managers intentionally expanding the number of problem formulations when confronted with a wicked problem are likely to generate more valuable solutions. The cognitive constraints of the strategic actor also appear to play a meaningful role in determining the extent to which comprehensive problem formulation is effective, suggesting careful consideration is needed when determining an optimal level of comprehensiveness.

Wicked problem formulation and subsequent solution development are likely drivers of value creation and competitive advantage as organizations asymmetrically define problems and develop solutions. Indeed "problem formulation profoundly determines what problem is solved and ultimately the quality of the solution" (Baer et al., 2013, p. 198). Despite its recognized importance, problem formulation remains largely understudied. Our objective was to theoretically develop and empirically test the role of comprehensive problem formulation on the development of novel and valuable solutions. We find that the level of comprehensiveness in problem formulation significantly impacts the value of the solution generated. As such, this study represents an important initial step in unpacking the microfoundations underlying value creation and competitive advantage.

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TABLE 2.1

Correlations, Means, and Standard Deviations for Study Variables

	Variable	Mean	*S.D.*	1	2	3	4	5	6
1.	Novelty	3.17	1.50						
2.	Value	2.93	1.00	.57**					
3.	Comprehensiveness (1=low, 2=medium, 3=high)	1.98	.81	- .04	.03				
4.	Time (0=no constraint, 1=constraint)	.48	.50	-.13*	-.12*	-.01			
5.	Age	25.61	5.49	-.04	.01	.05	.10		
6.	Native English Speaker (0=yes, 1=no)	.18	.39	-.14*	-.26**	.01	.01	-.18**	
7.	GPA	3.47	.30	.03	.10	.08	.00	-.01	-.10

[a] The results based on 284 observations.

*p < .05

**p <.01

TABLE 2.2

Estimated Marginal Means by Condition

Problem Comprehensiveness

	Low	*S.E.*	Medium	*S.E.*	High	*S.E.*	Collapsed	*S.E.*
Novelty								
No Time Constraint	3.38	0.21	3.26	0.21	3.39	0.22	3.35	0.12
Time Constraint	3.03	0.22	3.15	0.21	2.72	0.23	2.97	0.13
Time Collapsed	3.21	0.15	3.21	0.15	3.05	0.16	3.16	0.09
Value								
No Time Constraint	2.81	0.14	3.22	0.13	3.09	0.14	3.04	0.08
Time Constraint	2.77	0.14	3.03	0.14	2.62	0.15	2.81	0.08
Time Collapsed	2.79	0.10	3.13	0.10	2.85	0.10	2.92	0.06

Means by Condition

Problem Comprehensiveness

	Low	*S.D.*	Medium	*S.D.*	High	*S.D.*	Collapsed	*S.D.*
Novelty								
No Time Constraint	3.40	1.69	3.27	1.56	3.38	1.53	3.35	1.58
Time Constraint	3.01	1.55	3.15	1.35	2.71	1.18	2.97	1.37
Time Collapsed	3.21	1.63	3.22	1.45	3.06	1.40	3.17	1.50
Value								
No Time Constraint	2.83	1.00	3.23	0.99	3.07	1.08	3.04	1.03
Time Constraint	2.74	0.87	3.04	1.00	2.62	0.94	2.81	0.95
Time Collapsed	2.79	0.94	3.14	1.00	2.86	1.03	2.93	1.00

TABLE 2.3

Analysis of Covariance

Novelty

Source	Univariate ANCOVA		
	df	*F*	η_p^2
Main Effect			
Comprehensiveness	2, 275	0.33	0.00
Time	1, 275	4.56*	0.02
Interactive Effect			
Comprehensiveness x Time	2, 275	0.85	0.01
Covariate			
Age	1, 275	0.54	0.00
Native English	1, 275	5.72*	0.02
GPA	1, 275	0.10	0.00

*$p < .05$
**$p < .01$

Value

Source	Univariate ANCOVA		
	df	*F*	η_p^2
Main Effect			
Comprehensiveness	2, 275	3.44*	0.02
Time	1, 275	4.26*	0.02
Interactive Effect			
Comprehensiveness x Time	2, 275	1.17	0.01
Covariate			
Age	1, 275	0.06	0.00
Native English	1, 275	20.46**	0.07
GPA	1, 275	0.26	0.01

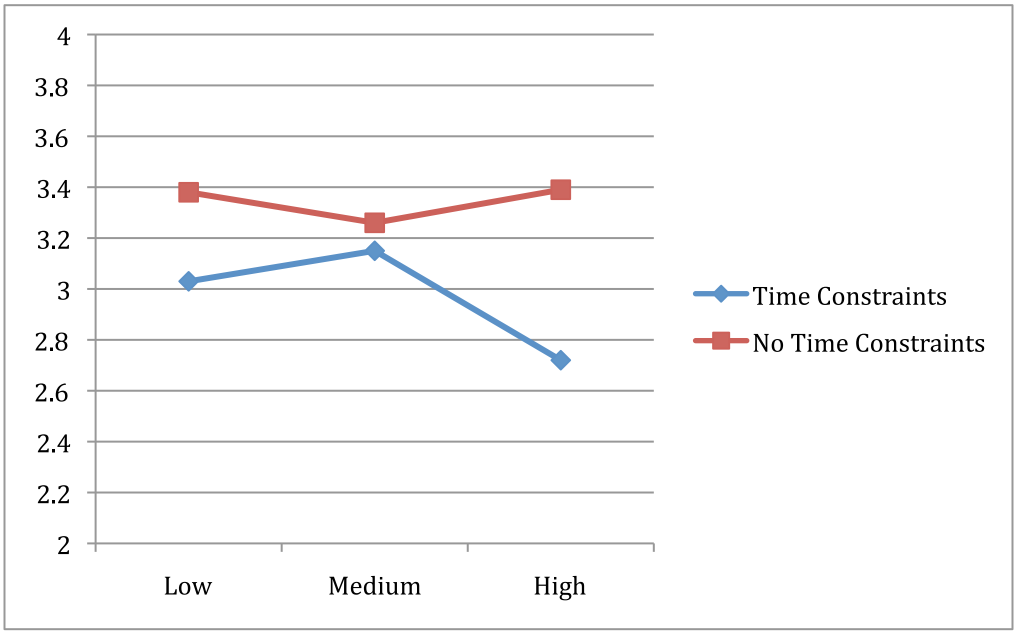
*$p < .05$
**$p < .01$

Level of Comprehensiveness in Wicked Problem Formulation

Nature of the Problem	Low	High
Simple	• Novelty – No Impact • Value – No Impact	• Novelty – No Impact • Value - Decreased (Wasted Resources)
Wicked	• Novelty – Decreased • Value - Decreased	• Novelty – Increased • Value - Increased

FIGURE 2.1: Problem Type and Comprehensiveness

Novelty



Value

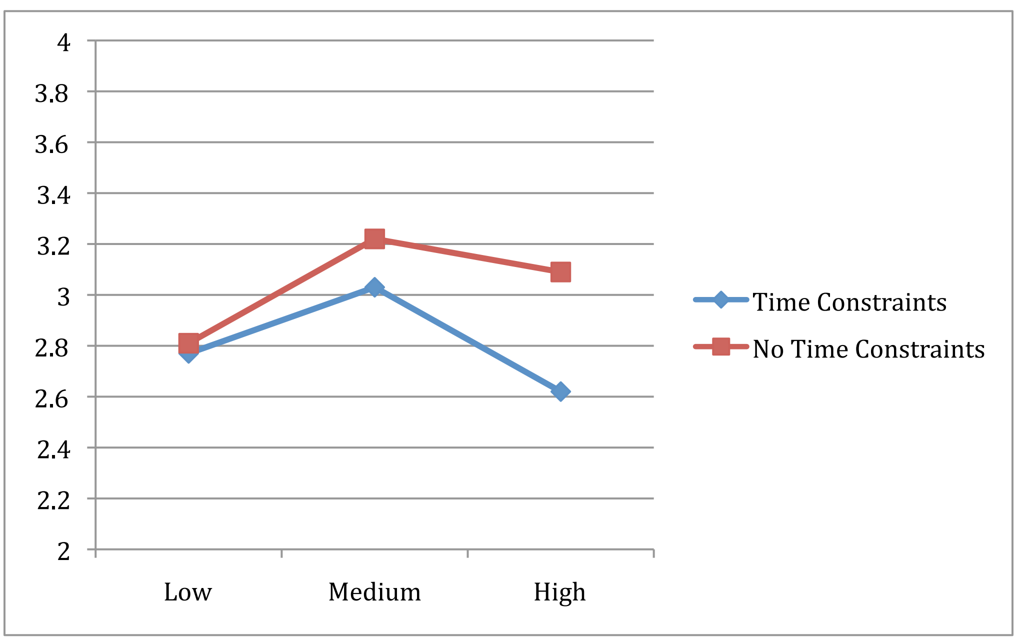


FIGURE 2.2: Estimated Marginal Means by Condition

Appendix

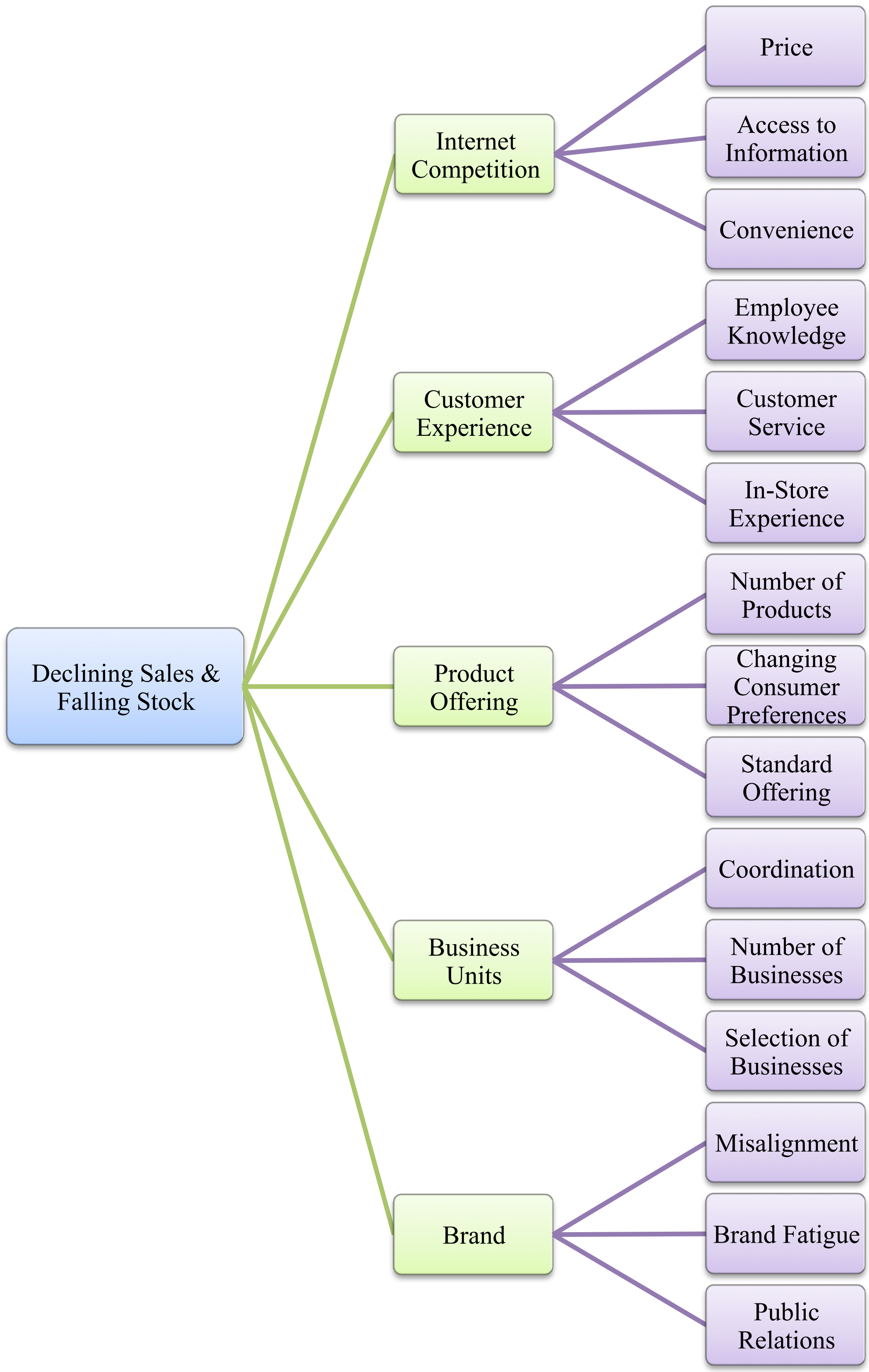


FIGURE 2.3: Hierarchical Illustration of the Wicked Problem

CHAPTER 3

EFFECTIVE AFFECT: ELUCIDATING MICROMECHANISMS OF VALUE-CREATING SOLUTIONS TO STRATEGIC PROBLEMS

Abstract

What are the antecedents of value creation and competitive advantage? A growing microfoundational literature provides several cognitive explanations, including experiential fragments, expectations, perceptions, and the imagination of possibilities. Scholars investigating the cognitive foundations of value creation, however, have largely ignored the influential role of affect in altering the storage, search, and recombination of knowledge elements. As such, extant models of value creation remain meaningfully underspecified. Leveraging NK landscape logic within the problem-finding problem-solving perspective, a model of how affect operates to enhance the generation of value-creating solutions is developed. Specifically, two separate cognitive mechanisms and their neurological correlates are identified producing systematic differences in both how knowledge search and recombination unfold and the types of solutions developed. Discriminating how specific affective states align with the proposed cognitive mechanisms as well as the types of solutions generated provides needed clarification and facilitates the integration of affect into micro-explanations of value creation.

"Feeling and longing are the motive forces behind all human endeavor and human creations."

- Albert Einstein

Introduction

The perpetual creation of novel and valuable solutions to the unique challenges faced by organizations is of central interest to strategic management scholars (Nickerson, Silverman, & Zenger, 2007; Teece, 2007; Teece, Pisano, & Shuen, 1997). Organizations able to identify and develop a continuous stream of novel and valuable solutions frequently enjoy superior performance and competitive advantage (e.g., Brown & Eisenhardt, 1997; Roberts, 1999; Verona & Ravasi, 2003). Indeed, given dynamic and complex environments, the importance of value creation in generating competitive advantages often outweighs that of value capture and protection (Rindova & Kotha, 2001; Teece, 2007; Teece et al., 1997). Scholars of dynamic capabilities, knowledge, and innovation have highlighted the need to explicate the underlying individual and cognitive processes involved in the generation of novel and valuable solutions (Baer, Dirks, & Nickerson, 2013; Felin & Hesterly, 2007; Hodgkinson & Healey, 2011; Teece, 2007). While microfoundational models of solution development have begun to unpack the specific cognitive processes involved, affect a likely moderator of these processes, is largely absent from existing explanations (Hodgkinson & Healey, 2011; Powell, Lovallo, & Fox, 2011). In contrast, the psychology literature documents the central role of affect in altering cognitive and neurological processes. Indeed, affect has been shown to have direct and pervasive impact on the storage, access, and recombination of information elements (Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007).

Subsequently, unpacking the role of affect in the generation of solutions to strategic management problems provides important insights into the microfoundations of value creation and competitive advantage.

Recent research within the microfoundation literature has begun to examine the cognitive foundations of value creation (Gavetti, 2005; 2012; Narayanan, Zane, & Kemmerer, 2010; Powell, 2011). For example, Felin and Zenger (2009) posit experiential fragments, perception, and the imagination of possibilities form the upstream antecedents of novel and valuable strategies. Although microlevel mechanisms are identified, the central role of affect in altering perceptions and/or enhancing the imagination of possibilities remains undeveloped. Similarly, Teece (2007) provides a framework of the microfoundations of sensing, seizing, and reconfiguring capabilities but makes no mention of how affect might impact these processes. Baron (2007) highlights a similar paucity of research investigating the role of emotion in entrepreneurial cognition. Indeed, microfoundational theories of value creation often omit the role of affect (Hodgkinson & Healey, 2011).

