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TECHNOLOGY-MARKET COMBINATIONS AND THE IDENTIFICATION OF ENTREPRENEURIAL OPPORTUNITIES: AN INVESTIGATION OF THE OPPORTUNITY-INDIVIDUAL NEXUS

DENIS A. GRÉGOIRE
Syracuse University

DEAN A. SHEPHERD
Indiana University

Although prior research has highlighted that individuals differ in their ability to identify opportunities for entrepreneurial action, little attention has been paid to the effects that differences among opportunities may have on their initial identification. Integrating theoretical work on the nature of entrepreneurial opportunities with cognitive science research on the use of similarity comparisons in making creative mental leaps, we develop a model of opportunity identification that includes both the independent effects of an opportunity idea's similarity characteristics and the interaction of these characteristics with an individual's knowledge and motivation. We test this model with a within-subject experiment in which we asked two samples of entrepreneurs to form beliefs about opportunity ideas for technology transfer. Results indicate that the superficial and structural similarities of technology-market combinations impact the formation of opportunity beliefs and that individual differences in prior knowledge and entrepreneurial intent moderate these relationships. In addition to casting light on cognitive reasons why some entrepreneurial opportunities may be more or less difficult to identify, our theorizing and findings point toward reasoning strategies that may facilitate the identification of multiple (and potentially more valuable) opportunities, not only for new technologies, but also for new products, services, and/or business models.

Given the difficulties in maintaining a competitive advantage in the face of globalization and "hypercompetition," management scholars have pointed to the importance of entrepreneurial action as a means by which organizations can innovate (Kaplan, 2008; Puranam, Singh, & Zollo, 2006), grow (Dencker, Gruber, & Shah, 2009; Tzabar, 2009), and/or renew themselves (Agarwal & Helfat, 2009; Shamsie, Martin, & Miller, 2009). Entrepreneurial action concerns the introduction of new products, services, technologies, or business models that may depart substantially from existing practices (Gruber, MacMillan, & Thompson, 2008; Samuelsson & Davidsson, 2009; Santos & Eisenhardt, 2009). As such, the origin of entrepreneurial action is found at the nexus of individuals and opportunities (Shane, 2003; Venkataraman, 1997). To date, research on entrepreneurial action has primarily focused on factors explaining which individuals or organizations are better able to identify and exploit promising opportunities (cf. Gruber, MacMillan, & Thompson, 2010; Plambeck & Weber, 2009; Short, Ketchen, Shook, & Ireland, 2010). In contrast, and despite continued theorizing about the nature and source(s) of opportunities (e.g., Alvarez & Barney, 2010; Jackson & Dutton, 1988; McMullen, Plummer, & Acs, 2007), little theoretical or empirical attention has focused on the influence of differences among opportunities, especially with respect to their initial identification. As Dahlqvist and Wiklund described it, "one part of the nexus is missing" (2012: 186).

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Although the notion that differences among opportunities should matter is rather obvious, an important theoretical challenge is to understand what characteristics of opportunity ideas influence the initial formation of opportunity beliefs, why, and for whom. In this regard, recent studies have theorized that individuals identify opportunities by using models of opportunities they already have (e.g., prototypes, exemplars) to organize what they perceive from their environment into "patterns" that suggest promising ideas for entrepreneurial action (cf. Baron, 2006; Baron & Ensley, 2006; Cornelissen & Clarke, 2010). More recently, Grégoire, Barr, and Shepherd (2010) documented that in their efforts to identify opportunities for a new technology, entrepreneurs use cognitive processes of structural alignment to zero in on meaningful "connections" between the new technology and markets in which to apply it.

These studies have undoubtedly advanced scholars' understanding of the cognitive dynamics fostering the emergence of entrepreneurial action. However, these papers neglect the effects that the characteristics of different opportunity ideas may have on the initial identification/imagining of such ideas. Unfortunately, this leaves academics with an incomplete understanding of the individual-opportunity nexus. Because each entrepreneur in these studies uses his/her own knowledge and cognitive abilities to make idiosyncratic mental connections between different stimuli and identify unique opportunity ideas, differences among opportunities are necessarily confounded with differences among individuals. As a result, scholars remain ill equipped to determine what specific mental connections are influential to spur opportunity ideas in the first place. By extension, one cannot determine whether and why some opportunities may be fundamentally more difficult to identify—independently of the effects that individual differences in motivation, knowledge, and cognitive resources/abilities have in facilitating opportunity identification.

To address these issues, we developed and tested a model of opportunity identification that pays particular attention to the effects of differences among opportunity ideas. Specifically, we integrate research about the nature of entrepreneurial opportunities with cognitive research on the role of analogies and similarities in creative mental leaps to focus on two opportunity characteristics that likely influence the formation of opportunity beliefs—the *superficial* and the *structural similarities* between a new/improved means of supply (e.g., a new product, service, business model or technology), and a target market in which this new means of supply can be introduced. In cognitive research on structural alignment and similarity comparison (cf. Gentner, 1989; Markman & Gentner, 1993), the terms "superficial" and "structural" reflect the notions that human reasoning involves the use of mental models (cf. Gentner & Stevens, 1983; Johnson-Laird, 1983) and that these models include both individual units of meaning (an object, characteristics of that object, etc.—also known as a mental model's *superficial* elements) and *structural* relationships between different units/elements. The structural relationships represent how superficial elements relate to, or influence, each other. In the context of entrepreneurial opportunities for new technologies, *superficial similarities* arise when the basic elements of a technology (e.g., who develops the technology, the context where it is developed, its parts and components, the inputs it uses, the materials/people it works with in the lab, and the output it produces) resemble the basic elements of a market (e.g., the people in the market, the materials, and tools they use, etc.). *Structural similarities* arise when the intrinsic capabilities of a new technology (what it can do and the logical/scientific/functional mechanisms underlying how it can do this, such as how the various parts and input of a technology "work" together) resemble the "causes" and "mechanisms" underlying latent demand in a market (i.e., the reasons why people in the market are not completely satisfied with current means of meeting their needs).

The central thesis we explore in this study is that variations in the superficial and structural similarities characterizing new technology-market combinations systematically influence the formation of opportunity beliefs—and that these effects are independent of those of individual differences in cognitive resources/abilities. We tested our model by conducting a within-subject experiment in which we asked two samples of entrepreneurs to form beliefs about opportunity ideas for technology transfer. Our analyses assess the independent and interactive effects of superficial and structural similarities on opportunity beliefs. In addition, we investigated the moderating role of individual variations in prior knowledge and entrepreneurial intent on these relationships while controlling for other differences in cognitive abilities. We base the study on technology transfer to anchor our theorizing with a well-documented phenomenon (cf. Mowery, Nelson, Sampat, & Ziedonis, 2004; Shane, 2001). By basing our material on real cases of transfer, we also augment the validity of our findings. In turn, we use this context to draw insights about the identification of other types of opportunities.

The major contributions of our study are to draw attention to the unique effects that differences among opportunity ideas have on entrepreneurs' opportunity beliefs and to show how these relationships vary systematically across individuals. Although we build on Grégoire, Barr, and Shepherd (2010) to leverage cognitive research on structural alignment to gain a deeper understanding of opportunity identification, the current study extends this previous research in important ways. For instance, that research explored entrepreneurs' cognitive processes by analyzing the think-aloud verbalizations of entrepreneurs as they tried to identify opportunities for new technologies. Because each entrepreneur leveraged his/her background and experience to think of opportunities in different markets, however, this prior study could not explain the role of differences among opportunity ideas in the formation of opportunity beliefs (nor was it its purpose to do so). In the current study, we used a within-subject experiment to specifically investigate the impact of "similarity differences" in opportunity ideas (i.e., differences in the extent and type of similarities between an opportunity idea's means of supply and market context) on the formation of opportunity beliefs—net of the effects of the individual differences known to foster opportunity identification. In doing so, we shine new light on the opportunity-individual nexus and offer theoretical insights that extend current scholarly conversations on opportunity identification, entrepreneurial cognition, and technological innovation and venturing.

First, prior research has shown that individuals differ in their ability to identify opportunities (cf. Baron & Ensley, 2006; Gruber et al., 2008, 2010) but has placed little attention on differences among opportunities (cf. Dahlqvist & Wiklund, 2012). In this article, we theorize and find that, even when controlling for the effects of individual differences in cognitive resources/abilities, variations in the superficial and structural similarity of technology-market combinations to impact the formation of opportunity beliefs. These findings for the impact of the similarity characteristics of opportunity ideas complement current explanations that emphasize differences among individuals.

Second, prior research has primarily emphasized the *independent* effects of individual differences in cognitive resources and abilities for explaining why some individuals are able to identify opportunities (e.g., Krueger & Dickson, 1994; Shepherd & DeTienne, 2005). However, it has relatively ignored the potential effects of *interactions* between individual differences and the information characteristics of opportunity ideas on opportunity identification. Here, we theorize and provide evidence that individual differences in entrepreneurial intent and prior knowledge moderate the effects of the similarity characteristics of opportunity ideas on the formation of opportunity beliefs. These findings expand understanding of the role of cognitive resources and abilities in opportunity identification.

Finally, prior research has highlighted the challenges that entrepreneurs, scientists, and technology transfer officers face when attempting to identify multiple opportunities for a new technology (cf. Dougherty, 1992; Gruber et al., 2008, 2010; Shane, 2000). In this study, we cast light on the cognitive reasons why some opportunities for technology transfer are more difficult to identify than others—and more difficult to identify for some entrepreneurs. Specifically, we document that entrepreneurs are ambivalent about opportunity ideas that present divergent types of similarities; one such case, for example, arises when the superficial elements of a new technology are dissimilar to the superficial elements of a target market, despite high structural similarity between the two. To many entrepreneurs, these opportunities appear nonobvious (cf. Shane, 2000: 456). At the same time, we theorize and find that some entrepreneurs are less ambivalent than others about such opportunities. Taken together, these observations cast light on the factors and dynamics that can foster efforts to identify multiple opportunities for the same technology.