The creativity literature, however, directly explores the role of affect in solution generation. Creativity is frequently defined as "the generation of ideas, insights, or problem solutions that are both novel and potentially useful" (Baas, De Dreu, & Nijstad, 2008, p. 780). Subsequently, findings in the creativity literature regarding the moderating role of affect have the potential to inform value creation and competitive advantage. Empirical findings indicate broad support for the hypothesis of positive affect increasing creativity (e.g., Amabile, Barsade, Mueller, & Staw, 2005; Baas et al., 2008; Grawitch, Munz, & Kramer, 2003; Isen, 2002; Isen, Daubman, & Nowicki, 1987; Subramaniam, Kounios, Parrish, & Jung-Beeman, 2008). Nevertheless, the positive affect-creativity link has not gone unchallenged. Kaufmann and Vosberg (1997) identify negative consequences of positive affect on creativity. Moreover, others suggest a positive association between *negative affect* and creative outcomes (Carlsson, 2002; Vosburg, 1998). Finally, a combination of both positive and negative affect experienced either simultaneously (Fong, 2006) or over time (De Dreu, Baas, & Nijstad, 2008; George & Zhou, 2007) has been posited to enhance creativity. In summary, competing theoretical arguments and mixed empirical findings of the affect-creativity link obscure central operating mechanisms, thereby limiting integration into microfoundational theories of value creation. A cogent explanation is needed of how affect impacts both the cognitive processes involved in solution generation as well as the type of solutions these processes are likely to generate.

Building on the creativity and neuroscience literatures, this paper disentangles the mechanisms of affect posited to enhance the generation of value-creating solutions. By refocusing on the central operating mechanisms, a clearer picture emerges. Specifically, we identify two separate cognitive mechanisms and their corresponding neurological correlates (i.e., alpha band activity). Positive affect is argued to enhance solution generation by defocusing attention, relaxing predefined patterns of thought, and ultimately increasing the number of knowledge elements considered. Novel and valuable solutions generated though this mechanism are likely to demonstrate more variance - building on a larger set of distinct and seemingly unrelated knowledge elements (i.e., global solutions). Negative affect is posited to increase cognitive perseverance, focus, and optimization. Novel and valuable solutions developed through increased perseverance are likely to demonstrate a focused and narrow combination of knowledge elements (i.e., local solutions). The proposed model clarifies much of the confusion surrounding the affect-creativity link by unpacking the central operating mechanisms of affect and their resultant neurological correlates.

This paper advances understanding of the microfoundations of value creation. First, by highlighting the role of affect in altering knowledge recombination and information processes, we identify an additional source of heterogeneity in solution generation. Second, while psychology has explored the role of affect in creativity, ongoing debate and confusion with respect to the central operating mechanisms has limited its integration into theories of value creation. Subsequently, two separate cognitive mechanisms are identified, producing systematic differences in the types of solutions generated. Discriminating how specific affective states align with the proposed cognitive mechanisms as well as the types of solutions generated provides needed clarification and facilitates integration into the extant literature.

The remainder of the paper proceeds as follows. We begin with a brief review of the relevant literature exploring the relationship between novel and valuable solution generation, dynamic capabilities, and cognition. Second, through a series of formal propositions, we build a model explicating the cognitive mechanisms of both positive and negative affect. The neurological correlates of each mechanism are identified. Differences in the types of solution generated are also linked to the specific mechanisms. We conclude by highlighting implications for the microfoundational perspective and issuing a call for additional scholarly investigation in this area.

Solution Generation, Capabilities, and Cognition

The ability of an organization to perpetually create new value represents an increasingly important source of competitive advantage and firm survival (Brown & Eisenhardt, 1997; Roberts, 1999; Teece, 2007; Verona & Ravasi, 2003). New value is created as individuals within organizations identify value-creating problems, develop unique and valuable solutions, and implement these solutions in a competitive landscape (Baer et al., 2013; Nickerson, Yen, & Mahoney, 2011; Nickerson & Zenger, 2004; Teece, 2007; Volkema, 1983). As such, novel and valuable solution generation represents a critical component of value creation, firm heterogeneity, and competitive advantage.

Several theories within strategic management address the important question of value creation. Most prominent among these are the dynamic capabilities and organizational learning perspectives (Cohen & Levinthal, 1990; Teece et al., 1997; Zollo & Winter, 2002). Relaxing assumptions of equilibrium, the dynamic capabilities perspective shifts the locus of competitive advantage away from industry and/or resource attributes to organizational routines and capabilities. Firms better able to dynamically build, integrate, and reconfigure resources and capabilities in a changing competitive landscape are argued to generate new value and enjoy competitive advantage (Eisenhardt & Martin, 2000; Teece et al., 1997). Although the dynamic capability perspective provides insights into value creation by shifting the focus of attention to organizational routines, little theoretical explanation is provided as to how firms identify and select the specific routines or resource combinations (i.e., solutions).

Theories of organizational learning and knowledge provide additional insight into how novel and valuable solutions are generated. Prominent bodies of literature include absorptive capacity (Cohen & Levinthal, 1990), deliberate learning (Zollo & Winter, 2002), and exploitation/exploration (March, 1991). The majority of this literature explores organizational-level mechanisms involved in the identification, acquisition, transfer, and application of knowledge (see Argote, McEvily, & Reagans, 2003), critical components in the generation of novel and valuable solutions. Similar to the dynamic capabilities perspective, learning and knowledge theories of strategic management, while providing valuable insight into how value can be created through organizational level mechanisms, largely ignore the upstream cognitive antecedents of novel and valuable solution generation.

Recognizing the need for additional theoretical development, several scholars have begun to elucidate the microfoundations and psychological antecedents of both the dynamic capability and organizational learning perspectives (Abell, Felin, & Foss, 2008; Baer et al., 2013; Felin & Foss, 2005; Felin & Zenger, 2009; Gavetti, 2005; Teece, 2007; Tripsas & Gavetti, 2000). This body of research emphasizes the often-overlooked role of individual actors and cognition in determining organizational level outcomes. While the majority of strategy research resides at the firm level of analysis, important firm-level outcomes are often driven by heterogeneity arising at the individual level (e.g., Amit & Schoemaker, 1993; Felin & Hesterly, 2007; Tripsas & Gavetti, 2000). Abell et al. (2008) argue the majority of capability research within strategic management remains incomplete, building primarily on organizational-level models while neglecting individual factors "… to say that a firm has a certain capability is essentially shorthand for a complex set of underlying individual actions and interactions" (p. 492).

Several scholars have subsequently narrowed this line of inquiry further by exploring the upstream cognitive processes underlying problem identification and value creation. Research as early as Penrose (1959) appropriately foreshadowed the need for explicit integration of individual cognitive explanations of firm heterogeneity. For example, Penrose argues that services (e.g., resources and capabilities) in combination with managerial knowledge result in an idiosyncratic managerial image of the unique productive opportunities available to the firm. In short, organizational heterogeneity results not only from an organization's unique resources or capabilities but also the manager's experience and imagination of how those resources and capabilities might be combined to generate new productive opportunities (Alvarez & Busenitz, 2001; Gavetti, 2005; Gavetti, Levinthal, & Rivkin, 2005; Tripsas & Gavetti, 2000). More recently, Teece (2007) elucidates the microfoundations of the dynamic capabilities perspective, highlighting the importance of organizational routines in aiding individuals in the scanning and creative processes underlying capability development. Lastly, Felin and Zenger (2009) highlight the role of experiential fragments, perception, and the imagination of possibilities in developing novel and valuable strategies.

The problem-finding problem-solving perspective (Nickerson & Zenger, 2004) presents a burgeoning theoretical apparatus to address the microfoundations of novel and valuable solution generation. Novel and valuable solutions are developed as relevant information/knowledge is perceived, assimilated, recombined, and applied in response to a unique strategic problem or opportunity. Shifting the level of analysis to the strategic problem, Nickerson and Zenger (2004) argue novel and valuable solutions are developed as unique knowledge sets, with accompanying design choices that are both (1) searched and (2) combined. Building on NK landscape models of organizational fitness (e.g., Fleming & Sorenson, 2004; Kauffman, Lobo, & Macready, 2000; Levinthal, 1997), the authors posit both the number (N) and degree of interaction (K) of knowledge elements involved in the development of the solution play a central role in determining the decomposability of the problem, appropriate governance mechanism, and the overall value of the solution. Increased interaction among knowledge elements results in rugged landscapes and higher value solutions while decreased interaction among knowledge elements results in more smooth landscapes and lower value solutions.

Strategy scholars have appropriately identified the need to establish the microfoundations and individual level cognitive mechanisms influencing novel and valuable solution generation. Few studies, however, explore the underlying emotional/affective mechanisms influencing heterogeneity in the search, recombination, or imagination of possibilities, key components of solution generation. Indeed, the majority of extant microfoundation research adopts an information processing view of the individual/firm building on assumptions of dual-cognitive processes and bounded rationality (Hodgkinson & Healey, 2011). Focusing on the attributes of knowledge, its transferability, and/or recombination, the information processing view centers on rational or deliberate mechanisms while characterizing unconscious and affective processes as biases restricting optimal decision-making and performance. For example, Teece (2007) builds solely on arguments of deliberate learning and rational processes to establish the microfoundations of sensing and shaping new capability or resource combinations. The role of affect in altering these processes is not mentioned. Similarly, Nickerson (2007) highlights, among others, motivational factors *contaminating* efforts of problem discovery and identification.

The omission and/or systematic removal of affective mechanisms within the cognitive microfoundational research is particularly troubling given the well-documented effect of affect on the acquisition, storage, access, and recombination of knowledge elements (e.g., Amabile et al., 2005; Dreisbach & Goschke, 2004; Fredrickson & Branigan, 2005; Gasper & Clore, 2002; Isen, 2002; Rowe et al., 2007). Defending the role of positive affect in enhancing cognitive flexibility, Isen (2002) notes, "the most important goal of my comment… is to remind readers that one of the most robust and widely confirmed findings in the affect literature is that positive affect increases cognitive flexibility" (p. 57).

In summary, the perpetual creation of novel and valuable solutions to strategic problems represents a central component of value creation and competitive advantage. Individuals within organizations develop solutions as unique knowledge sets are both searched and combined. Empirical evidence establishes the influential role of affect in altering cognitive search processes and recombination. As a result, microfoundational research building solely on information processing models of solution generation remain critically underspecified, failing to account for the role of affect in knowledge search and recombination.

Mechanisms of Affect and Solution Development

The creativity literature provides valuable insights into the moderating role of affect. Creativity is often seen as the generation of ideas or problem solutions that are both original and valuable (Baas et al., 2008). As such, creativity likely plays an important role in perpetual value creation and competitive advantage. While a substantial body of literature has investigated the relationship between affect and creativity, conflicting theoretical arguments and mixed empirical findings have obscured how affect operates to enhance creative solution development. For example, positive affect has been shown to both increase (e.g., Amabile et al., 2005; Baas et al., 2008; Isen, 2002; Isen et al., 1987) and decrease creative idea generation (Kaufmann & Vosburg, 1997) while other research suggests *negative* affect promotes creative performance (Carlsson, 2002; Vosburg, 1998). Moreover, some scholars posit both positive and negative affect experienced either concomitantly (Fong, 2006) or over time (De Dreu et al., 2008; George & Zhou, 2007) serve to enhance creative solution generation. These discrepant findings within the creativity literature reveal a need to reexamine the underlying cognitive mechanisms posited to operate in creative idea generation. Refocusing on the cognitive mechanisms of the affect-creativity relationship allows for the identification of corresponding neurological correlates. The introduction of neurological correlates provides insights into the posited neurological processes, aids in clarifying competing theoretical explanations, and facilitates integration of affect into the micro-explanations of value creation.

Defocused Attention and Flat Associational Hierarchies

The creativity literature has identified several cognitive mechanisms posited to enhance the generation of novel and valuable solutions. One of the most widely acknowledged mechanisms is frequently associated with positive affect. The general consensus is positive affect strengthens creativity by both increasing the storage and retrieval of positive information (e.g., Isen, Clark, Shalker, & Karp, 1978; Murray, Sujan, Hirt, & Sujan, 1990; Snyder & White, 1982) and broadening or defocusing attention and cognition (Fredrickson, 2001; Fredrickson & Branigan, 2005; Gasper & Clore, 2002; Rowe et al., 2007). For example, Rowe et al. (2007) find empirical support that "positive states, by loosening the reins on inhibitory control, result in a fundamental change in the breadth of attentional allocation to both external visual and internal conceptual space" (p. 383). The broadening of relevant knowledge elements, resulting from positive affect, reduces the reliance on established heuristics or patterns of behavior and enhances search, cognitive flexibility, and adaptive thinking. As heuristics and established cognitive patterns are abandoned, distant and unconventional cognitions pulling from diverse knowledge sets obtained through a more global search are better able to recombine and emerge, thus enhancing creativity (De Dreu et al., 2008; Fredrickson, 2001; Fredrickson & Branigan, 2005; Rowe et al., 2007). Moreover, the relative facility to recall positively tagged information and broader categorization of information elements while in a positive affective state enhances the generation of novel and valuable combinations. Amabile et al. (2005) identify three benefits of positive affect: increased number of knowledge elements, defocused attention resulting in a broader integration of relevant elements, and enhanced cognitive flexibility.

Several studies adopting a wide range of designs have shown the beneficial effects of positive affect on creative performance. For example, Isen and colleagues find positive affect significantly impacts creativity in the recall of positively tagged information (e.g., Isen et al., 1978; Isen, Johnson, Mertz, & Robinson, 1985; Snyder & White, 1982), the generation of related words in an association task (Isen et al., 1985), the expansion and flexible classification of material (e.g., Isen & Daubman, 1984; Murray et al., 1990), and the richness and variety of experience observed (e.g., Kraiger, Billings, & Isen, 1989). Rowe et al. (2007) and Gasper and Clore (2002) find positive affect enhances the identification and incorporation of remote or global concepts, suggesting an increase in semantic access. Moreover, positive affect has been shown to enhance performance in both the remote association test (Isen et al., 1987; Rowe et al., 2007), frequently used to assess insight, and the alternative usage test (Isen et al., 1987), a common instrument for creativity.

In summary, positive affect is argued to enhance access, search, and recombination of knowledge elements by flattening associational hierarchies and defocusing attention. The relaxing of predisposed cognitive patterns and mental maps serves to break set and overcome functional fixedness, resulting in the generation of novel and valuable solutions. While this cognitive mechanism is implied in the creativity literature, the burgeoning field of neuroscience identifies specific neurological correlates associated with defocused attention and widened search.

Neurological correlates. Several methodologies (e.g., EEG, PET, fMRI) are used within neuroscience to provide insights into underlying cognitive processes (for a review, see Camerer, Loewenstein, & Prelec, 2004; 2005). Electroencephalography (i.e., EEG) is often used in the study of creativity (e.g., Bowden, Jung-Beeman, Fleck, & Kounios, 2005; Fink, Graif, & Neubauer, 2009b; Fink & Neubauer, 2006; Kounios et al., 2006). EEG techniques decompose electrical activity within the brain into six major frequency bands ranging from slow to fast: Delta, (1-3 Hz), Theta (4-7 Hz), Lower Alpha (8-9 Hz), Upper Alpha (10-12 Hz), Beta (13-30), and Gamma (31-50). Alpha represents the most dominant rhythm within the brain (Fink, Grabner, Benedek, Reishofer et al., 2009a; Fink, et al., 2009b) and plays a central role in divergent thinking and creative cognition (Fink, et al., 2009a; Fink et al., 2009b). Elevated alpha activity is associated with relatively lower states of cognitive arousal - increasing as cortical deactivation occurs (Goldman, Stern, Engel, & Cohen, 2002; Martindale, 1999; Martindale & Hines, 1975; Pfurtscheller, Stancak, & Neuper, 1996). Lower cognitive arousal is argued to enhance creativity by defocusing attention and flattening associational hierarchies, the precise mechanisms through which positive affect is argued to operate (Fink & Neubauer, 2006; Martindale, 1999; Pfurtscheller & Lopez de Silva, 1999). Subsequently, alpha synchronization (i.e. increase in band power/amplitude relative to a baseline) provides a useful metric for predicting the emergence of novel and valuable solutions through the broadening and defocusing of attention. As such,

> P1: Positive affect resulting in alpha synchronization increases the novelty and value of the solutions to strategic problems by defocusing attention and enhancing the cognitive flexibility of the strategic actor.

NK landscapes and global search. Solutions to strategic problems are developed as distinct knowledge sets with accompanying design choices are both searched and combined (Nickerson & Zenger, 2004). Accordingly, an NK solution landscape can be built from the number of knowledge elements considered in the development of the solution (N) and their interaction (K). A central argument of this paper is that the degree of novelty and value can be enhanced by both positive and negative affect, suggesting that in the absence of these enhancing mechanisms, individuals select default solutions occurring at a cognitive "sticking point," below both local and global optima of the landscape. As such, there are two possibilities for enhancing the generation of novel and valuable solutions: move up towards the local optimum (e.g., local search, peak climbing) or jump to another more distant global optimum (i.e., global search, peak jumping). A depiction of this can be seen in Figure 3.1.

By definition, solutions developed through peak climbing (i.e., local solutions), although demonstrating increased novelty and value, combine fewer knowledge elements, while solutions obtained through peak jumping (i.e., global solutions) implement a more diverse set of information. The distinction between peak climbing and peak jumping maps well to the solution-enhancing mechanisms of both positive and negative affect. Positive affect is argued to expand the solution landscape by defocusing and broadening attention providing access to additional knowledge elements, thereby increasing N. In addition, as established cognitive patterns are relaxed unique and valuable combinations are more readily observed. As a result, solutions developed while experiencing positive affect are more likely to represent peak jumping or global search, incorporating and combining a wider range of broad and diverse knowledge elements. Subsequently,

> P2: Positive affect resulting in alpha synchronization generates more global solutions to strategic problems

Increased Focus and Cognitive Perseverance

Proponents of the positive affect–creativity link assert that positive affect serves to broaden while negative affect serves to narrow attention and cognitive processes (e.g., Fredrickson & Branigan, 2005; Isen, 2002; Isen et al., 1987). This argument is frequently referred to as the cognitive tuning effects of affect with positive affect broadening, opening, loosening, and defocusing cognitive processes and negative affect, narrowing, closing, tightening, and focusing. The threat rigidity and conflict literature highlights the narrowing mechanisms involved in negative affect. For example, conflict and threats have been shown to increase physiological activation, resulting in a decreased sensitivity to peripheral or nonrelevant stimuli and an increased reliance on mental maps or active knowledge sets (e.g., De Dreu & Nijstad, 2008). Several creativity scholars have found these narrowing cognitive mechanisms to be deleterious in the generation of creative output (see Baas et al., 2008).

George and Zhou (2007), however, demonstrate that the cognitive tuning effects of affect might be more complex than previously thought. Indeed, a growing body of literature identifies an additional mechanism enhancing creative performance – specifically, increased focus and cognitive perseverance produced by negative affect (De Dreu et al., 2008; Kaufmann & Vosburg, 1997; Vosburg, 1998). Mood as information theory posits affect signals information about the external environment and appropriate responses (Martin, Ward, Achee, & Wyer, 1993; Schwarz & Clore, 1983). Subsequently, proponents of the negative affect-creativity link suggest positive mood signals a favorable environment prompting "looser, less systematic and less effortful information processing…" (George & Zhou, 2007, p. 606), resulting in a satisficing approach or premature abandonment of the creative task. Conversely, negative affect is posited to signal a less than optimal environment, resulting in a systematic effort to identify and address underlying causes (Martin et al., 1993). While acknowledging the advantages of positive affect, De Dreu et al. (2008) elucidate the often overlooked beneficial role of negative affect. "However, in addition to cognitive flexibility, it is possible to achieve creative fluency and originality through hard work, perseverance, and a more or less deliberate, persistent and in depth exploration of a few cognitive categories or perspectives" (De Dreu et al., 2008, p. 740). Dietrich (2004) and Boden (1998) identify these deliberate mechanisms as the "exploration of a structured cognitive space" (Dietrich, 2004, p. 1016). The focusing effect of negative affect results in increased perseverance. Vosburg (1998) posits perseverance achieved through negative affect enhances creative idea generation through optimization, a systematic analysis of possible ideas within a current knowledge set. Similarly, dual-pathway models highlight the two mechanisms of creative idea generation. First, positive affect enhances creative outcomes by increasing cognitive flexibility (e.g., broad focus, defocused attention) of individuals or alternatively, negative affect enhances creativity through the increased focus and effort on salient problem elements.

Neurological correlates. As with the broadening and defocusing mechanism of positive affect, specific neurological correlates associated with focusing and perseverance produced through negative affect can be identified. As mentioned, the synchronization of alpha rhythms represents an open state of lower cognitive arousal, facilitating access to broad associations and distant information (Fink & Neubauer, 2006; Martindale, 1999; Martindale & Hines, 1975). In contrast, desynchronization of alpha rhythms is a result of increased cognitive load, deliberate effort, or focused attention (Fink, et al., 2009b; Goldman et al., 2002; Martindale, 1999; Stipacek, Grabner, Neuper, Fink, & Neubauer, 2003). In short, alpha synchronizes as attentional processes broaden and desynchronizes with increased focus, effort, and cognitive load. Penfield and Jasper (1954) provide an early example of these effects while monitoring the EEG activity of Albert Einstein.

> Simple arithmetical operations cause no appreciable effect, but when a difficulty is encountered which requires special concentration, the alpha waves are blocked, to reappear promptly when the problem is solved.

> For example, Einstein was found to show a fairly continuous alpha rhythm while carrying out rather intricate mathematical operations, which, however, were fairly automatic for him. Suddenly his alpha waves dropped out and he appeared restless. When asked if there was anything wrong, he replied that he had found a mistake in the calculations he had made the day before. He asked to telephone Princeton immediately. (pp. 189-190)

In summary, while alpha synchronization provides a useful metric for the enhancing mechanisms of positive affect (i.e., broadening and defocusing attention), alpha de-synchronization represents an important indicator of the distinct yet beneficial mechanism of negative affect (increased focus, effort, cognitive perseverance). As such,

> P3: Negative affect resulting in alpha de-synchronization increases the novelty and value of the solutions to strategic problems by increasing focus and cognitive perseverance.

NK landscapes and local search. Negative affect is posited to result in peak climbing processes yielding local solutions (i.e., local optimum). Local solutions occur as cognitive sticking points on the solution landscape are abandoned for increasingly novel and valuable solutions on the same peak in the solution landscape. Negative affect enhances cognitive perseverance and optimization (e.g., George & Zhou, 2007; Kaufmann & Vosburg, 1997). Perseverance and optimization result in a rigorous culling of active knowledge sets exploring alternative novel and valuable combinations. Although the domain of knowledge is limited, combinatorial iterations are increased, producing novel and valuable solutions. Exploring deliberate processes of creativity, Dietrich (2004) identifies a similar mechanism: "while the deliberate mode allows the thinker to direct cerebral capacities to a particular problem, it has the disadvantage of limiting the solution space" (p. 1016). Similarly, De Dreu (2008) highlights the beneficial focusing mechanism in the conflict literature, positing conflict is beneficial in domains related to the conflict and deleterious in areas unrelated to the conflict. In short, negative affect is posited to produce a form of a mental collapse and magnification of the nuanced topography of a particular peak on the solution landscape, allowing for the selection of more valuable and novel solutions (i.e., peak climbing). As such,

> P4: Negative affect resulting in alpha de-synchronization generates more local solutions to strategic problems.

Discussion

A burgeoning interest in the cognitive foundations of value creation has revealed a need for a more fine-grained examination of the knowledge recombination and information processes underlying solution development (Baer et al., 2013; Gavetti, 2012). While psychology has identified the instrumental role of affect in altering information processing, ongoing debate and confusion has limited its integration into theories of value creation. Building on the creativity and problem-finding problem-solving literatures, this paper elucidates how affect influences knowledge search and recombination. Specifically, affect is posited to enhance solution generation through two separate mechanisms. Positive affect is argued to defocus attention and flatten associational hierarchies while negative affect is posited to increase cognitive effort and perseverance. Importantly, the neurological correlates of these two mechanisms are identified. Alpha activity is argued to synchronize as attentional processes broaden or defocus and de-synchronize with increased cognitive effort and perseverance.

A refocusing on the mechanisms of affect, and their neurological correlates, provides added theoretical precision and facilitates integration into theories of value creation. Specifically, the enhancing mechanisms of both defocused attention and increased perseverance are more cleanly identified by their neurological correlates (i.e., alpha synchronization/de-synchronization) than by their corresponding affective states. Indeed, much of the ongoing confusion regarding affect's influence on creativity arises from the complex, multidimensional nature of affect. Baas (2008) identifies several dimensions of affect, including hedonic tone (positive or negative), activation, and regulatory focus. Subsequently, the emergence of a particular mechanism (i.e., defocused attention, increased perseverance) is dependent not only on hedonic tone but rather all three dimensions of affect and their complex interactions. For example, negative affect is argued to enhance creativity through increased focus and perseverance. Implicit in this argument is a high level of activation. It is unlikely, however, that negative affective states exhibiting low levels of activation (i.e., sad, depressed) result in the posited focusing and perseverance mechanism. The proposed model, identifying the mechanisms of affect and their neurological correlates, effectively side steps the need to disentangle the multiple dimensions of affect and allows for a more accurate understanding of knowledge search and recombination.

Building on the logic of NK landscapes, the problem-finding problem-solving perspective suggests value-creating solutions are developed as knowledge elements on solution landscapes are both searched and combined. The identification of the neurological correlates associated with affect informs how the cognitive search of the solution landscape unfolds as well as its likely outcome (i.e., type of solution). Positive affect exhibiting alpha synchronization is argued to enhance the search of solution landscapes by relaxing mental maps and operating heuristics, resulting in more global solutions to strategic problems. Negative affect resulting in alpha de-synchronization is also argued to enhance solution search but through a narrowing of focus and cognitive perseverance, resulting in more local solutions to strategic problems.

Unpacking the specific operating mechanisms of affect has important implications for the problem-finding problem-solving perspective. Nondecomposable/high interaction problems are most effectively addressed through a heuristic, nonsequential search (Nickerson & Zenger, 2004). Subsequently, positive affect accompanied by alpha synchronization is likely to enhance global search and recombination, avoiding the cognitive sticking points inherent in nondecomposable problems. Decomposable/low interaction problems, in contrast, are better solved through directional and motivated search. As such, the iterative and focusing mechanism of negative affect and alpha de-synchronization likely benefit the development of solutions to more decomposable problems.

The proposed model also contributes to a microfoundational framework of dynamic capabilities (Gavetti, 2005; Teece, 2007). The dynamic capabilities perspective highlights the importance of perpetual value creation in firm performance and organizational survival. Central to this argument is managerial cognition and the organizational processes supporting the sensing, seizing, and reconfiguring of resources. The finding, framing, and formulation of problems and solution development within the problem-finding problem-solving perspective closely parallels the sensing, seizing, and reconfiguring of resources within dynamic capabilities. For example, Teece (2007) highlights the importance of "recognizing problems and trends, directing (and redirecting) resources, and reshaping organizational structures and systems" (pp. 1346-1347). The dynamic capability perspective centers on organizational routines aiding the flow of strategically relevant information to its managers. As such, the moderating role of affect in the storage, access, and recombination of knowledge provides valuable insights into the construction and implementation of these routines as well as their likely outcomes.

A more complete understanding of the cognitive processes underlying knowledge search and recombination has implications for the field of entrepreneurship. Entrepreneurship is primarily concerned with questions of value creation and has made progress in specifying the cognitive mechanisms involved in the entrepreneurial process. Indeed, entrepreneurial cognition has emerged as a valuable framework within the entrepreneurship literature (Mitchell et al., 2002). The identification of two operating mechanisms of affect and their corresponding neurological correlates meaningfully refines theories of entrepreneurial cognition by identifying an overlooked and influential moderator of knowledge search and recombination. For example, exploring the decision-making processes of entrepreneurs, Busenitz and Barney (1997) highlight systematic differences in knowledge search between managers and entrepreneurs. How affect impacts the search processes of both entrepreneurs and managers might be directly explored through the use of neuroscientific measures (i.e., alpha activity), providing additional insights into the cognitive processes involved. Felin and Zenger (2009) argue entrepreneurs represent theorists building from experiential fragments, perceptions, and the imagination of possibilities to develop novel strategies. Heterogeneity in entrepreneurial theorizing might also be more accurately modeled by directly accounting for affect and its neurological correlates.

Conclusion

Perpetual value creation has become increasingly relevant in the competitive landscape (e.g., Roberts, 1999; Teece, 2007). Indeed, "success requires the creation of new products and processes and the implementation of new organizational forms and business models, driven by an intensely entrepreneurial genre of management constantly honing the evolutionary and entrepreneurial fitness of the enterprise" (Teece, 2007, p. 1346). The dynamic capabilities and organizational learning literatures provide several insights into value creation but stop short of unpacking the cognitive processes underlying the "imagination" of novel and valuable solutions. The need for a more complete understanding of the antecedent cognitive processes driving value creation has resulted in a growing interest in the cognitive microfoundations of novel and valuable solution generation (Baer et al., 2013; Felin & Zenger, 2009; Gavetti, 2005; 2012; Teece, 2007). This body of literature directly investigates the operating mental models and heuristics involved in the scanning, search, and recombination of knowledge elements and experiential fragments. While progress has been made along these lines of inquiry, the significant role of affect in altering knowledge search and recombination has been largely overlooked. The omission of affect in microfoundational models of value creation greatly reduces theoretical precision and fails to account for a source of heterogeneity in the value-creation process.

Building on the problem-finding problem-solving perspective, we have identified two separate mechanisms of affect and their neurological correlates. Incorporating affect into extant models of value creation yields a more complete understanding of how knowledge search and recombination unfold. The identification of the neurological correlates associated with affect provides needed theoretical clarification and facilitates its integration into microexplanations of value creation. Subsequently, this paper represents an initial step in answering the call for more accurate models of cognition in the filed of strategy (Powell et al., 2011).

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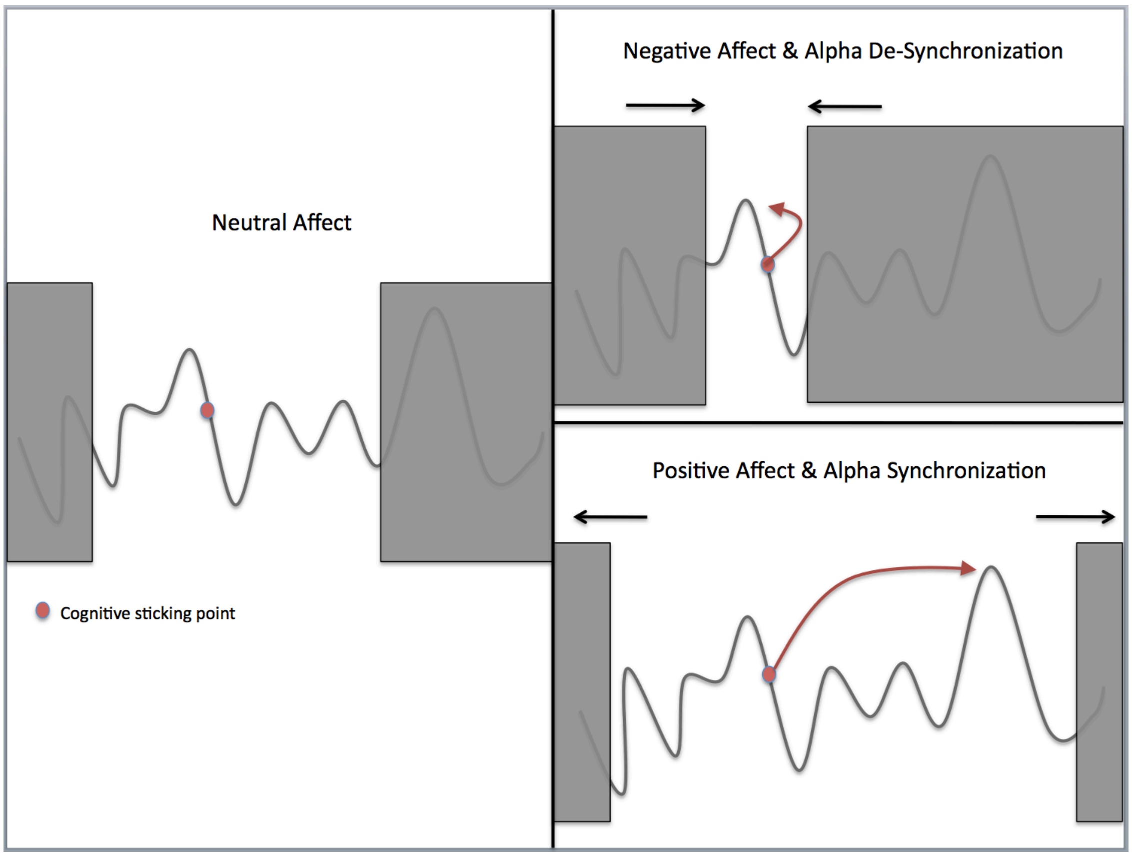

FIGURE 3.1: Affect and Solution Search on NK Landscapes

CHAPTER 4

ROUTINES, CREATIVITY, AND COMPETITIVE ADVANTAGES: ELUCIDATING NEUROLOGICAL MICROFOUNDATIONS OF VALUE CREATION

Abstract

A robust body of literature explores the role of organizational routines in creating value through the acquisition, reconfiguration, and application of knowledge. In contrast, how organizational routines foster in an organization's people the actual neurological genesis of novel and valuable solutions remains largely undeveloped. Leveraging NK landscape logic within the problem-finding problem-solving approach, this study theoretically develops and empirically tests organizational routines enhancing the generation of solutions to strategic management problems. A set of design goals is first identified, which when met, overcomes the impediments of novel and valuable solution generation (e.g., bounded rationality, mental maps, heuristics). Experimental methodologies are adopted from both neuroscience and cognitive psychology to examine the posited mechanisms. By elucidating the neurological correlates involved in knowledge search and recombination, organizational routines enhancing these mechanisms can be better theorized and tested, providing important insights into heterogeneous value creation and competitive advantage.