THEORY AND HYPOTHESES

Building on a Theory of Strategic Action

Our study builds on the broad foundation of strategic action theories (Child, 1997; Nadkarni & Barr, 2008) and, more specifically, on theories about the pursuit of strategic and entrepreneurial opportunities (Dutton & Jackson, 1987; McMullen & Shepherd, 2006). From this perspective, individual and collective actors initiate actions in light of the desires, conjectures, and other interpretations they form about their environment, their positions, the positions of other actors in that environment, and the likely consequences of all actors' actions (cf. Hastie, 2001; Morsella, Bargh, & Gollwitzer, 2009). Accordingly, entrepreneurial actions originate in thoughts and beliefs that—given what one perceives and understands about a particular situation—introducing a new product or service is a "worthwhile" and "feasible" endeavor (McMullen & Shepherd, 2006). To concretely anchor our research in this perspective, we build our model on four key conceptual assumptions. These assumptions are important for delineating what characteristics of opportunity ideas influence the formation of opportunity beliefs.

First, we build on the notion that, from an economic perspective, entrepreneurial actions are about carrying out more efficient supply-demand transactions (cf. Alvarez & Barney, 2010; Denrell, Fang, & Winter, 2003; Shane & Venkataraman, 2000). Consequently, we follow extant conceptualizations that entrepreneurial opportunities consist of situations that are relevant for introducing new or improved products, services, or ways of doing business to better serve the needs of consumers in one or more markets (cf. Casson, 1982; Hill & Birkinshaw, 2010; Venkataraman & Sarasvathy, 2001). As such, the basic components of entrepreneurial opportunities include a demand side (e.g., wants or needs in a market), a supply side (e.g., a new product, service, technology, or business model), and an economic means for transactions to take place between the two (e.g., one or more organizations that assume the production, distribution, sale, servicing, etc., of goods to clients). In the specific context of technology transfer, an entrepreneurial opportunity thus consists of applying a new technology in a particular market.

Second, we assume that from the perspective of the macroeconomic system ex post, the dynamics that make a new economic transaction more efficient can be either exogenous or endogenous to the actions of enterprising firms and individuals (cf. Alvarez & Barney, 2007). However, from the perspective of those enterprising firms or individuals ex ante, what makes a situation an entrepreneurial opportunity is not the parameters of the situation in and of itself but the realization that more efficient transactions would be made possible (and profitable) by taking one or more specific actions (cf. Davidsson, 2003; Sarasvathy, 2008). Thus, from a forward-looking perspective, an opportunity is neither solely about a new technology nor solely about a current market situation; rather, it is about the possibility of changing the current market situation by using the new technology. Accordingly, our model neither focuses on the discovery of objective arbitrage situations nor on the path-dependent development of opportunities through enterprising individuals' creative actions; rather, we focus on the *ex ante* interface between situation and action as individuals try to make sense of information signals that could indicate opportunities. In keeping with this approach, we focus on individual beliefs about opportunity ideas (cf. Davidsson, 2003; Grégoire, Shepherd, & Lambert, 2010; Shepherd, McMullen, & Jennings, 2007).

Third, we build on the notion that entrepreneurial opportunities are ex ante uncertain (Casson, 1982; Knight, 1921)—that is, the "true" value of an opportunity can only be determined after one or more entrepreneurs have tried to exploit it. The implication for our model is that efforts to infer what it could mean to introduce a new technology in a particular market involve the formation of subjective beliefs about the future (cf. Dimov, 2010; Sarasvathy, 2008; Shepherd et al., 2007). This idea is consistent with strategic action models in which beliefs about the future guide subsequent individual and organizational action (cf. Barr, 1998; Stevenson & Jarillo, 1990). However, uncertainty about the future can block or delay action (cf. Lipshitz & Strauss, 1997; McMullen & Shepherd, 2006). Thus, entrepreneurial action is not only influenced by the positive or negative valence of opportunity beliefs (e.g., "This is an opportunity versus this is a nonopportunity") but also by the varying uncertainty of these beliefs (e.g., I am more certain versus I am less certain that this is/is not an opportunity) (cf. Grégoire, Shepherd, & Lambert, 2010). We build on this approach to investigate the initial formation of opportunity beliefs—at the idea stage.

Finally, we follow arguments that identifying a potential opportunity (i.e., forming initial beliefs that applying a new technology in a particular market represents an opportunity for someone or some firm) is conceptually and empirically separate from deciding whether, when, and how to personally act upon these beliefs (cf. Dimov, 2007a; McMullen & Shepherd, 2006) and from actual efforts to pursue and exploit opportunities (cf. Dimov, 2010). Along this line, there is evidence that the cognitive processes at play in opportunity identification are different from the cognitive processes at play in opportunity evaluation (cf. Grégoire, Barr, & Shepherd, 2010; Haynie, Shepherd, & McMullen, 2009) and that measures of opportunity beliefs and opportunity intention are empirically distinct (Grégoire, Shepherd, & Lambert, 2010). Given these differences and the purpose of the current study, we focus on the initial stage of forming beliefs about potential opportunity ideas, rather than on the evaluation of opportunities for oneself or the formation of exploitation intentions.

A Cognitive Model of Opportunity Identification

Building on the assumptions detailed above, we propose that opportunity beliefs take shape through cognitive efforts to make sense of potential "matches" between new means of supply (i.e., new products, services, technologies, or business models) and the markets in which these new means of supply can be introduced. In the specific context of technology transfer, the formation of opportunity beliefs thus rests on entrepreneurs' considerations of the similarities between new technologies and markets. This conception is consistent with research by Grégoire, Barr, and Shepherd (2010) showing that in their efforts to identify promising opportunities for new technologies, entrepreneurs used cognitive processes of structural alignment to make connections to new markets in which to apply these technologies. The theory of structural alignment (Gentner, 1983, 1989) originates in cognitive research on the use of analogies, but its import was later expanded to the perception, processing, and use of similarities in a broad range of reasoning tasks (cf. Gentner & Markman, 2006; Markman & Gentner, 1993, 2000). At its core, structural alignment explains how individuals draw useful inferences about new objects/situations by comparing them with other objects/situations they know or understand better (e.g., Holland, Holyoak, Nisbett, & Thagard, 1986; Markman & Gentner, 2001).

Given our focus on the effects of differences in opportunity ideas, a particularly important finding of structural alignment research is that the human mind perceives two types of similarities—superficial and structural (Gentner, 1983, 1989). As we noted in the introduction, these terms reflect the notion that the human mind represents reality through mental models that not only identify individual units of information, but also the structural relationships between these units (cf. Gentner & Stevens, 1983; Johnson-Laird, 1983). Because the mind uses different cognitive structures to process mental models' basic elements and structural relationships, superficial and structural similarities have distinct roles in human reasoning, with distinct effects (cf. Holland et al., 1986; Keane, Ledgeway, & Duff, 1994). Combining these findings with the notions that (1) entrepreneurial opportunities consist of hitherto unexploited matches between a new means of supply and a market and (2) entrepreneurs use structural alignment cognitive processes in their efforts to find or imagine promising opportunities, we theorize that variations in the superficial and structural similarities between new technologies and markets will influence the formation of opportunity beliefs.

To better illustrate the import of such similarity differences for opportunity identification, Figure 1 contrasts four scenarios of a technology-market pair with varied superficial and structural similarities. In line with the modus operandi of technology transfer (wherein entrepreneurs learn about a new technology and start thinking about whether they can use it in particular markets [cf. Gruber et al., 2008; Shane, 2000]), each scenario reflects a situation in which potential entrepreneurs encounter information about a new technology, such as they might when the technology is showcased on technology transfer websites and in related communications. This information typically includes who developed the technology, what its components are, how it operates, what materials it uses, who used it initially (i.e., in the lab), and for what purposes it was used. In line with our focus on documented cases of technology transfer, we derive the scenarios in Figure 1 from the application of a new technology developed by the National Aeronautics and Space Administration (NASA) (2003). As such, the context of space exploration forms the initial application of the technology. From the standpoint of our model, opportunities for technology transfer are about applying this technology to *different* markets. For example, one market in Figure 1 is that of parents who seek nonpharmaceutical alternatives to treat their child's attention deficit hyperactivity disorder (ADHD). This opportunity is currently exploited by CyberLearning Technologies.

In the next subsections, we define the two forms of similarities, specify their articulation in the context of technology transfer opportunities, and build on cognitive research to formulate hypotheses about the effects of similarity differences on opportunity identification. To better clarify the impact of similarity differences on opportunity identification, we first explain how changes in the information about a new technology affect the superficial and structural similarities this technology may share with a potential target market (see Figure 1). We then discuss how changes in target markets could result in similarity differences with new technologies.

The Effects of Superficial Similarity

Superficial similarity arises when two objects, concepts, or situations share basic information elements that resemble each other (e.g., they share similar features, such as their form, color, attributes, qualities, etc.) (Gentner, Rattermann, Markman, & Kotovsky, 1995). For instance, two situations will be superficially similar if they involve the same kind of objects, locales, and/or actors (cf. Markman & Gentner, 1993). Accordingly, NASA's space shuttle is superficially similar to an airplane. In the context of entrepreneurial opportunities, superficial similarity is high when the basic elements of a technology (e.g., its parts and components, the

FIGURE 1
Similarity Variations in Opportunity Ideas for Technology Transfer

Documented Case of Technology Transfer

"True" new technology	NASA's EAST™ technology (extended attention span training), a training system originally developed to increase the concentration abilities of shuttle pilots training on flight simulators
"True" target market	Parents who seek nonpharmaceutical alternatives for their children's ADHD
	From the perspective of our model, this technology-market pair is characterized as: Low levels of superficial similarity (e.g., NASA pilot ≠ K–12 children) High levels of structural (i.e., capability train the concentration abilities of Shuttle pilots = need for training the concentration abilities of children with ADHD)

Experimental Manipulations of Similarity (Technology Only)

Manipulation no. 1: Increasing superfical similarity with target market	Instead of being developed at NASA, the technology is portrayed as developed by a famous university's Departments of Child and Adolescent Psychiatry and Biomechanical Engineering. The technology is embedded in video games for helping teenagers learning how to drive.
Manipulation no. 2: Decreasing structural similarity with target market	Instead of being used to help develop the concentration of individuals (shuttle pilots or teenage drivers), the technology is portrayed as helping to develop the abilities of individuals (shuttle pilots or teenage drivers) develop their abilities to manage their levels of stress and anxiety.