Introduction

An organization's ability to create new value in an ongoing way represents a fundamental component of competitive advantage (Nickerson, Silverman, & Zenger, 2007; Nickerson & Zenger, 2004; Roberts, 1999; Teece, 2007; Teece, Pisano, & Shuen, 1997). Indeed, some have argued that in dynamic and volatile environments, the importance of value creation frequently is a greater contributor to competitive advantage than value capture and protection (Eisenhardt & Martin, 2000; Rindova & Kotha, 2001; Teece, 2007; Teece et al., 1997). Individuals in organizations create value through finding, framing, and formulating problems, generating creative, novel, and feasible solutions, and subsequently implementing these solutions to generate revenue and capture economic rents (Baer, Dirks, & Nickerson, 2013; Nickerson, Yen, & Mahoney, 2011; Volkema, 1983). A central challenge for organizations is to generate new revenue and economic rents in a regular, repeatable, and continuous way.

Scholars from the dynamic capabilities and organizational learning literatures have begun to explore specific routines (e.g., dynamic capabilities, deliberate learning, absorptive capacity) for enhancing the perpetual creation of value through solutions such as those that involve acquisition, reconfiguration, and application of knowledge and capabilities (Cohen & Levinthal, 1990; Helfat & Peteraf, 2003; Helfat & Winter, 2011; Levitt & March, 1988; Rindova & Kotha, 2001; Teece et al., 1997; Zahra & George, 2002; Zollo & Winter, 2002). This body of research has overwhelmingly been focused on collective-level routines or processes and tends to be silent on the role of individuals in value creation (Felin & Hesterly, 2007). Recently, scholars have highlighted the need to elucidate heterogeneity arising from individuals to sufficiently explain how value is created by the organization, specifically how individual beliefs and cognition impact the perpetual creation of value (e.g., Abell, Felin, & Foss, 2008; Baer et al., 2013; Felin & Foss, 2009; Gavetti, 2005; Gavetti & Rivkin, 2007; Teece, 2007). Although research focusing on the microfoundations of strategic management has begun to theoretically establish the importance of individuals in creating value and competitive advantages, the microlevel mechanisms involved in this process have largely remained a black box. Indeed, none of the microfoundation research examines how routines foster in an organization's people the actual neurological genesis of novel and valuable solutions, a precondition for generating new revenue and surplus. If strategic management research is to enhance value creation, then understanding in detail how specific organizational routines spark underlying neurological processes to generate value-creating solutions is a necessary step (Teece, 2007). Indeed, understanding the interaction between routines and neurological activity involved in the development of solutions offers the potential for designing better routines in support of value creation. It is worth noting that while routines continue to play a central role in the fields of organizational theory and strategic management, a clear consensus as to their definition, level of analysis, and origins has not been reached (for a review see Becker, 2004; Felin & Foss, 2009). For the purposes of this study, routines are conceptualized as intentional and deliberately designed patterns of action.

The strategic management literature is relatively silent on how routines might impact neurological activity to enhance value-creating solutions. For example, the resource-based view highlights the role of "luck" or "managerial expectations" in value creation but provides little insight into how heterogeneous managerial expectations are formed or how routines might be leveraged in this process (Barney, 1986). According to Felin and Zenger (2009), experiential fragments, perception, and the imagination of alternative possibilities comprise the initial upstream determinates of value creation. Similarly, Gavetti (2005) explores how a manager's cognitive representation of a strategic problem influences the accumulation of organizational capabilities. Yet, despite the centrality of such psychological mechanisms in creating value, specific organizational routines that trigger in individuals the generation of novel and valuable solutions have not been sufficiently explored or developed in the strategic management literature.

In contrast, creativity scholars present several mechanisms that purportedly influence the generation of novel and valuable solutions. For instance, scholars have explored mechanisms such as brainstorming (Diehl & Stroebe, 1987; Osborn, 1957; Paulus & Yang, 2000), counterfactual priming (Galinsky & Moskowitz, 2000; Kray & Galinsky, 2003; Markman, Lindberg, Kray, & Galinsky, 2007), conflict/contradiction (Nemeth, Brown, & Rogers, 2001; Nemeth, Personnaz, Personnaz, & Goncalo, 2004), and incubation (Dijksterhuis & Meurs, 2006; Dodds, Ward & Smith, 2004; Hélie & Sun, 2010; Sio & Ormerod, 2009). Scholarly debate regarding the efficacy of these specific mechanisms, however, is ongoing and the creativity literature remains largely idiosyncratic, fragmented, and offers no organizational routines that leverage these mechanisms to enhance the generation of novel and valuable solutions to strategic problems.

The following study theoretically develops and empirically evaluates organizational routines for stimulating the neurological components of novel and valuable solution generation. Specifically, we begin by elucidating the cognitive and neurological processes of search and knowledge recombination as related to solution generation, highlighting the limitations of bounded rationality, mental maps, and heuristics. A set of design goals is identified, which when met through organizational routines, enhances the neurological mechanisms of novel and valuable solution generation. Routines leveraging contradiction mechanisms (i.e., counter arguments or presentations of conflicting frameworks prior to the development of the solution) are argued to increase active search and cognitive arousal, as mental maps are challenged and reassessed, thereby expanding the solution landscape through deliberate effortful processes. Organizational routines utilizing contradiction mechanisms are posited to result in neurological correlates of increased focus and cognitive effort, which suggests active solution search and purposeful mental reframing.

In contrast, routines incorporating incubation mechanisms (i.e., an abandonment of the solution search) are predicted to lower cognitive arousal and provide sufficient "space" to passively recombine unconscious coarse information in novel and valuable ways. Routines implementing incubation mechanisms are argued to result in neurological correlates of decreased cognitive activity, which suggests a quieting of active search and an increased ability to access remote and unconventional associations.

Routines incorporating both contradiction and incubation mechanisms have the potential to yield the most novel and valuable solutions. By explicating the neurological activity produced by these mechanisms, the optimal ordering or stages of the routine can be theorized. In particular, the neurological benefits of incubation mechanisms are enhanced if preceded by contradiction activities. Contradiction mechanisms explicitly challenge mental maps and heuristics, thus purposefully expanding the solution landscape, while incubation mechanisms allow individuals to release deliberate cognitive resources, thus further expanding the solution landscape and enhancing the combinatorial search of the newly expanded landscape. As such, a staged routine integrating contradiction mechanisms followed by incubation mechanisms is predicted to result in significantly more novel and valuable solutions by both (1) challenging and redefining mental maps, thus expanding the solution landscape and (2) providing the appropriate neurological conditions to enable passive expansion and combinatorial search.

In an experiment involving 120 students, we test the hypothesized routines by presenting a strategic problem and evaluating the novelty and value of the proposed solutions. Participants are randomly assigned to one of four routines: (1) problem presentation – solution generation – solution finalization, (2) problem presentation – contradiction mechanisms – solution finalization, (3) problem presentation – incubation mechanisms – solution finalization, and (4) problem presentation – contradiction mechanisms – incubation mechanisms – solution finalization. Neurological activity of a subset of the participants is monitored throughout the process using electroencephalography (i.e., EEG), providing an initial insight into the underlying neurological activity produced by the posited routines.

While we find no significant relationships between the routines and the novelty and value of the solutions generated, the elucidation of the cognitive processes underlying solution development represents an important first step in understanding how organizations create value. Specifically, by highlighting the importance of individuals and their underlying neurological dynamics, we develop and explore a previously overlooked component of an organization's ability to generate novel and valuable solutions. As such, this study contributes to recent efforts exploring the intersection of macro and micro models of value creation and competitive advantage (Abell et al., 2008; Baer et al., 2013; Gavetti, Levinthal, & Rivkin, 2005; Teece, 2007). The direct use of neuroscientific methodologies represents one of the first efforts to unpack how organizational level routines impact the neurological genesis of value-creating solutions. Moreover, the neurological findings provide valuable insights into possible explanations of the null-results, highlighting the utility of neuroscientific methodologies and guiding future research efforts to unpack the cognitive foundations of value creation.

The remainder of the study proceeds as follows. We begin with a brief review of the relevant literature in strategic management, neuroscience, and creativity. Second, through formal hypotheses, we develop organizational level routines for addressing challenges of solution generation (i.e., mental maps, heuristics, and bounded rationality) in support of value-creating solutions. Third, in an experiment, we test the proposed effectiveness of the various routines by evaluating the degree of novelty and value of proposed solutions. We conclude by analyzing results, reviewing implications for future research, and issuing a call for additional scholarly investigation in this area.

Microfoundations of Novel and Valuable Solutions

Value creation is achieved through the finding, framing, and formulation of relevant strategic problems, the generation of novel and valuable solutions, and their subsequent implementation (Baer et al., 2013; Nickerson et al., 2011; Volkema, 1983). Newly created value results in lower economic costs of operation and/or increased perceived value (Conner, 1991). Value creation plays a prominent role in answering central questions of strategic management. Firm behavior, scope, and performance are directly related to both a firm's ability to create value and subsequently protect and appropriate the recently created value. Given the increasingly dynamic nature of the business environment, an organization's ability to perpetually create value represents a central component of competitive advantage (Brown & Eisenhardt, 1997; Rindova & Kotha, 2001; Teece, 2007).

Despite the prominence of value creation, economic and sociological explanations within strategic management largely focus on mechanisms of value protection and appropriation, providing few insights into the value-creation process. For example, the resource-based view points to imperfect and incomplete factor markets as the source of value creation but remains relatively silent on the differences among firms in accessing the imperfect and incomplete markets beyond luck and/or superior managerial expectations (Barney, 1986; 1991). Similarly, organizational economics centers on governance mechanisms and/or incentive alignment in support of transaction efficiencies to reduce the loss of value between transacting parties, but provides few explicit insights into the creation of value itself (e.g., Williamson, 1979; 1985). As such, asymmetries in the generation of novel and valuable solutions to the strategic problems/opportunities frequently encountered in dynamic environments represent an often-overlooked source of value creation and firm heterogeneity.

Strategy, however, has not ignored the question of solution generation in its entirety. The dynamic capabilities and organizational learning literatures have begun to address the important question of how novel and valuable solutions are generated. Teece, Pisano, and Shuen (1997) establish the foundations of the dynamic capabilities framework by explicitly identifying the shortcomings of stable market assumptions, highlighting the role of dynamic routines (Nelson & Winter, 1982) or dynamic capabilities in addressing strategic problems and opportunities. Dynamic capabilities have been defined as the organizational processes to build, integrate, reconfigure, and redeploy resources or capabilities (Eisenhardt & Martin, 2000; Teece et al., 1997). As such, the dynamic capabilities literature suggests value-creating solutions result from an organization's ability to shuffle resources and capabilities to address relevant problems or opportunities. Although dynamic capability arguments facilitate conversations of value creation, by shifting the focus from stable to dynamic environments, the theoretical mechanisms of how the firm generates and selects specific reconfigurations (i.e., solutions) remain underdeveloped.

The knowledge and organizational learning literatures also provide insights into the generation of value-creating solutions. Prominent research streams within this literature include, among others, absorptive capacity (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Zahra & George, 2002), deliberate learning (Zollo & Winter, 2002) and exploitation/exploration (He & Wong, 2004; Katila & Ahuja, 2002; March, 1991). Much of this body of work focuses on collective level routines or processes aiding in the identification, acquisition, and transfer of knowledge. While collective level routines inform how organizational mechanisms might enhance value-creating solutions, they are less amenable to answering the questions of where and how the novel and valuable knowledge (i.e., solutions) originates. Similar to the dynamic capabilities literature, the majority of routines within the knowledge and organizational learning research stop short of examining the antecedents of value-creating solutions. One possible explanation for the reluctance of organizational scholars to open the black box of novel and valuable solution generation, an important antecedent of valuable and unique resources and competencies, is the shift in attention from macro organizational models of firm learning to the complex questions of individual cognitive processes. A complete understanding, however, of how unique and valuable solutions are generated necessitates a microfoundational perspective. At a basic level, *individuals* create value through the generation of novel and valuable solutions while operating within groups, organizations, and environments (Abell et al., 2008; Felin & Foss, 2005; Felin & Hesterly, 2007).

The problem-finding problem-solving perspective examines the interaction of organizational level processes and how individuals find, frame, and formulate problems, develop solutions, and implement the newly developed solutions (Baer et al., 2013; Nickerson et al., 2007; Nickerson & Zenger, 2004). By adopting the strategic problem as the unit of analysis, a theoretical apparatus integrating individual, group, and organizational mechanisms is achieved. "Here the critical question is not whether knowledge should be owned or acquired…but rather how a *manager* should organize *individuals* to generate knowledge that the *firm* seeks" (Nickerson & Zenger, 2004, p. 618). Subsequently, this literature successfully identifies and disentangles the role of individuals in creating value for the organization. For example, Baer et al. (2013) incorporate individual interests, informational structures, and cognitive sets with assumptions of bounded rationality to identify how individuals within groups can successfully identify valuable problems. As such, the problem-finding problem-solving literature approaches the locus of value creation, cognition, and neurological processes of problem formulation and solution search. However, how organizational level routines encourage the cognitive/neurological processes involved in the generation of novel and valuable solutions has yet to be explored. Indeed, organizational routines enhancing the breadth and depth of the solution search, as well as the combinatorial abilities of individuals, are likely to have a significant impact on the degree of novelty and value of the solutions generated.

Novel and Valuable Solution Generation (Models of Man, NK Landscape)

In developing organizational routines in support of novel and valuable solution generation, a foundational understanding of the neurological and cognitive processes involved is required. The origins of novel and valuable knowledge are frequently explained through search mechanisms of experience and/or asymmetrical perception. Building on Simon's (1962) work on complex systems as well as NK landscape models (Fleming & Sorenson, 2004; Kauffman, 1993; Levinthal, 1997; Rivkin, 2000), Nickerson and Zenger (2004) identify mechanisms whereby value-creating solutions are developed. Solutions are formed as distinct knowledge sets, with accompanying design choices, are (1) searched and (2) combined. The level of interaction between the knowledge sets applied to a given problem defines the topography of the solution landscape, a conceptualization of all possible solutions, with valleys representing low-value solutions and peaks representing high-value solutions. An increased level of interaction between knowledge sets results in rugged landscapes with higher value solutions. In contrast, limited interactions among knowledge sets result in flat landscapes and lower valued solutions.

Felin and Zenger (2009) provide a similar process of novel and valuable solution generation. Specifically, novel strategies (for our purposes, value-creating solutions) result as experiential fragments (i.e., knowledge sets) and perception lead to an imagination of possibilities (i.e., unique combinations) followed by a process of reasoning and justification. In summary, value-creating solutions are generated as individuals both search and identify relevant knowledge sets, the building blocks of solution generation, and recombine these knowledge sets to "imagine" unique and valuable solutions.