Technology-Market Pairs with Different Similarity Characteristics

		Superficial Similarity	
		Low	High
Structural similarity	High	Cell I *Superficial* elements of technology **mismatch** superficial elements of market: NASA engineers ≠ education specialists. NASA shuttle pilots ≠ K–12 children in school. Flight simulators ≠ toys children play with. Structural capabilities of technology **match** structural causes of latent demand in market: Developing shuttle pilots' abilities to concentrate ≈ developing abilities of ADHD children to concentrate.	Cell II *Superficial* elements of technology **match** superficial elements of market: Child psychiatrist ≈ education specialists. Teenagers in driving school ≈ children in school. Video games ≈ toys children play with. Structural capabilities of technology **match** structural causes of latent demand in market: Developing teenage driver's abilities to concentrate ≈ developing abilities of ADHD children to concentrate.
	Low	Cell III *Superficial* elements of technology **mismatch** superficial elements of market: NASA engineers ≠ education specialists. NASA shuttle pilots ≠ K–12 children in school. Flight simulators ≠ toys children play with. Structural capabilities of technology **mismatch** causes of latent demand in market: Developing shuttle pilots' abilities to manage their levels of stress ≠ developing children's abilities to concentrate to manage ADHD.	Cell IV *Superficial* elements of technology **match** superficial elements of market: Child psychiatrist ≈ education specialists. Teenagers in driving school ≈ children in school. Video games ≈ toys children play with. Structural capabilities of technology **mismatch** structural causes of latent demand in market: Developing teenage driver's abilities to manage their levels of stress ≠ developing children's abilities to concentrate to manage ADHD.

context in which it is developed, its developer, the inputs it uses, the materials/people it works with in the lab, and the output it produces) *resemble* the basic elements of a market (the people in the market, the materials and tools they use, etc.). In the right column of Figure 1 (cells II and IV), for instance, the technology is described as a car-driving video game system developed through a joint project between a famous university's Division of Child and Adolescent Psychiatry and its Department of

Biomechanical Engineering, *not by NASA*. The technology is embedded in video games and involves teenagers learning how to drive. In these scenarios, the technology's superficial elements (e.g., child psychiatrists are developing it, teenagers in driving schools are using it, it is embedded in video games) are similar to superficial elements of the target market (e.g., ADHD, K–12 children, school, games). As such, the two scenarios contained in cells II and IV of Figure 1 correspond to opportunity ideas characterized by high levels of superficial similarity between the technology and the market.

By contrast, the two scenarios in the left column of Figure 1 (cells I and III) correspond to opportunities with low levels of superficial similarity. The technology was developed by space and computer engineers at NASA's Langley Research Center. It involves big, bulky flight simulators and is used by space shuttle pilots. As such, the technology's superficial elements have low similarity with the superficial elements of the target market of K–12 schoolchildren and their parents. By contrast, a market with high levels of superficial similarity with the NASA-developed technology would be that of airline pilots training in flight simulators.

Cognitive research often portrays superficial similarities as the "default" mode of reasoning (cf. Holland et al., 1986; Keane et al., 1994). Indeed, scholars have shown that considerations of superficial similarity play an important role in guiding the retrieval of knowledge from memory (Gentner, Rattermann, & Forbus, 1993; Keane et al., 1994). When presented with a new stimulus, a human's associative mind naturally considers objects/ideas that have superficial elements resembling those of the target stimulus. One practical implication of this finding is that learning new concepts and categories is greatly facilitated when educators highlight their superficial similarities with "older" better-known concepts and categories (Namy & Gentner, 2002). By actively priming mental models already stored in long-term memory (instead of leaving learning to passive recall), this strategy effectively creates a cognitive path upon which to more easily build understanding of the new concepts and categories. The same phenomenon has been observed with consumers learning about radically new products (Moreau, Lehmann, & Markman, 2001), as well as in organizational strategies for innovation (Katila & Ahuja, 2002). In their study of efforts to find opportunities for new technologies, Grégoire, Barr, and Shepherd (2010) observed that the superficial elements of a new technology could indeed guide reasoning toward markets that had similar superficial elements.

We theorize that, just as superficial similarity between new stimulus and older knowledge fosters a cognitive path for thinking about new products or innovations, high levels of superficial similarity between a new technology and a target market can both facilitate entrepreneurs' thinking about the potential opportunity and reinforce their emerging beliefs that the technology would "work well" in the market. The more superficial elements technology and market have in common, the less uncertain entrepreneurs will be about the possibility of applying this technology in that market. This hypothesis is consistent with Santos and Eisenhardt's (2009) observations that when introducing new forms of business models (such as in the early days of e-commerce), successful entrepreneurs tended to adopt templates from other areas that included known and familiar elements (e.g., they created electronic "shopping carts," "registries," "check-outs," etc.). In the same way that these templates helped reduce ambiguity and accelerated user adoption, the perception of shared superficial elements between a new technology and a target market could reduce perceived uncertainty that introducing this technology in the focal market represents an opportunity. Accordingly, we offer the following:

> *Hypothesis 1. Beliefs that a new technology-market combination represents an opportunity are more positive when superficial similarity between the focal technology and market is high than when superficial similarity between the two is low.*

The Effects of Structural Similarity

Structural similarity arises when two objects, situations, or concepts share the same logical relationships between their respective components, parts, and other superficial elements (Gentner & Markman, 2006). For instance, two situations will be *structurally* similar if the actors in the two situations are doing the same action (e.g., giving or receiving something) (cf. Markman & Gentner, 1993). From a cognitive standpoint, the notion of structural similarity arises from the way people construct mental representations of different objects, situations, and concepts (cf. Holland et al., 1986; Johnson-Laird, 1983). As individuals learn about a new technology, they form mental models of how the various parts of the technology are related. For the technology underlying the descriptions in Figure 1, for instance, sensors attached to individuals' forefingers monitor the electric conductivity of their skin and send signals to the computer processors in another machine (flight simulator or video game) with which the pilots or teenage drivers interact. Ultimately, these one-to-one relationships (skin to sensor, sensor to computer) culminate in a network of higher-order relationships that reflects the overall capabilities of the technology, its aims, and/or its uses. In much the same way, mental models of target markets reflect relationships among how individuals use products/services, what motivates their purchases, and what spurs their collective behaviors. Cognitive scholars have shown that in the mental models individuals form for the world around them, complex thoughts such as causal chains, conditional rules, heuristics and, more importantly, statements of aims, goals, needs, purposes, or wants all correspond to higher-order networks of *relationships between relationships* (Gentner, 1989; Gentner & Markman, 2006; Holyoak, 1985). In the context of entrepreneurial opportunities then, it follows that structural similarity will be high when the intrinsic capabilities of a new technology (what it can do and the logical/scientific/functional mechanisms underlying its operation, including how the various parts and inputs work together) *resemble* the "causes" and "mechanisms" underlying latent demand in a market (i.e., not just consumer needs or demands, but also the underlying reasons why people in a market are not completely satisfied with current means of meeting their needs).

In the upper row of Figure 1, the technology is described as having capabilities to help shuttle pilots (cell I) or teenage drivers (cell II) improve their abilities to focus, pay attention, and concentrate for an extended period. As such, the technology shares high levels of structural similarity with the target market of parents who seek nonpharmaceutical alternatives to treat ADHD. In other words, the functional capabilities of the new technology match the latent needs of the target market. By contrast, in the lower row of Figure 1, the technology is described as helping pilots (cell III) or teenage drivers (cell IV) control their levels of stress or anxiety—phenomena that are distinct from attention deficit disorder. Therefore, the technology-market pairs in the lower row represent opportunity ideas with low structural similarity.

Cognitive research has documented that structural similarity is particularly influential in tasks that involve interpreting, making judgments, and/or drawing inferences. For instance, Clement and Gentner (1991) showed that in their efforts to interpret analogies and metaphors, people tend to disregard common elements/features between the concepts involved, and focus instead on the logical relationships that these concepts share with each other. For instance, when told that "a cloud is like a sponge," most adults typically ignore the fact that clouds and sponges can both be round and fluffy (superficial features of basic elements); rather, they focus on the structural notions that both clouds and sponges can take and hold liquids from one place and release them later somewhere else (Gentner, 1989: 222). This cognitive preference for structural relationships has been shown to underpin a range of cognitive tasks, from learning new concepts and forming new categories to solving scientific challenges. When faced with unexpected findings, for instance, scientists will first test whether some unique conditions of their methods created the unexpected results (i.e., superficial elements and first-order structural relationships). However, if they continue to obtain unexpected results, scientists will start to generate other explanations—explanations that emphasize higher-order causal mechanisms that generate the same effects but in different organisms or systems (cf. Dunbar, 1993). This phenomenon is akin to observations about the use and benefits of "distant search" in the strategy and innovation literature (cf. Gavetti, Levinthal, & Rivkin, 2005; Katila & Ahuja, 2002).

Building on cognitive research about the importance of structural relationships in interpretative tasks, we theorize that high levels of structural similarity between a new technology and a target market will lead entrepreneurs to form more positive opportunity beliefs. With increases in the similarities between the logical/functional reasons why a technology can do what it can and the causal dynamics explaining customers' limited satisfaction with existing attempts to meet their needs, entrepreneurs become more certain that applying that technology in that market represents an opportunity. This postulate is directly consistent with qualitative observations from Grégoire, Barr, and Shepherd (2010) showing that in their efforts to identify opportunities for new technologies, expert entrepreneurs devoted considerable attention to the structural aspects of potential target markets (e.g., the latent needs of consumers and the underlying reasons why they had such needs) and then to the structural similarities *between* the new technologies and these target markets. Thus, we suggest the following:

Hypothesis 2. Beliefs that a new technology-market combination represents an opportunity are more positive when the structural similarity between the focal technology and market is high than when the structural similarity between the two is low.

The Effects of Convergent and Divergent Variations in Similarity

As Figure 1 illustrates, superficial and structural similarities can vary independently of each other. From a modeling standpoint, this raises the question of whether the effects of superficial and structural similarity are simply additive, or whether the two dimensions interact. Our analyses test for a possible interaction between the two forms of similarity. Yet, from the standpoint of understanding the challenges of identifying potential opportunities, it becomes particularly important to examine the meaning and impact that divergences among types of similarity may have on the formation of opportunity beliefs.

As such, our theoretical model draws attention to scenarios in which the superficial and structural similarities of a technology-market combination are at odds with each other. In cell IV of Figure 1, the video game technology for teenage drivers shares high levels of superficial similarity with the target market of K–12 children and their parents, but the technology's core capabilities (to train individuals to manage stress and anxiety) share low levels of structural similarity with the latent needs of parents in the target market. By contrast, in cell I of Figure 1, the technology is presented as being developed by NASA to help space shuttle pilots develop their ability to stay alert and concentrate over long periods. Although the technology in this scenario shares low levels of superficial similarity with the target market of K–12 schoolchildren and their parents, it has high levels of structural similarity with that market; the technology's capabilities match the latent needs of parents of ADHD children who seek alternatives to Ritalin and other drugs.

Interestingly, this latter scenario of low superficial–high structural similarity corresponds with the actual case of transfer for this particular technology (NASA, 2003). More importantly, there is evidence that although new technologies are often portrayed with specific applications in mind (i.e., what the technology was used for "in the lab"), entrepreneurs often imagine promising applications in completely different markets than what the inventors of the technology (or the officers in charge of commercializing it) had imagined (cf. Shane, 2000). Yet Shane reported that the imagined opportunities for the technology he was studying often appeared "nonobvious" even to entrepreneurs pursuing other opportunities *for the same technology* (2000: 456). Prior explanations of this "nonobviousness" have stressed the role played by entrepreneurs' unique knowledge resources. That is, because they know and understand more about particular markets and industries than the originators of the technology, some entrepreneurs are able to identify market applications that the inventors could never have thought of (Gruber, MacMillan, & Thompson, 2010, 2012; Shane, 2000; Ucbasaran, Westhead, & Wright, 2009).

We propose a complementary explanation, one that draws attention to the distinct effects of superficial and structural similarity in the formation of opportunity beliefs. From the perspective of our model, the apparent nonobviousness of these opportunities seems to proceed from the divergences between the low levels of superficial similarities shared between technologies and markets, in spite of their high levels of structural similarities.

Cognitive scientists have shown that when interpreting ambiguous stimuli in the face of uncertainty, the human mind has a distinct preference for reasoning that involves higher orders of structural relationships (Gentner, 1989; Holland et al., 1986). When trying to make predictions about a new object, for instance, individuals tend to prefer predictions that are part of an overall causal system to predictions that are equally plausible but that do not proceed from such a causal system (Clement & Gentner, 1991). Along this line, research has shown that because they activate more neuronal connections, structural matches tend to generate more brain activity than superficial matches (Keane et al., 1994). This implies that when thinking about entrepreneurial opportunities, individuals are likely to be more "aroused" cognitively when noticing similarities between the structural capabilities of a new technology and the causes of latent demand in a market than when noticing superficial similarities between this technology and that market.

In spite of the cognitive preference for structural similarity, however, perceiving and processing structural similarities *in the absence of superficial parallels* is a particularly demanding task cognitively (cf. Catrambone & Holyoak, 1989). Thus, the lack of superficial similarities characterizing some technology-market combinations can make these opportunity ideas less obvious—even when the capabilities of the technology match the causes of latent demand in a market. As a result, beliefs about such potential opportunities may be more uncertain (less positive) than they would otherwise be with high superficial similarity (cf. cell I is less certain than cell II in Figure 1). This kind of challenge is illustrated by the difficulty many students experience in transferring the solutions learned in one content domain with particular superficial elements (e.g., math problems that use particular objects or units) to logically similar problems in other domains (e.g., physics problems that focus on different objects and units) (cf. Bassok & Holyoak, 1989; Novick & Holyoak, 1991). In other words, the lack of superficial similarities can make knowledge transfer more difficult. Conversely, a dominant emphasis on superficial similarities can sometimes lead to faulty reasoning, as may occur when superficial similarities are present without structural similarities. For instance, the presence of strong similarities between the superficial elements of a technology and a market could counteract the otherwise negative effects of structural mismatches between the capabilities of the technology and the causes of latent demand in the market. In such cases (cell IV in Figure 1), opportunity beliefs would be less negative than they could otherwise have been.

Taken together, these observations suggest an explanation for why opportunities in which a technology shares low superficial similarity but high structural similarity with a market are so difficult for casual observers to identify. Although the human mind prefers to base inferences on structural relationships, perceiving and processing such relationships in the absence of superficial parallels is cognitively demanding. Yet cognitive research has documented that this kind of low superficial–high structural reasoning is of utmost importance for drawing inferences that expand knowledge in the face of uncertainty (Holland et al., 1986) and making creative "mental leaps" (cf. Holyoak & Thagard, 1995)—such as the leaps and inferences made by scientists, engineers, designers, and strategists generating creative solutions to challenging problems (Dahl & Moreau, 2002; Dunbar, 1993; Gavetti & Rivkin, 2005).

Building on these observations about the role of superficial/structural similarities and the identification of nonobvious opportunities, we investigate the extent to which beliefs about technology-market pairs characterized by low superficial similarity and high structural similarity differ from opportunity beliefs for technology-market pairs with other similarity patterns. By doing so, we shed light on the cognitive reasons why some opportunities for technology transfer seem nonobvious. To the extent that the human mind has a distinct preference for reasoning that involves structural relationships, we offer the following:

Hypothesis 3a. Opportunity beliefs for new technology-market combinations with low levels of superficial similarity but high levels of structural similarity are more positive than beliefs for new technology-market combinations with low levels of both superficial and structural similarity.

Hypothesis 3b. Opportunity beliefs for new technology-market combinations with low levels of superficial similarity but high levels of structural similarity are more positive than beliefs for new technology-market combinations with high levels of superficial similarity but low levels of structural similarity.

Hypothesis 3c. Opportunity beliefs for new technology-market combinations with low levels of superficial similarity but high levels of structural similarity are less positive than beliefs for new technology-market combinations with high levels of both superficial and structural similarity.

The Nexus of Opportunity and Individuals

Because entrepreneurial action lies at the nexus between individuals and opportunities (Shane & Venkataraman, 2000: 218), it becomes important not only to examine the effects of similarity differences among opportunities but also to discuss the role of individual differences in our model of opportunity identification. In line with the considerations above, we investigate whether (and why) the effects of similarity characteristics on the formation of opportunity beliefs vary among individuals. We also examine why some individuals form more positive beliefs for nonobvious technology-market combinations than others.

To do so, we build on cognition research demonstrating that the perception and processing of structural similarities demand more cognitive effort than the perception and processing of superficial similarities (Gentner, 1989; Keane et al., 1994). As we noted above, cognitive research often portrays *superficial* similarities as the "default" mode of reasoning—the way most people spontaneously think about things. As such, the reliance on superficial similarity tends to be predominant under conditions of limited attention, time constraint, and individuals' limited knowledge structures (Catrambone & Holyoak, 1989; Keane et al., 1994). Because processing structural similarity requires more effort than processing superficial similarity, however, the use of structural similarity tends to increase with ability (and motivation) to encode new information in a rich and complex manner (Blanchette & Dunbar, 2001; Keane et al., 1994) and with the availability of complex knowledge structures that can be drawn upon to process the information (Chi, Feltovich, & Glaser, 1981; Dunbar, 1993). For instance, Novick (1988) observed that experts were better able than novices to transfer the solutions they had learned in their domains of expertise to other domains in which they were less knowledgeable.

Taken together, these observations provide an overarching logic with which to consider the moderating role of individual differences in our model.

Because the perception and processing of superficial similarities is spontaneous and requires little cognitive effort, there is no reason to expect individual differences to moderate the relationship between superficial similarity and opportunity beliefs. Because the perception and processing of structural similarities demand more cognitive effort, however, individual differences in cognitive resources, motivations, and abilities will likely moderate the impact of structural similarities on opportunity beliefs. To the extent that an individual factor enables rich encoding of information and processing complex information, this factor will likely increase the influence of *structural similarity* on the formation of opportunity beliefs. By extension, this effect will foster the formation of more positive beliefs about technology-market pairs that are characterized by high structural similarity despite low superficial similarity (the nonobvious opportunities discussed above).

Past research has documented the effects of several individual and organizational differences on entrepreneurship (cf. Baum & Bird, 2010; Hmieleski & Baron, 2009; Tuggle, Schnatterly, & Johnson, 2010). With respect to the specific formation of opportunity beliefs, however, McMullen and Shepherd (2006) highlighted the predominant role of two classes of factors: *personal motivations* (more specifically, concerns for "doing something" about particular issues or problems in one or more contexts) and *prior knowledge* (not only of what is going on in a market or industry, including changes, but also of the problems and issues in these contexts). In keeping with their emphasis on the role of these two factor classes in efforts to identify potential opportunities, we focused our theoretical development on the effects of individual differences in *entrepreneurial intent* and in *prior knowledge* of technologies and markets. In turn, our study controlled for the possible effects of other differences in cognitive abilities.

Although motivation has long been investigated in entrepreneurship research (cf. Shane, Locke, & Collins, 2003), the question of intent to engage in entrepreneurship has received particular attention in efforts to predict entrepreneurial action in various settings and populations (Krueger, Reilly, & Carsrud, 2000; Zhao, Seibert, & Lumpkin, 2010). *Entrepreneurial intent* refers to individuals' stated desire to engage in start-up activities in the near future (Linan & Chen, 2009; Thompson, 2009). Research has shown that individuals who intend to engage in entrepreneurial activities are more alert to opportunity signals (Hills & Singh, 2004) and are more favorably inclined toward these signals than those who do not intend to engage in future entrepreneurial activities (Dimov, 2010). Building on the overarching logic developed above, entrepreneurial intent likely encourages individuals to be more mindful of new information, to encode this information in a richer and deeper manner, and to process this information more thoroughly, which, in turn, all likely increase the impact of structural matches on the formation of opportunity beliefs. Thus, we propose:

Hypothesis 4. Entrepreneurial intent moderates the relationship between structural similarity and opportunity beliefs in such a way that the positive relationship between structural similarity and opportunity beliefs is more positive when entrepreneurial intent is high than when entrepreneurial intent is low.