The complex cognitive processes underlying novel and valuable solution generation have historically been difficult to disentangle (Dietrich, 2007; Gabora, 2002). Numerous mechanisms operating on various levels of analyses constrain search and recombination. Particularly germane are those arguments related to the computational limits of the mind. Bounded rationality, mental maps, and heuristics provide lenses through which knowledge is filtered, stored, selected, and applied. Mental maps or relationships of extant knowledge sets provide structured cognitive representations of reality (Tversky, 2003). These cognitive maps aid individuals in the selection, filtering, and implementation of the vast amount of knowledge available. Given that individuals have limited capacity to evaluate full information (i.e., bounded rationally), mental maps are required and often beneficial (Gabora, 2002). Heuristics, cognitive shortcuts, serve as a type of cognitive hyperlink jumping to various associations within the mental map. Heuristics are frequently employed when cognitive demands require rapid and efficient resolution. Bounded rationality, mental maps, and heuristics, although surprisingly efficient at times, constrain the number of knowledge sets entering into the development of the solution landscape (Sandkühler & Bhattacharya, 2008). Individuals within organizations may possess relevant and valuable knowledge for addressing strategic problems but fail to incorporate this knowledge due to the bounded rationality of the actor, dominant mental map or previously developed heuristic. Moreover, mental maps and heuristics also impact the individual's ability to recombine this knowledge in unique and valuable ways as established patterns or knowledge set combinations are emphasized and repeatedly applied in the development of a solution (Gabora, 2002). Bounded rationality, mental maps, and heuristics represent impediments in the generation of novel and valuable solutions by both reducing the N, or number of relevant knowledge sets applied to a particular problem, and narrowing the imagination of how the knowledge sets may be recombined.

Adopting the assumptions that individuals are bounded rationally and conserve cognitive resources by implementing mental maps and heuristics, a set of design goals for enhancing the development of novel and valuable solutions can be posited. First, value-creating solutions can be more readily developed as the dampening effects of bounded rationality, mental maps, and heuristics are overcome. As such, an organizational routine activating previously obscured knowledge sets serves to rebuild and expand the solution landscape resulting in the potential for more novel and valuable peaks. Second, solutions are enhanced as individuals are able to effectively imagine or construct new and valuable combinations of knowledge sets. Organizational routines enhancing the combinatorial capabilities of the individual will ultimately result in the identification of the highest and most valuable peaks. In the following section, a series of organizational routines addressing these design goals are theoretically developed and empirically evaluated.

Hypotheses

The creativity literature provides insights into the generation of novel and valuable ideas. Common mechanisms explored include brainstorming, counterfactual mind-sets, devil's advocacy, conflict/contradiction, and incubation. A careful review of the creativity literature reveals significant overlap among mechanisms, as well as ongoing debate regarding their efficacy and relationships. For example, brainstorming, while extensively used to enhance idea generation, has received mixed empirical support (McGrath, 1984; Nemeth et al., 2004; Sutton & Hargadon, 2008). Moreover, the mechanisms of counterfactual mind-sets, devil's advocacy, conflict, and contradiction share common theoretical foundations. As such, this study focuses on elucidating and testing how contradiction and incubation mechanisms can be implemented in organizational routines to overcome the impediments of novel and valuable solution generation.

Contradiction mechanisms include counter arguments or positions representing conflicting mental frameworks. Several constructs within the creativity literature inform how contradiction mechanisms might operate to enhance the generation of novel and valuable solutions. Kray, Galinsky, and Wong (2006) suggest that counterfactual mindsets, an examination of past events in which an outcome may have turned out differently, aid in (1) structuring thought, (2) reexamining elements and relationships relating to the event, and (3) building solutions on existing knowledge structures. As questions of "what if" challenge extant mental representations, contradiction occurs. Dissent and conflict mechanisms closely parallel those of contradiction. Conflict scholars posit dissent and opposition enhance both the quantity and quality of ideas produced (Janis, 1972; Nemeth et al., 2004). Dissent and related mechanisms stimulate the consideration of additional information by directly challenging current solution formulations (Mitroff & Emshoff, 1979). Several studies provide empirical support for the role of dissent mechanisms in enhancing a "search for more information on all sides of an issue, a consideration of more strategies…more creativity and detection of solutions that otherwise would have gone undetected" (Nemeth et al., 2001 p. 708; see also, De Dreu & Nijstad, 2008; Nemeth et al., 2004).

A framework for integrating common theoretical arguments of the creativity literature is possible by adopting an NK solution landscape to elucidate the cognitive and neurological processes involved. Solution landscapes are formed as knowledge sets interact and combine to produce possible solutions. Subsequently, the degree of novelty and value of the solution can be enhanced by two underlying processes: first, increasing the number of knowledge sets employed in the development of the solution, and second strengthening the combinatorial ability to experiment with varied permutations of knowledge. As previously mentioned, bounded rationality, mental maps, and heuristics serve to limit the number of knowledge sets considered as well as possible combinations of knowledge. Contradiction mechanisms are posited to overcome the detrimental effects of mental maps and heuristics by deliberately disrupting and challenging extant mental frameworks. As alternative knowledge sets and combinations are suggested, solution landscapes are expanded and rebuilt. It is worth noting that dormant knowledge sets activated by contradiction mechanisms most likely reside in the individual but are either not structurally connected within the mental map or are skipped over by the operating heuristic.

Explicating cognitive processes enhanced by contradiction mechanisms provides an initial step in developing an organizational routine for enhancing value-creating solutions. Nevertheless, a more complete understanding of the neurological correlates of contradiction is needed. By stepping inside the black box of creativity, neuroscience provides apposite insights and precision into how contradiction mechanisms might operate. Specifically, neuroscience aids in answering questions of novel and valuable solution generation by providing objective measures for the neurological correlates of contradiction, insights into what these neurological correlates represent, and if they are distinguishable from other mechanisms of creativity.

Several creativity scholars have begun to leverage neuroscience to identify the specific neural pathways involved in the generation of novel and valuable ideas (e.g., E. M. Bowden, Jung-Beeman, Fleck, & Kounios, 2005; Dietrich, 2004; Fink, Graif, & Neubauer, 2009b; Gabora, 2002; Jung-Beeman et al., 2004; Sandkühler & Bhattacharya, 2008). A comprehensive review of the neurological structures and pathways involved in creativity is beyond the scope of the current investigation; however, a brief review of relevant structures is warranted (Arden, Chavez, Grazioplene, & Jung, 2010). Neuroscientists and decision theorists frequently offer a 2x2 matrix of cognition, resulting in four unique conditions (Camerer, Loewenstein, & Prelec, 2005; Hodgkinson & Healey, 2011; Kahneman, 2003). On the first axis, two systems of processing are frequently presented, system 1 representing spontaneous, parallel, unconscious processing and system 2 capturing deliberate, sequential, and effortful reasoning. On the second axis, the type of information is often distinguished, emotional "hot" and cognitive "cold." Building on a similar 2x2 matrix, Dietrich (2004) identifies four forms of creativity and their accompanying neurological structures and pathways. Four lobes of the brain are implicated in creative thought, the frontal lobe and the three "TOP" lobes, temporal, occipital, and parietal. The three TOP lobes are generally argued to be the site of long-term memory, as well as the location of sensory information. In contrast, the prefrontal cortex, located in the frontal lobe, is believed to serve as the executive region of the brain, integrating and evaluating information from the other regions of the brain, enabling higher functions such as self-reflective consciousness, abstract thinking, cognitive flexibility, and planning (Dietrich, 2004). Representing the end point of all four neurological pathways of creativity, the prefrontal cortex plays a central role in creative idea generation. Whether emotionally tagged or through system 1 or system 2 processes, unique and valuable information must arrive into the seat of consciousness and working memory (i.e., prefrontal cortex). "With its ability to sustain online processing in real time, the working memory buffer appears to be a prerequisite for cognitive flexibility, abstract thinking, strategic planning, access to long-term memory and sentience" (Dietrich, 2004 p. 1013).

Novel and valuable solutions are generated as relevant knowledge, determined by extant mental maps stored in long-term memory, is pushed into the prefrontal cortex. The prefrontal cortex, in turn, represents the site of mental mixing where knowledge sets are pulled in, rearranged, and tested. If an optimal solution is achieved, it is refined and expressed. By disrupting and challenging mental maps, contradiction results in more knowledge sets being pushed into and evaluated in the prefrontal cortex, effectively expanding the neurological representation of the solution landscape, resulting in an increased likelihood of novel and valuable solution generation.

The field of neuroscience relies on several techniques to study human brain functioning, including EEG, PET, and fMRI (for a review, see Camerer 2005). While each technique offers advantages and disadvantages, EEG provides superior temporal resolution and has been frequently employed in the study of creativity (E. M. Bowden et al., 2005; Fink, Grabner, Benedek, Reishofer, et al., 2009a; Fink & Neubauer, 2006; Jung-Beeman et al., 2004; Kounios et al., 2006). Raw EEG signals are often analyzed through decomposition into spectral elements or bands. These bands range from slow to fast, (i.e., Delta, (1-3 Hz), Theta (4-7 Hz), Lower Alpha (8-9 Hz), Upper Alpha (10-12 Hz), Beta (13-30), and Gamma (31-50)) and have been shown to correlate with specific brain functioning and processes (Goldman, Stern, Engel, & Cohen, 2002; Stipacek, Grabner, Neuper, Fink, & Neubauer, 2003). Differences in power (uV) between baseline activity and the activity during an interval of interest, event-related synchronization (ERS), or de-synchronization (ERD), provide a proxy for the cognitive activity produced by a given event. The deliberate focusing and evaluation of conflicting mental frameworks produced by contradiction is likely to be manifest in the alpha frequency band. Alpha activity has been shown to synchronize (i.e., increase) during a relaxed and open mental state and desynchronize (i.e., decrease) with increased cognitive load, deliberate effort, or focused attention (Fink & Neubauer, 2006; Goldman, Stern, Engel & Cohen, 2002; Martindale, 1999; Pfurtscheller, Stancak, & Neuper, 1996; Stipacek et al., 2003). Subsequently, contradiction is likely to result in alpha band de-synchronization as increased numbers of knowledge sets are actively recalled from long-term memory and mixed and evaluated in the prefrontal cortex. As such,

H1: Organizational routines implementing contradiction mechanisms elevate neurological activity associated with increased focus and deliberate cognitive effort (i.e., alpha ERD), suggesting a reevaluation of mental maps and an expansion of the solution landscape.

H2: Organizational routines implementing contradiction mechanisms increase the degree of (a) novelty and (b) value of solutions to strategic problems.

Contradiction mechanisms operate to overcome the dampening effects of mental maps and heuristics by promoting deliberate system 2 cognitive processing. As previously obscured knowledge sets are activated, thought is directed to a deliberate, effortful, and sequential search of their potential utility and recombination. Contradiction mechanisms, while designed to weaken the constraining effects of mental maps and heuristics, operate within the boundaries of effortful consciousness.

Incubation mechanisms provide an alternative method for the enhancement of novel and valuable solutions by activating additional knowledge sets and increasing the combinatorial ability of the individual. Incubation, a deliberate abandonment of the solution search, has been shown to impact the likelihood of insight and creativity (see Dodds et al., 2004; Sio & Ormerod, 2009). Insight occurs as an individual "breaks free of unwarranted assumptions, or forms novel, task related connections between existing concepts or skills (E. M. Bowden et al., 2005, p. 322). However, unlike solutions achieved through contradiction, insight produces novel and valuable solutions through system 1 processes of cognition, requiring little conscious effort and arriving seemingly spontaneously. Well-known anecdotes of both incubation and insight include Archimede's insight into buoyancy and Newton's law of gravity. The incubation and insight literatures present two prominent neurological mechanisms of how incubation might operate to enhance creativity.

Building on primary process cognition (Kris, 1952), associative hierarchies (Mednick, 1962), and defocused attention (Mendelsohn, 1976), Martindale (1999) presents a low arousal theory of creativity. Specifically, Martindale (1999) posits that as secondary or system 2 analytical processes are abandoned (i.e., incubation), primary or system 1 associative processes emerge, enhancing the generation of creative and novel ideas. The deliberate, narrow, and effortful search of system 2 processes is argued to overpower the quieter processes of system 1 cognition, prohibiting their integration into working memory (E. M. Bowden et al., 2005; Gabora, 2002). Only upon reaching an impasse in system 2 cognition, or abandoning the problem, can important primary cognition be utilized. "Primary process cognition, defocused attention and flat associational hierarchies are more likely to occur if an individual is in a state of low cortical arousal" (Fink et al., 2009a, p. 735).

Numerous studies have adopted the theory of low cognitive arousal, pointing to the high alpha band synchronization in the frontal, parietal, and occipital regions with emphasis on right hemisphere asymmetries for those subjects exhibiting increased creativity (E. M. Bowden et al., 2005; Dietrich, 2004; N. Jausovec & Jausovec, 2000; Jung-Beeman et al., 2004; Sandkühler & Bhattacharya, 2008). As mentioned, alpha band EEG activity represents a lower state of cognitive arousal and is assumed to increase as cortical deactivation occurs. Relying on both EEG and FMRI measures, Fink et al. (2009a) present an alternative explanation of the observed high alpha synchronization. In place of cortical deactivation, high alpha synchronization in the prefrontal region is posited to represent an active top-down restricting of external stimulus information, allowing for "free floating associations, mental imagery and planning" (von Stein & Sarnthein, 2000, p. 311). In short, once an impasse is reached, a mental umbrella, represented by alpha synchronization, allows increased internal recombination of knowledge elements. Fink et al. (2009a) also observed increased alpha synchronization in the right posterior regions of the brain.

Although mixed interpretations of the data remain, substantial empirical evidence establishes the connection between alpha synchronization and increased creativity with higher synchronization occurring in the right hemisphere (E. M. Bowden et al., 2005; Dietrich, 2004; N. Jausovec & Jausovec, 2000; Jung-Beeman et al., 2004; Sandkühler & Bhattacharya, 2008). Incubation is posited to increase the generation of novel and valuable solutions by increasing alpha synchronization. Building on the theory of low cognitive arousal, incubation serves to defocus attention and lower arousal, enhancing the generation of novel and valuable solutions through the unconscious recombination of knowledge sets. The loud thought processes of system 2 are quieted, enhancing the generation of novel and valuable combinations. Alternatively, building on the active theory of alpha synchronization, incubation is posited to aid in the establishment of the mental filter/switch by reducing external stimulus or loud system 2 mental processes, and providing an appropriate mental environment for free floating associations and mental imagery to occur. Both theories suggest incubation activates additional knowledge sets and enhances their recombination, thus increasing the generation of novel and valuable ideas. As such,

H3: Organizational routines implementing incubation mechanisms elevate neurological activity associated with low arousal and defocused attention (i.e., alpha ERS), suggesting an increase in combinatorial ability.

H4: Organizational routines implementing incubation mechanisms increase the degree of (a) novelty and (b) value of solutions to strategic problems.

Routines incorporating contradiction mechanisms are posited to directly disrupt and rearrange extant mental maps and heuristics, enhancing the generation of novel and valuable solutions as previously unconsidered knowledge sets are introduced. In contrast, organizational routines implementing incubation mechanisms are predicted to increase the generation of novel and valuable solutions by both passively activating additional knowledge sets and enhancing the combinatorial ability of the individual as the mind quiets, either through deactivation or an active cognitive filter. Although both contradiction and incubation are predicted to enhance the generation of value-creating solutions, it is important to note the distinct neurological mechanisms involved. Specifically, contradiction expands the solution landscape by increasing alpha ERD as additional knowledge sets are deliberately considered, while incubation results in a predominance of alpha ERS as conscious search of the solution landscape is abandoned. Given that each mechanism is predicted to enhance value-creating solutions, an organizational routine combining the beneficial yet disparate neurological activity of both contradiction and incubation has the potential to yield significantly more novel and valuable solutions than either one individually. Indeed, Gabora (2002) suggests that the creative process not only involves the use of system 1 associative cognition or system 2 analytic cognition, but "the ability to adjust the mode of thought to match the demands of the problem and how far along one is in solving it" (pp. 126-127). As such, although both types of cognition are beneficial at any given point in time in the solution generation process, one form of cognition and its subsequent enhancing mechanism (i.e., contradiction, incubation) may prove more effective than another, hinting at an underlying sequential ordering.