Building on Hayek's (1945) observations about the distribution of knowledge in society, scholars have shown that prior knowledge helps explain why some individuals (or firms) are better able than others to imagine and/or identify entrepreneurial opportunities (cf. Dimov, 2007b; Miller, Fern, & Cardinal, 2007; Shepherd & DeTienne, 2005) and why individuals are able to recognize some but not all opportunities from a specific "signal" (Gruber et al., 2008, 2010; Shane, 2000). Cognitive research suggests that when individuals encounter information that is related to domains they know well, they are able to encode more of the information in a richer and more complex manner (Chi et al., 1981; Dunbar, 1993). Because they have richer and deeper knowledge structures with which to interpret the information they receive, their reasoning tends to place more emphasis on structural similarities than on superficial similarities (cf. Holland et al., 1986; Novick, 1988). Accordingly, we propose that when developing beliefs about opportunity ideas, individuals with greater prior knowledge likely rely more heavily on structural similarity than individuals with less prior knowledge. Although the same theoretical logic underpins the influence of different dimensions of prior knowledge, our analysis distinguishes between the effects of prior knowledge of technologies (Lichtenthaler, 2009) and prior knowledge of markets (Shane, 2000). Thus, we offer the following hypotheses:

Hypothesis 5a. Prior knowledge of technologies moderates the relationship between structural similarity and opportunity beliefs: the positive relationship between structural similarity and opportunity beliefs is more positive when prior knowledge is high than when prior knowledge is low.

Hypothesis 5b. Prior knowledge of markets moderates the relationship between structural similarity and opportunity beliefs: the positive relationship between structural similarity and opportunity beliefs is more positive when prior knowledge is high than when prior knowledge is low.

METHODS

To test the hypotheses stated above, we conducted a within-subject experiment with two samples of entrepreneurs. Concretely, we presented participants with a series of technology-market combinations and asked them to report their certainty that these scenarios represented potential opportunities—or nonopportunities. This approach allowed us to test the independent and interactive effects of superficial and structural similarities on opportunity beliefs, controlling for the effects of individual differences in cognitive resources and abilities.

Samples

Responding to calls for more replications in management research (cf. Amir & Sharon, 1991; Eden, 2002; Tsang & Kwan, 1999), we conducted our experiment with two samples of entrepreneurs. Replications are "vital for establishing the external validity of the study's findings (Cook & Campbell, 1979; Hendrick, 1991; Rosenthal, 1991) and key to the accumulation of scientific knowledge (Amir & Sharon, 1991)" (Colquitt & Zapata-Phelan, 2007, 1284). Indeed, Tsang and Kwan (1999) highlighted that replications using the same measurement and analysis but different populations provide information on empirical generalization and a more solid foundation for subsequent theory development. In the current study, we used the same experimental design, procedures, measurement, and analysis but collected data in two different samples of entrepreneurs. The first sample consisted of 98 entrepreneurs heading United States–based start-ups in the domains of life science, medical, and biological technologies. The second sample consisted of 51 U.S. entrepreneurs operating a more diverse set of businesses in different industries.[1]

Two additional reasons motivated our focus on these particular samples. First, this strategy allowed us to conduct our studies with individuals who were familiar with both the task of identifying opportunities and the challenges of exploiting opportunities based on new scientific knowledge. This minimized the possibility that participants' lack of familiarity with the focal task would influence our empirical observations. At the same time, the entrepreneurs in our samples had varied levels of work and entrepreneurial experience; we controlled for such differences in our analyses. Second, our strategy of basing the scenarios and manipulations on real cases of technology transfer demanded that we conduct our research with entrepreneurs who varied in their prior knowledge of the described technologies and the particular market applications for these technologies but who were unlikely to be experts about the specific opportunities that were actually exploited for these technologies.

For sample 1, we approached 37 U.S. incubators supporting new life science ventures listed in the National Business Incubator Association directory (http://qwww.nbia.org). We contacted each incubator's director to ask permission to invite their incubator's entrepreneurs to take part in our research; 22 directors from 14 different states accepted (a 59.5 percent acceptance rate). Working from the incubators' websites, we located the contact information for the CEOs of each firm operating in life sciences, medicine, and other biotechnology domains, as well as that of any senior officer who was *also* identified as a firm founder. We invited all of these individuals to take part in our research. Of the 196 entrepreneurs we contacted by phone and e-mail, 98 completed the experiment (a 50 percent response rate).[2] As was consistent with their focus on life science technologies, the majority of participants (51) held a Ph.D. in a science-based field. All participants occupied top-level positions in their firms, and 80 of them (82%) were the founders/cofounders of their firms. The median age of these firms was five years, and the median size was seven and a half full-time employees, three patents, and $1.0 million in sales.

We derived the second sample from two sources: (1) entrepreneurs from the 22 business incubators above who were operating businesses in sectors other than life sciences and (2) associate members of the University of Colorado at Boulder's Deming Center for Entrepreneurship. Of the 160 listed en-

[1] Power analyses for a 2×2 repeated-measures design indicated that given an alpha of .05, a target power of .85, and "moderate" correlations of .5 between the repeated measures, a sample size of 50 was sufficient to detect effect sizes of $f = .18$ (i.e., in between Cohen's [1988] "small" and "medium" effect sizes for f).

[2] Individuals' reasons for declining participation generally stressed a lack of time. To assess the possibility of nonresponse bias, we tested whether early and late respondents differed on the hypothesized parameters and in their individual or firm characteristics (Dooley & Lindner, 2003). We found no significant differences.

trepreneurs we invited, 11 incubator entrepreneurs (from the 29 contacted) and 40 entrepreneurs from the entrepreneurship center database (of the 131 contacted) completed the research, giving a combined response rate of 32 percent. By design, these 51 respondents represent a more heterogeneous sample than those of sample 1, with operations in industries ranging from travel services to specialized computer software. All participants occupied senior positions, and 42 (82%) were the founders/cofounders of their firms. Their education levels ranged from high school to Ph.D. and included degrees in fields as diverse as culinary science, engineering, law, and business. The median age of these entrepreneurs' firms was eight years, and the median size was 17 full-time employees, no patents, and \$1.5 million in sales.

Research Design and Procedures

Articulation of research task. To augment the validity of our research, we modeled our task, scenarios, and manipulations on documented cases of technology transfer. Technology transfer concerns situations in which research organizations develop new technologies but do not exploit the commercial application(s) of these technologies themselves; rather, they offer the rights to use specific technologies to entrepreneurs willing to exploit their application(s) in particular market(s) (cf. Mowery et al., 2004; Shane, 2001). The modus operandi of technology transfer is thus consistent with our theoretical development—in the sense that the opportunity ideas in our scenarios consist of new technology-market combinations. Likewise, our exercises reflect the actual efforts of entrepreneurs who, upon learning about a new technology, start thinking about whether or not applying this technology to a particular market might be an entrepreneurial opportunity (Shane, 2000). Thus, we assume that entrepreneurs base their mental representations of new technologies on the information they receive, including information about the similarity characteristics that a technology may share with a target market. We validated this assumption as part of the pretests for the experiment (see below).[3]

Data collection. We collected data to test our hypotheses by conducting a 2×2 within-subject experiment embedded in an online survey. In part I of the study, we presented participants with short opportunity scenarios pairing a market need situation and a new technology. For each scenario, we asked a series of questions targeting participants' opportunity beliefs—that is, the extent of participants' *certainty* that a scenario does (or does not) constitute a potential business opportunity (cf. Grégoire, Shepherd, & Lambert, 2010). These questions formed our dependent variable. In part II, the entrepreneurs answered a series of questions about their background, abilities, and resources. We developed and validated the research material and then conducted the online experiment as part of a larger series of studies in the spring of 2005.

The within-subject nature of the experiment implied that every participant evaluated four scenarios (one for each cell in the 2×2 matrix). Each scenario involved a different new technology and a different target market. To prevent order and habituation effects from biasing our results, we randomly assigned participants to one of eight different versions of the experiment: the versions are based on a latin square design with four different orders of similarity manipulations, each with two different orders of technologies.

Dependent Variable

In keeping with the theoretical development presented above, we used the measure of opportunity beliefs developed and validated by Grégoire, Shepherd, and Lambert (2010), which showed that in the early phase of entrepreneurial action, opportunity beliefs are primarily articulated along two dimensions: the fit between a new means of supply (e.g., a new product, service, technology or business model) and a potential target market, and the feasibility of introducing the new means of supply in that market. The dimension of *fit* reflects the theoretical notion that, to lead to more efficient economic transactions (cf. Denrell et al., 2003; Shane & Venkataraman, 2000), an entrepreneurial opportunity's new "means of supply" (in the present study, a new technology) has qualities that meet the needs and requirements of a target market (cf. Eckhardt & Shane, 2003; Venkataraman & Sarasvathy, 2001). The notion of *feasibility* concerns beliefs that "an opportunity is seen as reasonably possible to achieve within a foreseeable future" (Grégoire, Shepherd, & Lambert, 2010: 122).

The measure of opportunity beliefs includes three items capturing fit and two items capturing feasibility. Appendix A presents the relevant instructions and scale items. For both samples, we observed item-total correlations ranging from .73 to

[3] We acknowledge that technology transfer is only one among many relevant contexts for studying opportunity identification. From a methodological standpoint, however, focusing on this single context allowed us to control for the dynamics that could characterize the identification of different types of opportunities in different contexts.

.89 (means of .84 and .82 for samples 1 and 2) and obtained Cronbach's alpha reliability coefficients of .94 and .93 for samples 1 and 2. These results indicate that the target items form an internally consistent and reliable scale. We used confirmatory factor analysis (CFA) techniques to assess the measures' discriminant validity. The results indicate that answers to the five target items load on a construct that is empirically distinct from answers to separate questions about intent to pursue a particular opportunity or evaluation of the market size and potential of this opportunity (CFA loadings in the .5–.8 range as opposed to .9 and above for the target items); furthermore, the fit indexes of these alternate models did not meet acceptable thresholds (Marsh, Hau, & Wen, 2004).