Creativity research provides some direction into how contradiction and incubation mechanisms might be meaningfully combined. Of particular note are those scholars presenting various stages within the creative process (Amabile, 1983; M. A. Bowden, 1990; Sawyer, 1999; Wallas, 1926). Although this body of literature hypothesizes underlying mechanisms, until recently, there has been no meaningful methodology to establish the neurological pathways involved or the specific benefits of contradiction and incubation (Sandkühler & Bhattacharya, 2008). In an effort to address this gap, Bowden et al. (2005) use visual-hemifield presentation, priming, and neuro-imaging techniques to identify three processes or stages of creativity and their salient neurological networks and patterns. The first process is comprised of initial processing of the problem and results in (1) strong activation of available information that is less likely related to the solution and (2) weak activation of information critical to the solution - "so weak that it is unconscious or unavailable for output" (E. M. Bowden et al., 2005, p. 324). Developing a spatial grid of memory locations, Gabora (2002) presents a similar model of strongly and weakly activated knowledge constellations with deliberate analytic thought producing strong narrow activations and defocused associative thought enhancing broad weak activations. The second process of Bowden's 2005 model represents an "integration of problem elements across relations or interpretations that are not dominant for the individual or are contextually biased…" (p. 324). Lastly, the third stage of creativity is identified when individuals *switch* from the strongly activated information to the unconscious activation of the weak information. Bowden et al. (2005) suggest that the right hemisphere of the brain is most likely the sight of the weak associations, coarse semantic information and associative cognition, while the left hemisphere is the location of the dominant interpretation, fine-semantic coding or analytical cognition. "Although normally effective this activation pattern makes the left hemisphere particularly vulnerable to misdirecting features of insight problems" (E. M. Bowden et al., 2005, p. 325).

The neurological mechanisms of contradiction and incubation map effectively to Bowden et al. (2005) processes of insight, providing justification of a four-staged organizational routine of novel and valuable solution generation. The first stage represents the presentation of the problem. As individuals within organizations are exposed to strategic problems, strong activations (i.e., knowledge sets) selected by extant mental maps and heuristics are activated. Mental maps and heuristics provide quick information relevant to the particular strategic problem but are unlikely to lead to unique and valuable solutions due to their frequent use and, more often than not, obscure novel and valuable "weak" associations. The second stage of the proposed routine consists of exposure to contradiction mechanisms. Contradiction mechanisms are posited to strengthen creativity by activating nondominant and previously overlooked knowledge sets resulting in a conscious and analytic cognitive search of an expanded solution landscape. The third stage of the routine incorporates incubation mechanisms. Incubation is suggested to directly aid in the development of creative solutions by providing an appropriate mental environment for the switching from analytic and strong associations to associative and weak associations. Free from the limitations imposed by dominant system 2 processes, the ability to recombine new knowledge sets in the newly expanded solution landscape is subsequently enhanced.

Novel and valuable solution generation is increased when contradiction mechanisms are followed by incubation mechanisms within the organizational routine. Contradiction mechanisms expand solution landscapes by deliberately increasing the number of knowledge sets and associations under consideration. Incubation, in turn, allows for unconscious weak associations to coalesce and integrate, thus further expanding the solution landscape and enhancing the recombination of the knowledge elements. Incubation mechanisms followed by contradiction mechanisms would result in an emergence of potentially novel and valuable “weak” combinations but from a much narrower solution landscape, having not passed through a process of contradiction. As such,

> H5: Organizational routines first expanding the solution landscape through contradiction mechanisms (i.e., active search, elevated alpha ERD), followed by incubation mechanisms or an abandonment of active search (i.e., passive search, elevated alpha ERS) result in more (a) novel and (b) valuable solutions to strategic problems than routines incorporating either contradiction or incubation alone.

Methods

Sample and Research Design

An experiment was used to test the proposed routines. Experimental methodologies effectively isolate variables of interest by controlling for potential confounds (Falk & Heckman, 2009; Shadish, Cook & Campbell, 2001). Subsequently, experiments are particularly beneficial in unpacking the cognitive foundations of a given phenomenon. Several microfoundational studies within the field of strategic management rely on experimental methodologies to investigate cognitive processes, including strategy selection and performance (Gary & Wood, 2011), anchoring in strategic investments (Shapira & Shaver, 2013), heuristics in the analysis of the competitive environment (Song, Calantone & Di Benedetto, 2002), and the transfer of knowledge in strategic decision-making (Gary, Wood, & Pillinger, 2012). This study develops a set of routines posited to operate on a neurological level to overcome the impediments of novel and valuable solution generation. As such, an experimental design is warranted.

Hypothesized routines were evaluated in an experiment involving 120 undergraduate business students from a large research institution. Two responses were excluded due to unintelligible solutions, resulting in a total sample of 118 participants (72 male and 46 female). Course credit was awarded for participation in the experiment. Participants were randomly assigned to one of the four routines. The novelty and value of the responses were evaluated by a panel of experts. Neurological activity of a subset of the participants (75) was recorded and aggregated across regions (frontal, centrotemporal, parietotemproal, occipital) and hemispheres (left, right). Excessive movement, forehead tension, and poor connections resulted in a total of 50 participants (35 male, 15 female) with usable EEG recordings. Moreover, technical complications and sampling biases in early data collection resulted in unequal group sizes. Subsequently, both the test and interpretation of the hypothesized neurological effects are limited as a result of the small sample size and unequal groups.

Problem Development and Procedures

The development of the strategic problem began by identifying real organizations facing complex, difficult problems with a wide range of novel and valuable solution possibilities. Six potential problems across multiple industries were examined. In order to evaluate the posited routines, a stylized description of each problem was developed and reviewed. Information regarding the companies' resources and capabilities was collected and presented at the end of each problem description. A final selection was made based on the adaptability of the problem to an experimental setting and its ability to generate meaningful variance in both the novelty and value of solutions. The resultant problem description placed participants in the position of a turn-around specialist at Bordet Electronics, a fictitious consumer electronics firm facing declining sales and falling stock prices. Several potential problem formulations were presented, including declining service, increasing competition, and an undifferentiated product offering. A short list of the company's most relevant resources and capabilities was included as well as specific instructions to develop a solution that was both novel and would create economic value.

Participants were randomly assigned to one of the four routines: (1) problem presentation – solution generation – solution finalization, (2) problem presentation – contradiction mechanisms – solution finalization, (3) problem presentation – incubation mechanisms – solution finalization, and (4) problem presentation – contradiction mechanisms – incubation mechanisms – solution finalization. All participants were first presented with the problem and instructed to explore and write initial ideas. Participants assigned to the first routine (neutral) were again presented with the problem and instructed to continue developing and formalizing a solution in their mind. Participants receiving the second routine (contradiction mechanisms) were presented with a video of five contradictory statements and were instructed to contemplate whether or not they agreed with the contradictions and what implications the contradictions might have for their final solutions. Participants assigned to the third routine (incubation mechanisms) were instructed to abandon the development of the solution and follow a short, guided relaxation video. Participants assigned to the fourth routine (contradiction and incubation mechanisms) first received the contradiction presentation followed by the incubation presentation. Next, all participants were again presented with the problem and instructed to write down their solution by responding to five questions: what is your idea for your new strategy, how do you intend to use the company's resources and capabilities to support your plan, what, if any, new resources or capabilities need to be developed or acquired, does your strategy involve expansion into other businesses or partnering with other companies, and how would your strategy position the company within the industry? Lastly, participants were asked to complete a brief demographic questionnaire.

EEG Procedure

An EEG was conducted on a subset of the participants to explore the posited neurological effects. Participants receiving an EEG were greeted by the researcher and oriented to the EEG process. Upon consent, participants were fitted with the EEG cap and given instructions to avoid excessive or repetitive movements. Participants were then instructed to keep their eyes open and focus on a white box on a computer screen for a period of 2 minutes. The recording for this interval served as the assessment of reference brain activity. A second recording was next conducted with the participants' eyes closed for a period of 2 minutes. Participants were then randomly assigned one of the four routines as described above. EEG recordings were also conducted for each participant during the activation interval according to the routine assigned (e.g., solution development, contradiction, incubation).

Manipulation

Routines. Each of the four routines began with the problem presentation and concluded with solution finalization. As a result, the manipulation occurred in the second stage of the routine and resulted in participants receiving solution development, contradiction, incubation, or contradiction followed by incubation. Solution development served as the neutral condition and consisted of a presentation of the problem and instructions to continue developing an idea mentally for 2 minutes and 30 seconds. Contradiction represented a 2 minute 30 second presentation of contradictory statements. Contradictory statements were developed by pretesting the problem description and identifying the five most common solutions. Subsequently, statements contradicting these five solutions were formulated and presented to participants one at a time. Incubation, or the abandonment of the task, was achieved through the presentation of a guided relaxation video approximately 4 minutes in length. Manipulation checks were conducted corroborating the effectiveness of contradiction and incubation manipulations.[3]

Dependent Variables

An expert panel (n=3) rated both the novelty and value of the solutions. Expert panels are frequently employed in the study of creativity (Amabile, 1990) and have been used to evaluate the value of strategic alliances (Lavie, Haunschild, & Khanna, 2012), the novelty and value of entrepreneurial ideas (Chua, 2013), and the innovativeness of solutions (Shepherd & DeTienne, 2005). Raters were selected based on education, managerial experience, and working knowledge of strategic management theory and practice.

[3] Participants who received only contradiction mechanisms reported their initial ideas were more challenged than those receiving only incubation mechanisms ($F_{1\ 55} = 5.31$, p = .03). Participants receiving only incubation mechanisms reported abandoning the task more than those assigned to only contradiction mechanisms ($F_{1\ 55} = 6.13$, p = .02).

Novelty. The novelty of the solutions was evaluated on a 7-point Likert-type scale with 1 representing a common or frequently proposed idea and 7 representing an uncommon or infrequently proposed idea. The greatest discrepancies among raters were resolved through discussion. Interrater reliability was high (α = .89); subsequently, the three novelty scores were averaged for each participant.

Value. Raters were first asked to evaluate how the proposed solutions would lower economic costs and/or increase the perceived benefits of the products or services. Solutions were then scored on a 7-point Likert-type scale in response to the question: how much economic value is the proposed solution likely to generate, where 1 represents no value and 7 represents significant value? The largest discrepancies among raters were again resolved through discussion. Interrater reliability was acceptable (α = .83); subsequently, the three value scores were averaged for each participant.

Alpha ERS / ERD. EEG signals were recorded with a Brainmaster Discovery DC amplifier by means of tin electrodes in an electrode cap with 19 positions arranged according to the international 10-20 system. Linked-ear electrodes (A1, A2) were used as a reference resulting in a monopolar montage. EEG signals were sampled at a frequency of 512hz and digitized to 256hz. A 50 & 60hz notch filter were applied to avoid power line contamination.[4]

Two intervals were used to calculate the alpha event-related synchronization/de-synchronization (ERS/ERD) scores for each participant, the reference interval (i.e., eyes

[4] The default setting in the Discovery Acquisition Software is a notch filter for both 50 and 60hz. Appropriate filtering of power-line artifacts should only use the corresponding filter for the geographic region (50hz-Europe & China, 60hz-United States). While, the application of both filters resulted in unnecessary distortion of the data around 50hz, the use of the 50hz notch filter should not impact the focus alpha-band activity (8-12hz) as it is far from the filter frequency.

open), and the activation interval assigned (i.e., solution development, contradiction, incubation). EEG recordings from both the reference and activation intervals were checked for artifacts resulting from muscle tension, eye blinks, and movement. Artifactual epochs were subsequently removed post acquisition via software (neuroguide) and excluded from further analysis. Band power (μV^2) was extracted for both lower alpha, *alpha1* (8-10 hz), and upper alpha, *alpha2* (10-12 hz) by means of a time-frequency analysis involving a fast Fourier-transformation (FFT) with a window size of 1000 ms and an overlap of 125 ms. Alpha1 and alpha2 have been shown to demonstrate different patterns of activation and are frequently distinguished in neurological studies of creativity (Fink, et al., 2009b; Jauk, Benedek & Neubauer, 2012; Sandkühler & Bhattacharya, 2008). ERS/ERD was used to quantify changes in cortical activity between the reference and activation intervals (Fink, et al., 2009b; Jauk et al., 2012; Pfurtscheller & Lopez de Silva, 1999; Sandkühler & Bhattacharya, 2008). ERS/ERD techniques provide robust measures of band-power and allow for the stabilization of variance through logarithmic transformations (Jauk et al., 2012; Pfurtscheller & Lopez de Silva, 1999). Paralleling Fink and colleagues (2009b), ERS/ERD was calculated at electrode *i* by subtracting the log-transformed power during the reference interval ($Pow_{i\ \mathrm{reference}}$) from the log-transformed power during the activation interval ($Pow_{i\ \mathrm{activation}}$) using the formula $\mathrm{ERS/ERD}_{(i)}=\log(Pow_{i\ \mathrm{activation}}) - \log(Pow_{i\ \mathrm{reference}})$. Subsequently, alpha synchronization (ERS) is indicated by positive values while alpha de-syncrhonization (ERD) is evidenced by negative values. Electrode positions were aggregated for statistical analyses as follows: frontal left (FP1,F3, F7), frontal right (FP2, F4, F8), centrotemporal left (C3, T3), centrotemporal right (C4, T4), parietotemporal left (P3, T5), parietotemporal right (P4, T6), occipital left (O1), occipital right (O2).

Covariates

Hand. The subset of participants receiving an EEG was comprised of both left- and right-hand dominant individuals; subsequently, a dummy code in the neurological analyses was used to account for the potential influence of hand dominance in the EEG recording.

EEG. Given not all participants received an EEG in the complete data set, a dummy code was used to disentangle potential effects of the EEG process in the novelty and value of the solutions.

Results

Hypothesized effects were evaluated through a series of ANCOVAs. Predictions of alpha ERS/ERD were first evaluated from a subset of data. The effects of the posited routines on the novelty and value of the solutions were then explored using the full data set. Means for all variables are shown in Tables 4.1 and 4.2. ANCOVA results examining alpha ERS/ERD are depicted in Table 4.3, while results for both novelty and value are shown in Table 4.4.

As previously mentioned, the small sample of participants with acceptable EEG recordings limits interpretation of the neurological findings, and greatly increases the chances of Type II error. Moreover, while ANCOVAs are somewhat robust to unequal group sizes, unmet assumptions in the smaller sample produced additional difficulties when interpreting results.[5] Recognizing these limitations, however, several trends were present, providing initial insights into the posited effects.

A comparison of alpha ERS/ERD between the neutral, contradiction, and incubation routines was used to test the hypothesized neurological effects. An exploratory examination of alpha ERS/ERD for both the contradiction and incubation stages of the combined routine can be found in the discussion section below. The impact of the routines on alpha ERS/ERD was evaluated by means of two ANCOVAs (alpha1, alpha2) for repeated measures with REGION (frontal, centrotemporal, parietotemproal, occipital) and HEMISPHERE (left, right) as within-subject variables and ROUTINE (neutral, contradiction, incubation) as a between-subject variable. In cases of violation of sphericity, a Greenhouse-Geisser correction was used.

ANCOVA results examining alpha1 indicated no significant multivariate, within-subject or between-subject effects. Planned contrasts between the contradiction and neutral routines ($F_{1\ 33} = .08$, $p > .05$, $\eta_p^2 = .00$), and the incubation and neutral routines ($F_{1\ 33} = .78$, $p > .05$, $\eta_p^2 = .02$) also revealed no significant main effects. Moreover, no significant interactions were observed. Subsequently, with respect to alpha1, no support was found for hypothesis 1, routines implementing contradiction mechanisms result in alpha ERD, or hypothesis 3, routines implementing incubation mechanisms result in alpha ERS.

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[5] Several assumptions of repeated measure ANCOVAs were not met. Specifically, Levene's Test was significant for several variables in the ANCOVA examining alpha2, suggesting heterogeneity of error variance across groups. Box's Test of Equality of Covariance Matrices was also significant for the ANCOVA evaluating alpha1. Lastly, Macuhly's Test of Sphericity was significant for the ANCOVAs examining both alpha1 and alpha2, indicating a violation of sphericity.

The ANCOVA examining alpha2 also yielded no significant multivariate or within-subject effects. A significant between-subject main effect for ROUTINE was identified ($F_{2\ 33} = 5.01$, $p <.05$, $\eta_p^2 = .23$). Subsequently, planned comparisons of the main effects of ROUTINE were conducted to test the hypothesized effects. A planned contrast between the contradiction and neutral routines indicated no significant main effect ($F_{1\ 33} = .24$, $p >.05$, $\eta_p^2 = .01$). However, a planned contrast between the incubation and neutral routines revealed a moderately significant main effect ($F_{1\ 33} = 3.81$, $p < .10$, $\eta_p^2 = .10$). As such, with respect to alpha2, no support was found for hypothesis 1, routines implementing contradiction mechanisms result in alpha ERD, while moderate support was found for hypothesis 3, routines implementing incubation mechanisms result in alpha ERS. As suggested by the statistically insignificant interactions, the routine assigned did not result in distinct topographical patterns of alpha synchronization within regions ($F_{2.96\ 48.91} = .57$, $p >.05$, $\eta_p^2 = .03$), hemispheres ($F_{2\ 33} = .196$, $p >.05$, $\eta_p^2 = .01$), or both ($F_{5.50\ 90.69} = 1.16$, $p >.05$, $\eta_p^2 = .07$). Graphs depicting alpha ERS/ERD according to routine, region, and hemisphere can be see in Figure 4.1.

Hypothesized effects of routines on the novelty and value of solutions were evaluated on the full data set through a series of ANCOVAs. ANCOVA results evaluating novelty indicated no significant main effect for routine on the novelty of the solution ($F_{3\ 113} = .39$, $p >.05$, $\eta_p^2 = .01$). Planned contrasts between the solution development (i.e., neutral) and contradiction routines ($F_{1\ 113} = .02$, $p >.05$, $\eta_p^2 = .00$) as well as solution development and incubation routines ($F_{1\ 113} = .97$, $p >.05$, $\eta_p^2 = .01$) also revealed no significant main effects. These findings indicate no support for hypothesis 2a or 4a. Planned contrasts between the combined routine (i.e., contradiction and incubation) and contradiction routine ($F_{1\ 113}$= .16, p >.05, η_p^2= .00) as well as the combined routine and the incubation routine ($F_{1\ 113}$= .20, p >.05, η_p^2= .00) also revealed no significant main effects. Subsequently, no support was found for hypothesis 5a.

ANCOVA results examining value demonstrated no significant main effect for routine ($F_{3\ 113}$= .82, p > .05, η_p^2= .02). Planned contrasts between solution development (i.e., neutral) and contradiction ($F_{1\ 113}$= .79, p >.05, η_p^2= .01), and solution development and incubation ($F_{1\ 113}$= 2.03, p >.05, η_p^2= .02) again demonstrated no significant main effects. Subsequently, no support was found for hypotheses 2b or 4b. Finally, planned contrasts between the combined and contradiction routine ($F_{1\ 113}$= .41, p >.05, η_p^2= .00) and combined and incubation routine ($F_{1\ 113}$= 1.35, p >.05, η_p^2= .01) yielded no significant main effects, indicating no support for hypothesis 5b.

Discussion

The generation of novel and valuable solutions to the unique challenges facing organizations represents an important component of value creation and firm performance (Baer et al., 2013; Teece, 2007). Leveraging NK landscape logic within the problem-finding problem-solving framework, this study theoretically develops and tests a set of organizational routines posited to enhance the neurological processes underlying solution generation. Bounded rationality, heuristics, and mental maps are identified as impediments of novel and valuable solution development, restricting both the number of knowledge sets applied in the development of the solution as well as how the knowledge sets may be recombined.

Contradiction mechanisms are posited to reduce the dampening effects of heuristics and mental maps by directly disrupting and challenging extant mental maps, resulting in an expansion of the solution landscape and enhancing solution generation. Alpha ERS/ERD has been shown to be sensitive to cognitive load, deliberate effort, and focused attention (Fink & Neubauer, 2006; Martindale, 1999; Pfurtscheller & Lopez de Silva, 1999). Subsequently, alpha ERD is hypothesized to be a neurological indicator of the deliberate refocusing and reevaluating produced by contradiction. Results indicated no support for the hypothesis, organizational routines implementing contradiction mechanisms result in alpha ERD. One potential explanation may be the degree to which contradiction disrupted and challenged extant mental maps. A preliminary review of the solutions developed by participants receiving the contradiction routine indicated little disruption of mental maps and heuristics. Frequently, solutions developed in the contradiction routine were comprised of a restatement of one or more of the five contradictory arguments. As suggested, contradiction likely challenged initial ideas; however, rather than initiating a deliberate and effortful reevaluation of mental maps, solutions demonstrated a simple adoption of the proposed contradictions. Subsequently, few additional knowledge sets were introduced in the development of the solution, resulting in a limited expansion of the solution landscape.

Neurological findings also offer potential insights into the extent to which contradiction challenged existing mental maps. While not significant, participants receiving contradiction demonstrated increased levels of alpha2 ERD across all regions, hinting at a small increase in cognitive effort and focus (see Figure 4.1). This alpha2 ERD may represent an initial contradiction and subsequent switching of mental maps. Moreover, the relatively small size of the effect may be evidence of limited reevaluation.

Contradiction resulting in a deliberate and extended reevaluation of knowledge sets would be more likely to demonstrate significant alpha ERD.

Organizational routines leveraging incubation are posited to enhance the generation of novel and valuable solutions through largely unconscious and spontaneous cognitive processes (i.e., system 1 cognition). The purposeful abandonment of the solution search results in a quieting of active knowledge sets, reveals previously obscured knowledge, and facilitates recombination. Alpha ERS is argued to be a neurological indicator of incubation processes as it has been shown to increase with defocused attention and lower cognitive arousal. Findings indicate moderate support for hypothesis 3, predicting organizational routines implementing incubation mechanisms result in alpha ERS. As seen in Figure 4.1, incubation routines demonstrated a relatively large alpha2 ERS across all regions of the brain, while the other routines resulted in alpha2 ERD. Moreover, an exploratory analysis indicated incubation resulted in a significant alpha2 ERS in the right centrotemporal region ($F_{1\ 45}$= 6.74, p <.05, η_p^2= .13). Previous research investigating creative performance has documented similar alpha2 ERS in the right hemisphere (Fink, et al., 2009b). Taken together, these findings suggest incubation increases alpha2 ERS.

Hypotheses 4a and 4b predict incubation will enhance the generation of novel and valuable solutions. No support, however, was found for the effects of incubation on novelty and value. As indicated by the presence of alpha2 ERS, incubation mechanisms most likely resulted in defocused attention and lower states of cognitive arousal. As such, it is unclear why incubation failed to enhance solution generation. One potential explanation may be the cognitive processes preceding the incubation stage of the routine.

The incubation routine is comprised of three stages: problem presentation, incubation, and solution finalization. Incubation is posited to enhance solution generation through the unconscious and spontaneous recombination of knowledge sets. An underlying assumption in this process is that problem and relevant knowledge sets are effectively activated in the mind prior to incubation. Indeed, if few problem-related knowledge sets are activated before incubation, unconscious recombination is unlikely to enhance solution generation. Recombination may be occurring, but with knowledge sets unrelated to the problem. In order to activate problem-related knowledge sets in this study, participants were presented with the problem and were instructed to write down their initial ideas during the problem presentation stage of the routine. A review of the data, however, reveals 30% of the participants failed to provide any initial ideas, which may suggest insufficient activation of problem-related knowledge sets. A neurological measure of cognitive engagement during the problem presentation stage would prove helpful in ensuring sufficient activation prior to incubation.

Routines first expanding the solution landscape through contradiction then enhancing the recombination of the newly expanded landscape through incubation were argued to produce more novel and valuable solutions than either contradiction or incubation routines alone. Results indicate, however, no support for this hypothesis. Possible explanations as to why the combined routine failed to enhance solution generation may parallel those presented above: contradiction was less effective at disrupting mental maps, insufficient activation of problem-relevant knowledge sets prior to incubation, or a potential interaction between insufficient contradiction and knowledge set activation.

An exploratory examination of the neurological results for the combined routine reveals interesting trends and raises additional questions. Alpha2 ERS/ERD for both the contradiction stage and incubation stage of the combined routine can be seen in Figure 4.2. As depicted, alpha2 ERD for contradiction in the combined routine closely parallels the alpha2 ERD in the contradiction only routine. This similarity is to be expected and corroborates findings with respect to contradiction. Interestingly, the alpha2 ERS for the incubation stage of the combined routine demonstrated a noticeably different trend when compared to the incubation only routine. Specifically, incubation when preceded by contradiction resulted in almost no alpha2 ERS across all regions of the brain. It would appear participants receiving the combined routine were unable to access the solution enhancing benefits afforded by defocused attention and lower cognitive arousal. The effectiveness of the combined routine centers on the sequential introduction of two separate yet beneficial neurological conditions, a deliberate and effortful reevaluation and expansion of the solution landscape as evidenced by alpha ERD, followed by a relinquishing and passive recombination of the newly expanded landscape, as evidenced by alpha ERS. Subsequently, the apparent difficulty of transitioning from the neurological conditions produced by even small degrees of contradiction to those produced by incubation represents an important phenomenon hindering the effectiveness of routines leveraging both mechanisms. Additional research exploring this cognitive inertia is needed.

This study contributes to the growing microfoundational literature exploring the cognitive foundations of value creation and competitive advantage (e.g., Gavetti, 2005; Gavetti et al., 2005; Teece, 2007). While few significant effects were observed, a theoretical explanation of both the impediments and beneficial neurological processes underlying the generation of novel and valuable solutions was developed. Specifically, a set of organizational routines enhancing the neurological conditions of solution development was explored. Additionally, neurological correlates of the central operating mechanisms within each routine were identified and tested.

Recent research within the organizational learning and dynamic capabilities literatures has emphasized the need to incorporate the role of individuals and managerial cognition in the value-creation process (Felin & Hesterly, 2007; Gavetti, 2005; Helfat & Peteraf, 2003; Teece, 2007). For example, Teece (2007) explores how organizational routines operate to both filter and direct information to strategic decision makers. This study extends microfoundational explanations of dynamic capabilities by exploring how routines alter the evaluation and synthesis of information in the cognitive processes of the strategic actor. Specifically, routines were shown to meaningfully alter the neurological activity underlying solution development, highlighting a potential source of heterogeneity in the value-creation process.

This research also contributes to the problem-finding problem-solving literature. By explicitly recognizing the importance of solution generation in value creation, the problem-finding problem-solving perspective provides a theoretical framework for investigating the individual cognitive processes involved. Solutions to strategic problems are generated as knowledge elements are searched and recombined on solution landscapes (Gavetti, 2005; Nickerson & Zenger, 2004). This study develops and tests a set of organizational routines influencing how the search and recombination of knowledge elements unfold. Moreover, specific neurological correlates were identified facilitating the measurement of the posited search processes and providing opportunities for future empirical verification. Nondecomposable/high interaction problems represent difficult challenges, resulting in a need for nonsequential search (Nickerson & Zenger, 2004). Routines leveraging contradiction followed by incubation would likely be effective at addressing nondecomposable problems by first expanding the solution landscape and subsequently enhancing recombination.

The lack of support for many of the hypotheses in this study indicates a need for additional research. First, activation of problem-related knowledge elements is required for the enhancing mechanisms of both contradiction and incubation to be effective. Future research directly measuring cognitive engagement during this stage of the routine would aid in identifying and resolving this potential problem. Second, the contradictory statements resulted in a small but insufficient reevaluation of mental maps and heuristics, indicating the need for further development. Research leveraging neuroscientific methodologies may again provide insights by disentangling the various types and effects of contradiction. Lastly, factors influencing the transition between the neurological conditions produced by contradiction to those produced by incubation merit investigation. As mentioned, participants receiving the combined routine demonstrated noticeably lower levels of alpha ERS during the incubation stage than those receiving the incubation routine. This finding suggests the emergence of a cognitive inertia limiting the usefulness of the combined routine.

This study presents several promising avenues for future research. Solution development represents only one stage in the value-creation process, indicating possibilities for additional research exploring the antecedent events of finding, framing, and formulating problems or opportunities. As with solution development, alpha synchronization may provide a useful indicator of the attention, scanning, and sense-making processes identified in microfoundational explanations of organizational learning and dynamic capabilities (Hodgkinson & Healey, 2011; Ocasio & Joseph, 2005; Zahra & George, 2002). Specific organizational routines and structures enhancing these processes may then be theorized and tested (Gavetti, 2005; Teece, 2007). Moreover, as suggested by the insight literature, gamma band EEG activity may reliably indicate the moment of insight or recognition of a value-creating opportunity. Finally, while experimental methodologies allow for the clean identification and measurement of neurological processes, field research establishing the findings across various contexts would provide valuable insights.

Conclusion

An organization's ability to identify new problems and develop value-creating solutions plays a central role in firm performance and survival (Baer et al., 2013; Brown & Eisenhardt, 1997). As competitive environments become increasingly complex and dynamic, sources of competitive advantage emerging from the cognitive processes of knowledge search and recombination become more salient. In place of defensible industry positions, or asymmetries in factor markets, competitive advantage centers on an organization's ability to perceive and reconfigure resources and capabilities to addresses new problems and opportunities (e.g., Augier & Teece, 2009; Teece, 2007). Organizational-level routines significantly influence the filtering and flow of relevant strategic information. Strategic actors, however, ultimately process the information and develop value-creating solutions. The microfoundational literature has begun to investigate the cognitive foundations of value creation, but stops short of identifying the specific neurological processes involved. Building on the problem-finding problem-solving and neuroscience literatures, a set of organizational routines enhancing the neurological conditions underlying solution development was developed and tested. Moreover, neurological correlates were identified providing an additional level of precision for investigating the knowledge search and recombination processes of value creation. Future research exploring the cognitive sources of firm heterogeneity is needed. Indeed, "until theories of firm heterogeneity fully incorporate psychology, the empirical facts will continue to frustrate our attempts to explain them, and researchers will find it impossible to integrate theory with strategy practice" (Powell et al., 2011, p. 1377).

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TABLE 4.1
Estimated Marginal Means by Condition – Alpha1 ERS/ERD

		Routine							
		Neutral	*S.E.*	Contradiction	*S.E.*	Incubation	*S.E.*	Collapsed	*S.E.*
Frontal									
	Left	-.005	.092	.043	.065	.089	.061	.042	.042
	Right	.008	.090	.051	.063	.103	.059	.054	.042
	Collapsed	.001	.090	.047	.063	.096	.059	.048	.042
Centrotemporal									
	Left	.003	.085	-.006	.060	.091	.056	.029	.039
	Right	-.024	.076	-.001	.054	.098	.050	.025	.035
	Collapsed	-.010	.078	-.003	.055	.094	.052	.027	.036
Parietotemporal									
	Left	.001	.089	-.012	.063	.115	.059	.035	.041
	Right	.033	.089	-.020	.063	.131	.059	.048	.041
	Collapsed	.017	.087	-.016	.061	.123	.058	.041	.040
Occipital									
	Left	.120	.106	-.021	.075	.183	.070	.094	.049
	Right	.126	.112	-.009	.079	.177	.074	.098	.052
	Collapsed	.123	.108	-.015	.076	.180	.071	.096	.050
All Regions									
	Collapsed	.033	.086	.003	.060	.123	.057	.053	.040

TABLE 4.1 Continued
Estimated Marginal Means by Condition – Alpha2 ERS/ERD

		Routine							
		Neutral	*S.E.*	Contradiction	*S.E.*	Incubation	*S.E.*	Collapsed	*S.E.*
Frontal									
	Left	-.047	.080	-.072	.057	.108	.053	-.004	.037
	Right	-.039	.076	-.067	.054	.126	.050	.007	.035
	Collapsed	-.043	.077	-.070	.055	.117	.051	.002	.036
Centrotemporal									
	Left	-.073	.076	-.130	.054	.074	.050	-.043	.035
	Right	-.097	.072	-.098	.051	.123	.047	-.024	.033
	Collapsed	-.085	.071	-.114	.050	.098	.047	-.033	.033
Parietotemporal									
	Left	-.091	.090	-.130	.063	.121	.059	-.033	.042
	Right	-.031	.094	-.133	.066	.159	.062	-.002	.043
	Collapsed	-.061	.090	-.131	.063	.140	.059	-.017	.042
Occipital									
	Left	-.058	.114	-.126	.080	.165	.075	-.006	.053
	Right	-.049	.125	-.121	.088	.165	.083	-.002	.058
	Collapsed	-.053	.118	-.124	.083	.165	.078	-.004	.055
All Regions									
	Collapsed	-.060	.081	-.110	.057	.130	.054	-.013	.038

TABLE 4.2
Estimated Marginal Means by Condition – Novelty and Value

	Routine							
	Neutral	*S.E.*	Contradiction	*S.E.*	Incubation	*S.E.*	Contradiction & Incubation	*S.E.*
Novelty	3.52	.284	3.46	.302	3.12	.285	3.30	.285
Value	2.60	.157	2.40	.167	2.29	.157	2.54	.157