Independent Variables: Similarity Characteristics of Opportunity Ideas

In keeping with the theoretical developments above (see Figure 1), we designed our experiment around a series of opportunity scenarios that manipulated the superficial and structural similarities characterizing different technology-market combinations. To augment the external validity of our findings, we constructed our scenarios from four documented cases of technology transfer identified from the websites of U.S. universities and other institutions. To strengthen the internal validity of our manipulations and to limit the confounding of our results by variations in market knowledge, we kept the descriptions of the target markets constant and focused our manipulations on the descriptive elements and inherent capabilities of the four technologies.

Manipulation of superficial similarity. Cognitive studies of problem solving and structural alignment have empirically investigated the effects of superficial similarity by manipulating the content and situational elements of different problems. For instance, Bassok and Holyoak (1989) contrasted the transfer of solutions across similar domains (e.g., from algebra to other algebra problems and from physics to other physics problems) and across dissimilar domains (e.g., from algebra to physics or vice versa). Likewise, Novick and Holyoak (1991) studied the transfer of solutions across math problems involving different contexts, characters, and objects (e.g., vegetable gardens, marching bands, bake sales, and seashell collections). As did these previous studies, the current experiment involves the transfer of a solution (in our case, a technology) from one context to another (e.g., NASA's space shuttle pilots to parents of ADHD children). In keeping with these works, we operationalized superficial similarity by varying elements such as where the technology was first developed, who its first users were (in the lab or as it was developed), what materials its developers worked with, and what object(s)/service(s) its developers produced with the technology. For instance, the market of ADHD children and their parents shares *low* superficial similarity with the original NASA technology developed for space shuttle pilots training in flight simulators (see Figure 1, cells I and III). By contrast, the same market would share *high* superficial similarity with a new technology developed by child psychiatrists to train teenagers in driving schools (see Figure 1, cells II and IV).

Manipulation of structural similarity. Cognitive studies of problem solving have examined the effects of structural similarity by focusing on the logical operations necessary to solve different problems. Interestingly, the studies of transfer cited above (e.g., Bassok & Holyoak, 1989; Novick & Holyoak, 1991) did not vary structural similarity per se; they focused on how students were able to apply the same structural relationships (in this case, mathematical operations, such as subtractions, arithmetic progressions, constant acceleration, etc.) to many problems with different superficial elements. To specifically explore the effects of variations in structural similarity, Schmid, Wirth, and Polkehn (2003) manipulated the extent to which a solution for a source problem (i.e., a *series* of mathematical operations) could be used in its entirety, partially, or not at all to solve different target problems. We follow the same basic approach; we operationalized structural similarity through variations in the capabilities of the technology—what it could and could not do—holding market descriptions constant. For instance, a NASA technology used to develop pilots' ability to stay focused over extended periods of time shares *high* levels of structural similarity with the market of parents who seek nonpharmaceutical alternatives to treat ADHD (see Figure 1, cells I and II). By contrast, a NASA technology used to develop pilots' ability to control their stress and anxiety would share *low* levels of structural similarity with that market (see Figure 1, cells III and IV).

Development and pretest of research materials. For each technology, we used the manipulation guidelines above to develop four different scenarios corresponding to our 2×2 research design. This strategy allowed us to decouple the manipulations from any particular technology and market. In keeping with our observations above regarding the challenges of technology transfer, the scenarios with low superficial similarity and high structural similarity always corresponded to the real-life cases of nonobvious opportunities. Appendix B describes the four technologies and markets we utilized in our scenarios and the procedures we followed to develop the scenarios. Appendix C presents two scenarios illustrating the manipulations. The complete material is available from the first author upon request.

To validate the scenarios, we met individually with each of five engineer-entrepreneurs and discussed with them whether our manipulations of technologies were plausible. Having confirmed the face validity of all scenarios, we conducted a pretest of our manipulations of superficial and structural similarity with three academic experts in managerial and organizational cognition research, and 17 nascent entrepreneurs. The pretest asked participants to read an opportunity scenario and list the aspect(s) in which they thought the technology and market were dissimilar (indicating a low level of similarity) and then the aspect(s) in which they thought the technology and market were similar (indicating a high level of similarities). The three experts evaluated all 16 scenarios (i.e., four technologies times two [superficial: high and low] by two [structural: high and low]); thus, they made a total of 48 evaluations of similarities and dissimilarities. The nascent entrepreneurs evaluated four scenarios (one for each cell, each time with a different technology, for a total of 68 evaluations). We randomly assigned nascent entrepreneurs to four different versions of the pretest so that we could test all four manipulations for all four technologies.

Results confirmed the internal validity of our manipulations. Specifically, both academic experts and nascent entrepreneurs listed more *superficial similarities* for scenarios with a high level of superficial similarities than for scenarios with a low level of superficial similarities (2.83 vs. .88, $p \leq .001$, for academic experts; and 1.85 vs. .94, $p \leq .01$, for nascent entrepreneurs), and they listed more *superficial dissimilarities* for scenarios with a low level of superficial similarities than for scenarios with a high level of superficial similarities (2.00 vs. 0.44, $p \leq .001$; and 1.79 vs. 0.82, $p \leq .01$). Additionally, both groups listed more *structural similarities* for scenarios with a high level of structural similarities than for scenarios with a low level of structural similarities (2.39 vs. 0.83; $p \leq .001$; and 1.50 vs. 0.94, $p \leq .05$); and they listed more *structural dissimilarities* for scenarios with a low level of structural similarities than for scenarios with a high level of structural similarities (1.33 vs. 0.46, $p \leq .001$; and 1.74 vs. 0.77, $p \leq .01$).[4]

Independent Variables: Individual Differences

New start-up intentions. Some entrepreneurs start multiple new ventures over the course of their professional careers (cf. Ucbasaran, Alsos, Westhead, & Wright, 2008). As such, it is posssible that some entrepreneurs in our sample were considering starting subsequent ventures in the future. We focused on this possibility for capturing entrepreneurial intent. More specifically, we followed Krueger et al.'s (2000) simple, yet direct, approach of asking respondents to state their intent to "start another new firm within the next five years" (1, "I certainly will not," to 9, "I certainly will." We chose to measure start-up intentions with a single item because our study meets the three conditions stipulated by Wanous and Hudy (2001: 368) for using a single item—namely, that the construct of interest is (1) unidimensional (cf. Linan & Chen, 2009; Thompson, 2009), (2) clear to the respondents (qualitative pilot tests did not reveal any content validity or interpretation issues), and (3) sufficiently narrow. More importantly, and following Wanous and Hudy (2001), we used data from other studies to evaluate the reliability of our target item. Results supported the validity and reliability of our target item for measuring participants' variations in entrepreneurial intent.[5]

Prior knowledge. Although we conducted our studies with entrepreneurs who were unlikely to have knowledge of the technologies showcased in our opportunity scenarios (and their real-life applications), participants still varied in their knowledge of

[4] We note that in spite of our efforts to develop theoretically and practically consistent manipulations, there is no guarantee that these manipulations are "substantively equivalent" across technologies. To control for this possibility (and other order and habituation effects noted above), we included a series of contrast codes in our analyses that parceled out the variance associated with the different versions of the experiment.

[5] Drawing from the factor analyses reported in Linan and Chen's (2009) Table 2 (n = 310 students), we observed that with a factor loading of .86, an item using the words "I have the firm intention to start a firm someday" shared 74 percent of variance (communality, or h^2) with a six-item construct assessing entrepreneurial intentions. Along this line, we took advantage of a separate project to replicate these observations with a sample of entrepreneurs. Results indicated that our target item showed high levels of shared variance with a unidimensional factor of five items targeting entrepreneurial intent ($h^2 = .87$, $n = 155$ entrepreneurs). As organization behavior scholars have argued about single-item measures of job satisfaction (cf. Wanous, Reichers, & Hudy, 1997), we contend that our target measure of entrepreneurial intent alleviates the need for redundant items and adequately captures what we are testing with Hypothesis 4—that is, whether entrepreneurs' intentions to start another new venture in the near future moderates the effects of structural similarity on their beliefs about different technology-market combinations.

both how these technologies worked and the focal markets represented in the scenarios. To capture the effects of prior knowledge of technologies and markets, we followed each opportunity scenario with four questions. To assess prior knowledge of technologies, we asked participants to report their prior knowledge of (1) the technology presented and (2) the scientific and engineering principles underpinning the technology. To assess prior knowledge of markets, we asked participants to report their prior knowledge of (1) the market of interest and (2) the problems affecting this market and current solutions to this problem. Participants answered each question on a scale anchored at 1, "minimal knowledge," and 7 "considerable knowledge." Strong correlations between the items targeting the same dimension justified the creation of average scores for each dimension of prior knowledge.

Control Variables

In parallel to our focus on the moderating role of entrepreneurial intent and prior knowledge, we readily acknowledge that individual differences in intelligence or cognitive abilities could affect participants' understanding of our scenarios—not to mention their abilities to identify opportunities with varying levels of superficial and structural similarities. To control for such possibilities, we collected data on participants' human capital and self-efficacy. In addition to forming adequate proxies for different forms of cognitive abilities, these variables have been shown to play influential roles in fostering the identification of entrepreneurial opportunities.

Education, background, and experience. Human capital plays an important role in the propensity to engage in start-up activities (cf. Davidsson & Honig, 2003; Ucbasaran et al., 2009) and in opportunity recognition (cf. Gruber et al., 2008, 2010). Accordingly, we controlled for individual variations in education and, more specifically, the highest degree achieved (high school, two-year college, four-year college, master's, or doctorate). In addition, we controlled for participants' length of work experience (in years, log-transformed) and for the number of new ventures they had founded in the past (a proxy for entrepreneurial experience).