TABLE 4.3
Analysis of Covariance – Alpha1 ERS/ERD

Source	Multivariate		
	df	*F*	η_p^2
Region	3, 31	1.32	0.11
Hemisphere	1, 33	0.44	0.01
Region x Hand	3, 31	1.79	0.15
Region x Condition	6, 62	1.26	0.11
Hemisphere x Hand	1, 33	0.12	0.00
Hemisphere x Condition	2, 33	0.01	0.00
Region x Hemisphere	3, 31	0.54	0.05
Region x Hemisphere x Hand	3, 31	0.52	0.05
Region x Hemisphere x Condition	6, 62	0.57	0.05

N=37
*$p < 0.05$, **$p < 0.01$

Source	Within-Subjects Effects		
	df[a]	*F*	η_p^2
Region	1.62, 53.29	1.66	0.05
Hemisphere	1, 33	0.44	0.01
Region x Hand	1.62, 53.29	1.07	0.03
Region x Condition	3.23, 53.29	2.21	0.12
Hemisphere x Hand	1, 33	0.12	0.00
Hemisphere x Condition	2, 33	0.01	0.00
Region x Hemisphere	2.79, 92.17	0.47	0.01
Region x Hemisphere x Hand	2.79, 92.17	0.53	0.02
Region x Hemisphere x Condition	5.59, 92.17	0.54	0.03

N=37
*$p < 0.05$, **$p < 0.01$
[a] Greenhouse-Geisser Correction

Source	Between-Subjects Effects		
	df	*F*	η_p^2
Condition	2, 33	1.12	0.06
Hand	1, 33	0.33	0.01

N=37
*$p < 0.05$, **$p < 0.01$

TABLE 4.3 Continued
Analysis of Covariance – Alpha2 ERS/ERD

Source	Multivariate		
	df	*F*	η_p^2
Region	3, 31	0.42	0.04
Hemisphere	1, 33	0.05	0.03
Region x Hand	3, 31	1.31	0.11
Region x Condition	6, 62	0.39	0.04
Hemisphere x Hand	1, 33	0.05	0.00
Hemisphere x Condition	2, 33	0.20	0.01
Region x Hemisphere	3, 31	1.21	0.11
Region x Hemisphere x Hand	3, 31	0.94	0.08
Region x Hemisphere x Condition	6, 62	1.49	0.13

N=37
*$p < 0.05$, **$p < 0.01$

Source	Within-Subjects Effects		
	df [a]	*F*	η_p^2
Region	1.48, 48.91	0.10	0.00
Hemisphere	1, 33	1.11	0.03
Region x Hand	1.48, 48.91	0.76	0.02
Region x Condition	2.96, 48.91	0.57	0.03
Hemisphere x Hand	1, 33	0.05	0.00
Hemisphere x Condition	2, 33	0.20	0.01
Region x Hemisphere	2.75, 90.69	1.01	0.03
Region x Hemisphere x Hand	2.75, 90.69	0.61	0.02
Region x Hemisphere x Condition	5.50, 90.69	1.16	0.07

N=37
*$p < 0.05$, **$p < 0.01$
[a]Greenhouse-Geiser Correction

Source	Between-Subjects Effects		
	df	*F*	η_p^2
Condition	2, 33	5.01*	0.23
Hand	1, 33	0.01	0.00

N=37
*$p < 0.05$, **$p < 0.01$

TABLE 4.4
Analysis of Covariance – Novelty and Value

Novelty

Source	Univariate ANCOVA		
	df	*F*	η_p^2
Main Effect			
Routine	3, 113	0.39	0.01
Covariate			
EEG	1, 113	1.52	0.01

N=118
*p < 0.05, **p < 0.01

Value

Source	Univariate ANCOVA		
	df	*F*	η_p^2
Main Effect			
Routine	3, 113	0.82	0.02
Covariate			
EEG	1, 113	0.24	0.00

N=118
*p < 0.05, **p < 0.01

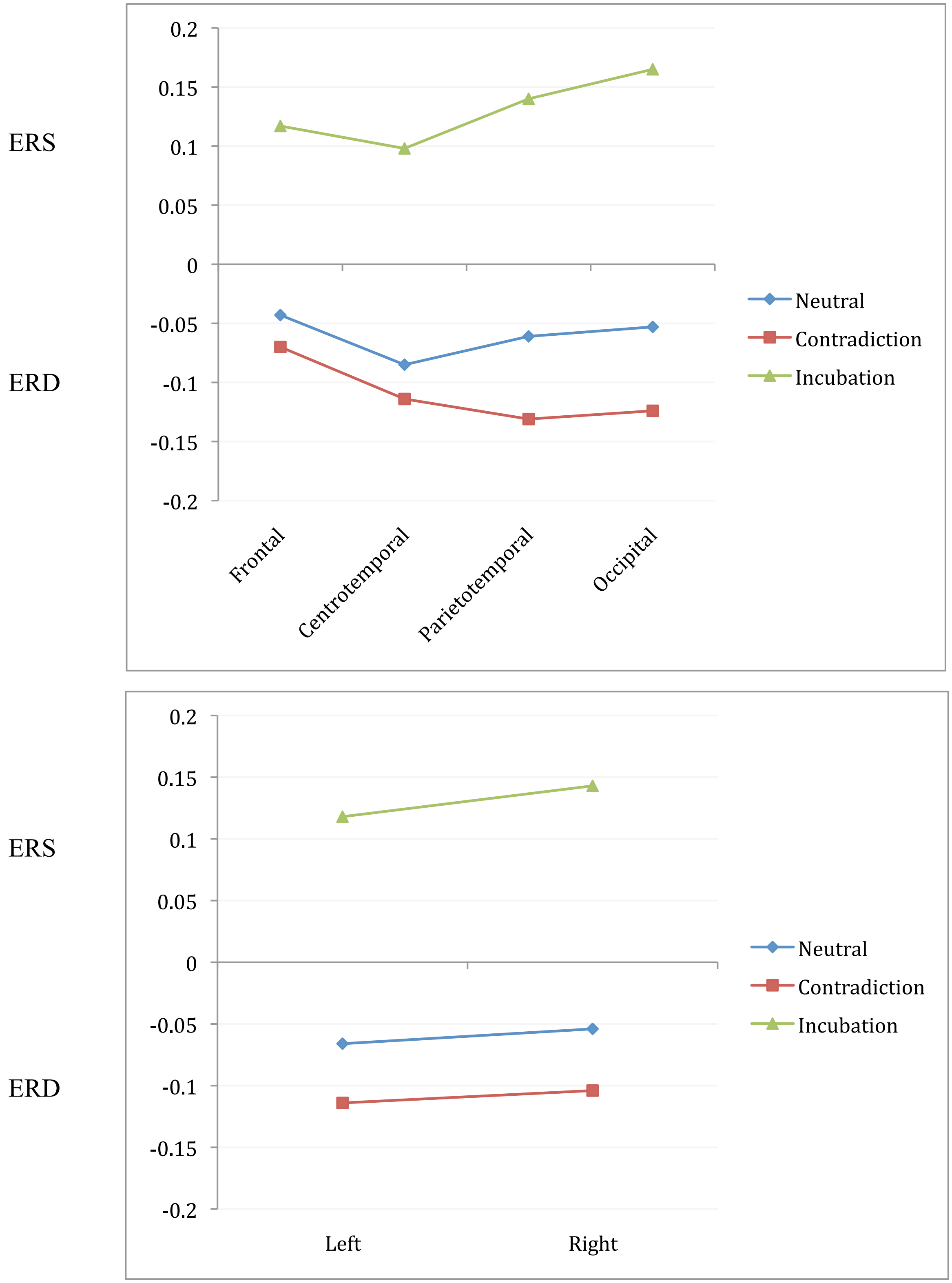

FIGURE 4.1: Alpha2 ERS/ERD by Routine, Region, and Hemisphere

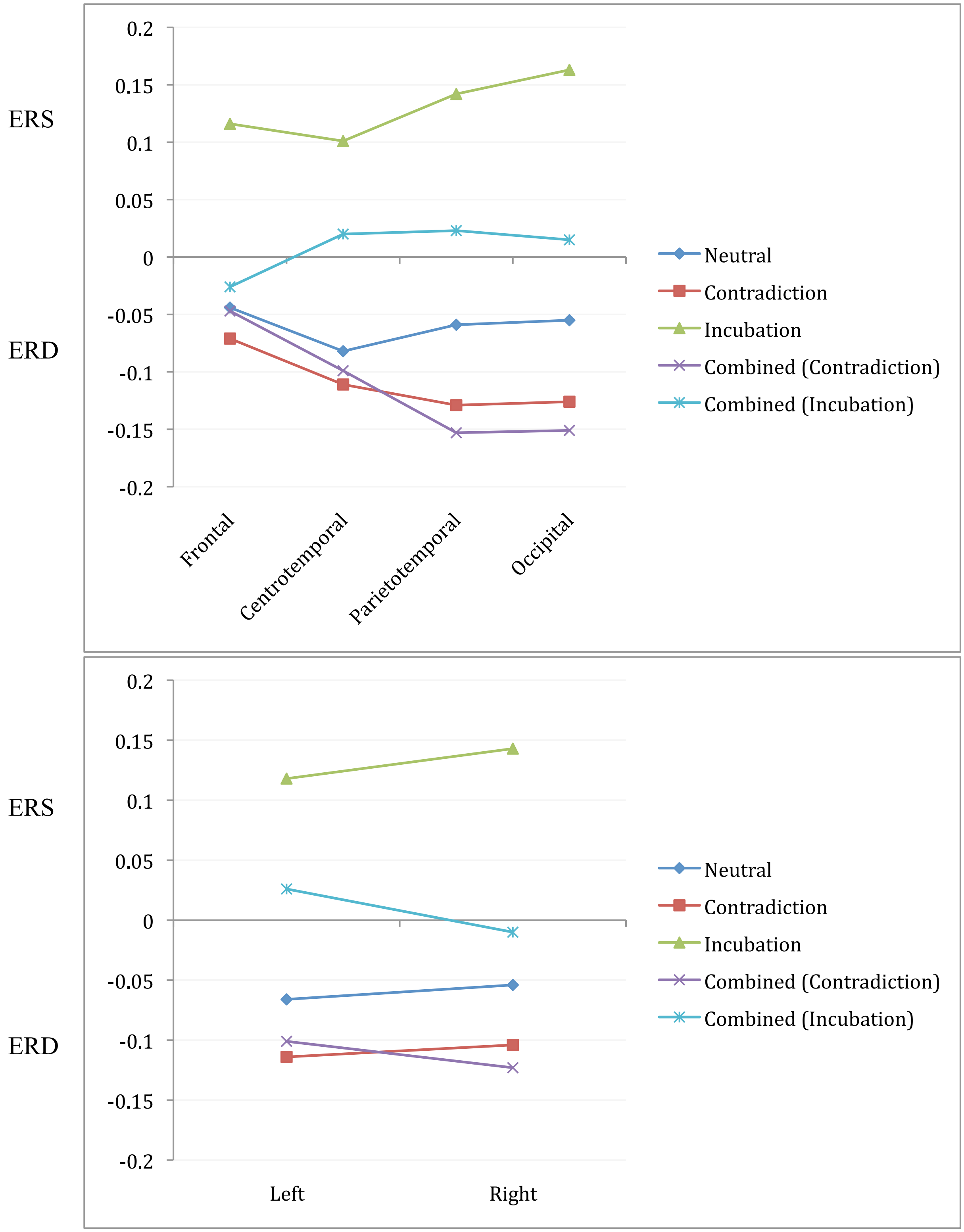

FIGURE 4.2: Alpha2 ERS/ERD by Routine, Region, and Hemisphere with Combined Routine

CHAPTER 5

CONCLUSION

A frequently raised critique of the field of strategic management is the absence of paradigmatic consensus (Nag, Hambrick, & Chen, 2007). Indeed, strategic management draws on multiple disciplines including economics, sociology, and psychology. A review of the relatively brief history of the field reveals the emergence and decline of several theoretical paradigms (Farjoun, 2002; Gavetti & Levinthal, 2004; Hoskisson, Hitt, Wan, & Yiu, 1999). Interestingly, this wide breadth of theoretical lenses has largely been able to coexist within the field. One potential explanation as to how these eclectic perspectives have been able to simultaneously contribute to strategic management is a general consensus among scholars with respect to the central questions of strategy and their practical significance (Nag et al., 2007). Strategic management comprises the scientific exploration of firm behavior, heterogeneity, scope, and performance (Rumelt, Schendel, & Teece, 1994). Subsequently, multiple academic disciplines informing these central questions have been leveraged, resulting in unique opportunities for cross-fertilization and insight.

An important and less-developed antecedent of firm heterogeneity and performance is the psychological and cognitive processes of strategic actors (Gavetti, 2012; Hodgkinson & Healey, 2011). While individual cognition is frequently acknowledged within extant theory (either implicitly or explicitly), scholarly interest has largely focused on aggregate constructs and phenomenon, obscuring sources of heterogeneity arising from individual cognition (Abell, Felin, & Foss, 2008; Felin & Hesterly, 2007). If indeed strategic management is defined by its central questions, and individual cognition is an upstream antecedent of firm heterogeneity and performance, then the application of constructs and methodologies from psychology and neuroscience is both warranted and needed (Powell, Lovallo, & Fox, 2011).

Building on the problem-finding problem-solving framework, this dissertation directly addresses this gap by investigating the cognitive processes underlying the generation of novel and valuable solutions to strategic problems, an important component in the value-creation process (Baer, Dirks, & Nickerson, 2013; Nickerson & Zenger, 2004). The first study investigates the role of comprehensive problem formulation and time constraints in the development of solutions to complex and ill-defined problems (i.e., wicked problems). Experimental findings indicate comprehensive problem formulation significantly influences the value of the solutions generated. Specifically, comprehensiveness enhances the value of the solutions when moving from low to medium levels of comprehensiveness but decreases the value of the solutions when moving from medium to high levels of comprehensiveness. Time constraints are also shown to negatively impact both the novelty and value of the solutions. Highlighting the strategic relevance of wicked problems, the first study clarifies and tests the role of comprehensive problem formulation on the generation of value-creating solutions.

The second study addresses a frequently overlooked source of heterogeneity in the value-creation process, namely, affect. The psychology literature has documented the role of affect in significantly altering the search and recombination of knowledge elements (Fredrickson & Branigan, 2005; Isen, 2002). Nevertheless, microfoundational models of value creation often fail to account for the moderating effects of affect. Leveraging the creativity and neuroscience literatures, a model of how affect might operate to enhance value-creating solutions is presented. Specifically, two separate cognitive mechanisms and their neurological correlates are identified and argued to result in systematic differences in search processes and solution types. Delineating how affective states and their neurological correlates align with cognitive mechanisms to enhance the generation of value-creating solutions provides additional precision and facilitates the integration of affect into existing microfoundational theories.

Lastly, the third study theoretically develops and tests a set of organizational routines posited to enhance the neurological processes of novel and valuable solution generation. Experimental methodologies from both neuroscience and cognitive psychology are adopted to examine the hypothesized routines. While findings do not demonstrate any significant relationships between the routines and the novelty and value of the solutions, the explication of the specific cognitive processes involved as well as how organizational routines might operate to overcome the cognitive impediments in solution generation represents an important first step. Moreover, the identification of the neurological correlates associated with the proposed routines provides a level of precision traditionally absent from microfoundational explanations of value creation and informs future research.

In conclusion, research investigating the cognitive microfoundations of value creation effectively repositions the "strategist" at the center of strategic management

(Montgomery, 2012). Early research within the field directly acknowledged and explored the psychological and cognitive foundations of firm performance and competitive advantage (see Gavetti & Levinthal, 2004). The subsequent emergence of prominent economic and sociological theories, while recognizing the importance of cognition, resulted in increased scholarly attention on aggregate constructs and phenomenon. Indeed, the field of strategic management is often identified by its level of analysis. As argued by microfoundational scholars, however, heterogeneity arising from lower levels of analysis significantly influences organizational level outcomes (Felin & Foss, 2005). Subsequently, research within organizational learning (Felin & Hesterly, 2007), dynamic capabilities (Gavetti, 2005; Hodgkinson & Healey, 2011; Teece, 2007), and the problem-finding problem-solving perspective (Baer et al., 2013) has begun to explicitly investigate individual cognitive mechanisms. Microfoundational explanations of value creation and competitive advantage will be greatly enhanced by leveraging the fields of psychology and neuroscience. Building on the problem-finding problem-solving framework, this dissertation increases understanding of the cognitive processes underlying novel and valuable solution generation and lays the foundation for future research investigating models of cognition within the field of strategy.

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