Innovation and creative self-efficacy. Several studies have observed positive relationships between relevant dimensions of self-efficacy (Bandura, 1997) and entrepreneurial action (cf. Baum, Locke, & Smith, 2001; Zhao, Seibert, & Hills, 2005). In this regard, Krueger and Dickson (1994) showed that individuals with high self-efficacy tend to perceive more opportunities in risky choices than individuals with low self-efficacy. By the same logic, individuals who are more confident in their abilities to innovate and to be creative could form more positive beliefs about opportunities that other individuals dismiss. To control for this possibility, we used instruments developed by Chen, Greene, and Crick (1998) and Tierney and Farmer (2002) to capture individual variations in innovation and creative self-efficacy.[6]

Data Analysis

We analyzed the data using repeated-measures regression techniques that decompose observed variance into its between- and within-subject components (cf. Judd, McClelland, & Smith, 1996). More specifically, we computed a series of observed dependent variables measuring participants' average opportunity beliefs (the between-subject variance), as well as the within-subject effects of superficial similarity, structural similarity, and a potential interaction between superficial and structural similarity on opportunity beliefs (Judd & McClelland, 1989). This technique addressed potential violations of the sphericity assumption that could arise from repeated measures (cf. Bergh, 1995; Judd, 2000: 383). More importantly, the technique allowed us to isolate the independent effect of each dimension of similarity on opportunity beliefs (e.g., superficial, as in Hypothesis 1)—controlling for the effect of the other dimension (e.g., structural), for their interaction (superficial times structural), and for other independent and control variables.[7]

[6] CFAs indicated that creative and marketing self-efficacy were two distinct dimensions, but the innovation items tended to load on both constructs. Considering the problem from a theoretical standpoint, we reasoned that creativity and innovation are more directly relevant for opportunity identification than marketing. On that basis, we investigated the dimensionality of a creative/innovation self-efficacy construct. Analyzing the data from both samples, we found that a five-item construct (two creativity items and three innovation items) was structurally sound (with fit indexes of χ^2/df = .93; CFI = .99; SRMR = .05; RMSEA = .00), had acceptable levels of internal consistency (α = .78), and was only moderately correlated with the marketing self-efficacy construct (r = .71). We used this measure of innovation/creative self-efficacy as a control variable in our analyses.

[7] Calculations of these observed dependent measures correspond to the average of the independent effect of interest across all levels of the other effects in the 2×2 design. For instance, the measure for the effect of superficial similarity corresponds to w_{su} = ([effect of superficial similarity {high minus low} at level of structural similarity = low] + [effect of superficial similarity {high minus low} at level of structural similarity = high])/2. To verify that our tests

Following recommendations for analyzing within-subject experimental data (cf. Judd & McClelland, 1989; Judd et al., 1996), we ran separate regression analyses for the independent effects of superficial similarity, structural similarity, and their potential interaction. The constant of each regression model captured the effect of interest, net of the effects of the other explanatory variables included in the models. Conversely, parameters for the other control and independent variables assessed whether the effect of interest (i.e., the constant) varied systematically with variations in these variables. Because participants gave prior knowledge ratings for all of the scenarios in the design, we used the same variance decomposition techniques to calculate prior knowledge measures corresponding to each effect of interest (e.g., high prior knowledge across scenarios with high versus low superficial or structural similarity).

RESULTS

Table 1 presents the descriptive statistics for samples 1 and 2. Columns 1, 2, and 3 display correlations with participants' average opportunity beliefs across scenarios, the effects of superficial similarity, and the effects of structural similarity, respectively. With only a few exceptions (which we examine below), the correlations among the variables are generally small in magnitude and nonsignificant. Examination of the tolerance and variance inflation statistics indicated that multicollinearity did not unduly influence the results we report below. Figure 2 reports participants' opportunity be-

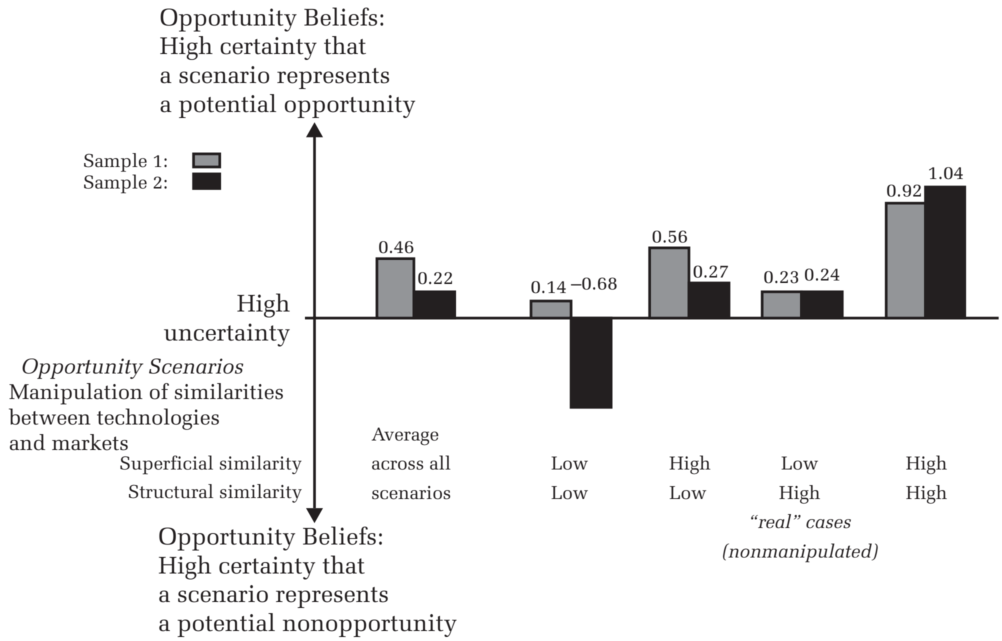
TABLE 1
Means, Standards Deviations, and Correlations

Variables, Sample 1 (n = 98)	Mean	s.d.	1	2	3	4	5	6	7	8	9
1. Average opportunity beliefs (four scenarios)	0.46	2.37									
2. Effect of superficial similarity	0.55	1.44	.11								
3. Effect of structural similarity	0.23	1.91	−.11	−.02							
4. Highest education level	4.58	1.03	.04	−.14	−.03						
5. Length of work experience[a]	1.44	0.44	−.17	.11	.02	.02					
6. Start-up foundings[a]	0.91	0.60	−.02	.03	−.01	−.14	.22*				
7. Innovation/creative self-efficacy	5.38	1.04	−.05	−.03	−.12	−.16	−.02	.19			
8. Entrepreneurial intention	4.41	2.59	.01	−.13	.12	.06	−.24*	.22*	.17		
9. Prior knowledge of technologies	−1.90	2.37	−.02	.18	.25*	.03	.06	.15	.21*	−.01	
10. Prior knowledge of markets	−0.90	2.49	.06	−.03	−.31**	−.07	.15	.10	.27**	−.12	.59**
Variables, Sample 2 (n = 51)	**Mean**	**s.d.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. Average opportunity beliefs (four scenarios)	0.22	2.64									
2. Effect of superficial similarity	0.88	1.72	−.07								
3. Effect of structural similarity	0.84	1.63	−.07	.09							
4. Highest education level	3.75	0.82	−.10	.08	−.05						
5. Length of work experience[a]	1.34	0.56	−.01	−.09	−.07	−.07					
6. Start-up foundings[a]	1.05	0.60	.03	−.21	−.06	.05	.38**				
7. Innovation/creative self-efficacy	5.42	1.00	−.08	−.15	−.13	−.05	.19	.38**			
8. Entrepreneurial intention	4.69	2.96	−.03	−.22	.14	.03	−.03	.44**	.20		
9. Prior knowledge of technologies	−2.40	1.74	−.17	−.28*	.08	−.03	−.05	.13	.29*	−.05	
10. Prior knowledge of markets	−0.90	2.40	−.25	.02	.14	−.13	.02	.11	.40**	−.04	.65**

[a] Logarithm.
* $p \leq .05$
** $p \leq .01$

accounted for the total variance observed in all cells in the design, we conducted a series of analyses of variance (ANOVAs) decomposing the variance for both the within-subject components (main effects of superficial, structural, and superficial by structural similarity) and the between-subject variance in average opportunity beliefs. In keeping with Judd and McClelland (1989), we divided the between-subject component not by the number of scenarios (4) but by the square root of that number (2) (cf. Judd & McClelland, 1989). Results showed that the sum of the squares for the between- and within-subject analyses added up to the total sum of the squares across all cells, thereby confirming that the computations were correct. We also made sure that all of the variables met the assumptions of normality and heteroskedasticity and checked that potential outliers did not unduly influence the results (McClelland, 2000). Following Bergh (1995) and Edwards (1995), we also used multivariate regression analyses to assess whether the effects of the independent and control variables varied over the range of the dependent measures. The results were nonsignificant, and tests of individual parameters supported the results presented below.

FIGURE 2
Opportunity Beliefs for Scenarios with Different Similarity Characteristics



Within-sample means difference between scenarios (with significance t-test)

	Sample 1: High-Low	Sample 1: Low-High	Sample 1: High-High	Sample 2: High-Low	Sample 2: Low-High	Sample 2: High-High
Low-low	0.42	0.09	0.78**	0.95*	0.92**	1.72***
High-low		−0.33	0.36		−0.03	0.77*
Low-high			0.69**			0.80*

liefs across all cases and for the manipulations of superficial and structural similarity. This figure illustrates that participants made important distinctions between the patterns of superficial and structural similarity embedded in the experiment's scenarios. Participants rated opportunities with low levels of both superficial and structural similarity most negatively (with ratings of 0.14 and −0.68 for samples 1 and 2, respectively), and they rated opportunities with high levels of both superficial and structural similarity most positively (e.g., 0.92 and 1.04). Participants were more ambivalent about opportunities with high superficial/low structural similarity and with high structural/low superficial similarity. The mean difference tests reported in the lower panel of Figure 2 indicate that opportunity beliefs differed significantly across opportunity scenarios. We examine these differences below.

Effects of the Characteristics of Opportunity Ideas on Opportunity Identification

Table 2 reports the results of regression analyses concerning the effect of similarity characteristics of different technology-market combinations on participants' opportunity beliefs. We first observed that for both samples, the coefficient for superficial similarity was positive and significant (model 1b, $b = .63$, $p \leq .001$; model 2b, $b = .99$, $p \leq .001$). This indicates that beliefs that a new technology-market combination represents an opportunity are more positive when the superficial elements of a technology share high levels of similarity with the superficial elements of a target market. These findings support Hypothesis 1. Second, we observed that the coefficient for structural similarity was positive and significant (model 3b, $b = .62$. $p \leq .001$; model 4b, $b = .71$, $p \leq .001$). This indicates that beliefs that a new technology-market combination represents an opportunity are more positive when the structural capabilities of a technology share high levels of similarity with the structural reasons underlying latent demand in a target market. These findings support Hypothesis 2.[8]

[8] In keeping with a variance-decomposition approach to the analysis of within-subject designs, we also tested for a possible interaction between superficial and structural similarity on opportunity beliefs. For both samples, results indicated that such an interaction was not significant.

TABLE 2
Results of Within-Subject Regression Analyses: Effects of Superficial and Structural Similarity on Opportunity Beliefs[a]

	Effect of Superficial Similarity on Opportunity Beliefs				Effect of Structural Similarity on Opportunity Beliefs			
	Sample 1		Sample 2		Sample 1		Sample 2	
Variables	Model 1a	Model 1b	Model 2a	Model 2b	Model 3a	Model 3b	Model 4a	Model 4b
Effect of interest (constant)	.64***	.63***	.81**	.99***	.58***	.62***	.71***	.71***
Highest education level	–.25†	–.21	.23	.31	–.02	–.01	–.08	–.05
Length of work experience	.73*	.52	.06	–.06	–.09	–.01	–.39	–.14
Start-up foundings	–.11	.02	–.33	–.01	.19	.02	–.02	–.53
Innovation/creative self-efficacy	–.08	–.08	–.16	–.17	–.01	–.01	–.03	–.06
Entrepreneurial intention		–.07		–.09		.14*		.24**
Prior knowledge of technologies		.24		–.47		.39*		.03
Prior knowledge of markets		–.06		.07		–.14		.07
R^2	.17	.21	.21	.26	.49	.55	.43	.55
F	1.64	1.55†	.92	.90	7.40***	7.13***	2.69**	3.08***
df	86	83	39	36	86	83	39	36
ΔR^2		.03		.05		.06*		.11*

[a] Sample 1 consisted of life science entrepreneurs (n = 98). Sample 2 consisted of entrepreneurs from various industries (n = 51). All continuous variables were mean-centered prior to analyses.
† $p \leq .10$
* $p \leq .05$
** $p \leq .01$
*** $p \leq .001$

Opportunity Beliefs for Nonobvious Opportunities

Table 3 reports the results of the regression analyses concerning participants' beliefs about technology-market combinations characterized by low superficial similarity but high structural similarity. Although we theorized that these opportunity ideas would be difficult to identify, we advanced the view that the human mind's reliance on structural considerations for interpreting ambiguous stimuli and drawing creative insights would lead partici-

TABLE 3
Results of Within-Subject Regression Analyses: Opportunity Beliefs for Different Opportunity Ideas[a]

	Differences in Beliefs for Opportunities with Low/High and Low/Low Levels of Superficial and Structural Similarity		Differences in Beliefs for Opportunities with Low/High and High/Low Levels of Superficial and Structural Similarity		Differences in Beliefs for Opportunities with High/High and Low/High Levels of Superficial and Structural Similarity	
Variables	Model 5 Sample 1	Model 6 Sample 2	Model 7 Sample 1	Model 8 Sample 2	Model 9 Sample 1	Model 10 Sample 2
Effect of interest (constant)	.55	.76**	.15	–.04	.82***	.99**
Highest education level	–.15	–.21	.19	–.27	–.05	.29
Length of work experience	–.41	–.01	–.50	–.13	.89	–.31
Start-up foundings	.21	–.82	.01	–.28	–.19	.06
Innovation/creative self-efficacy	.18	.07	.08	.11	–.23	–.29
Entrepreneurial intention	.09	.28*	.19*	.30*	–.01	–.09
Prior knowledge of technologies	.46**	.13	.17	.14	–.02	.60†
Prior knowledge of markets	–.02	.09	–.10	–.04	.05	–.18
R^2	.42	.48	.37	.35	.40	.32
F	4.23***	2.45*	3.53***	1.39	3.96***	1.23
df	83	36	83	36	83	36

[a] Sample 1 consisted of life science entrepreneurs (n = 98). Sample 2 consisted of entrepreneurs from various industries (n = 51). All continuous variables were mean-centered prior to analysis.
† $p \leq .10$
* $p \leq .05$
** $p \leq .01$
*** $p \leq .001$

pants to form more positive beliefs for these scenarios than for scenarios with low levels of both superficial and structural similarity (Hypothesis 3a). This particular distinction was not significant in sample 1 (model 5: $b = .55$, $p = .29$), but it was in sample 2 (model 6: $b = .76$, $p \leq .01$). These findings provide partial support for Hypothesis 3a. Hypothesis 3b advances the idea that participants form more positive beliefs for technology-market combinations with low levels of superficial and high levels of structural similarities than for combinations with high superficial and low structural similarities. This particular distinction was not significant (model 7: $b = .15$, $p = .61$; model 8: $b = -.04$, $p = .92$); therefore, Hypothesis 3b is not supported. In Hypothesis 3c, we advance the idea that opportunity beliefs for technology-market combinations with low levels of superficial similarity but high levels of structural similarity are less positive than beliefs for technology-market combinations with high levels of both superficial and structural similarity. This particular distinction was significant for both samples (model 9: $b = .82$, $p \leq .001$; model 10: $b = .99$, $p \leq .01$), thus supporting Hypothesis 3c.

The Moderating Role of Individual Differences

For both samples, the results in Table 2 reveal a significant and positive effect for the interaction between entrepreneurial intent and structural similarity on opportunity beliefs (model 3b, $b = .14$, $p = .03$; model 4b, $b = .24$, $p \leq .01$). To interpret the nature of this interaction, we plot in Figures 3A and 3B the effects of structural similarity (x-axis) on opportunity beliefs (y-axis) for different levels of entrepreneurial intent (high, moderate, and low). Figures 3A and 3B illustrate that the positive relationship between structural similarity and opportunity beliefs is more positive when entrepreneurial intent is high than when it is low, which supports Hypothesis 4.

Interestingly, the results from Table 3 suggest that individual differences in entrepreneurial intent can help explain variations in the identification of nonobvious opportunities. Specifically, participants' distinctions between low superficial/high structural and high superficial/low structural scenarios increase in magnitude with higher levels of entrepreneurial intent (model 7: $b = .19$, $p = .04$; model 8: $b = .30$, $p = .04$). From these findings we infer that individuals with higher entrepreneurial intent form more positive beliefs about nonobvious opportunities (cases in which a new technology shares low superficial similarity but high structural similarity with a target market) than those with lesser entrepreneurial intent.

The results in Table 2 also reveal a positive interaction between prior knowledge of technologies and structural similarity on opportunity beliefs for sample 1 (model 3b, $b = .39$, $p = .01$) but not for sample 2 (model 4b, $b = .03$, $p = .91$). Figure 3C plots the effects of structural similarity (x-axis) on opportunity beliefs (y-axis) for different levels of prior knowledge for different technologies. As Figure 3C illustrates, the rela-

FIGURE 3A
Effects of Structural Similarity by Levels of Entrepreneurial Intent, Sample 1

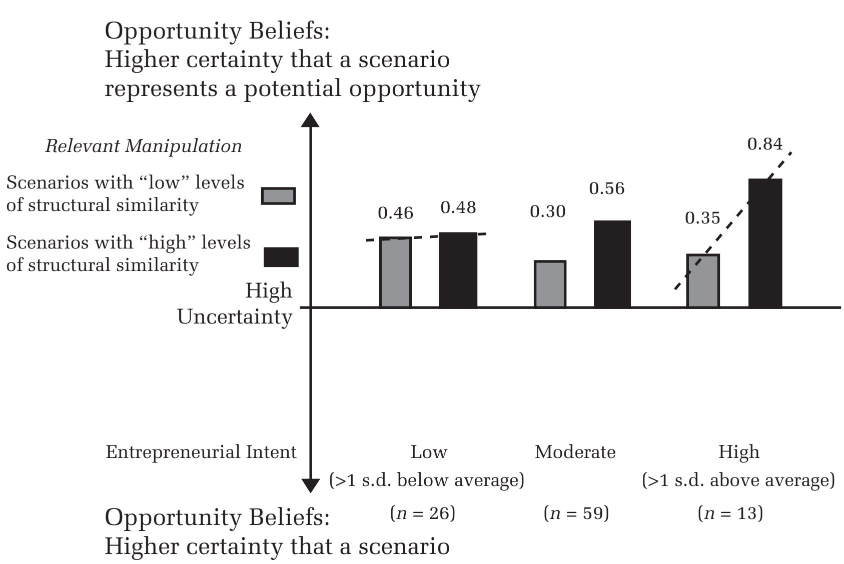
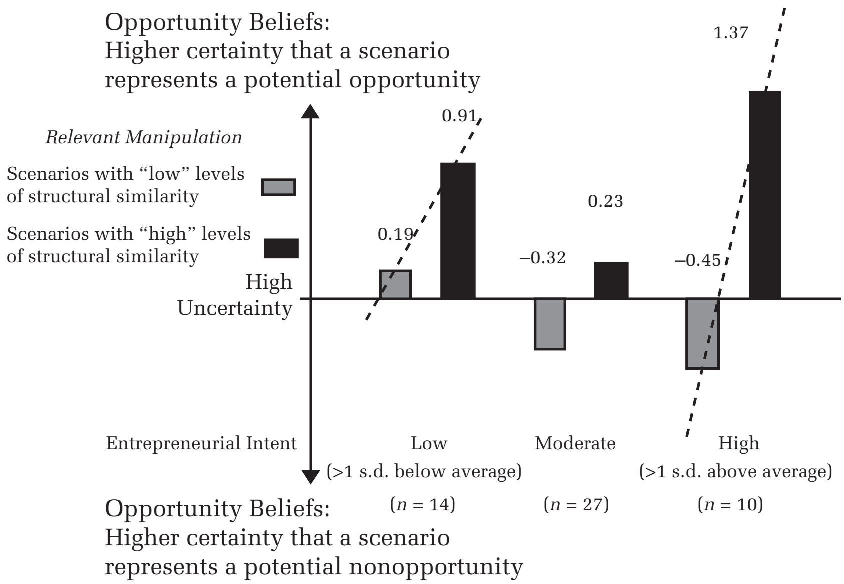
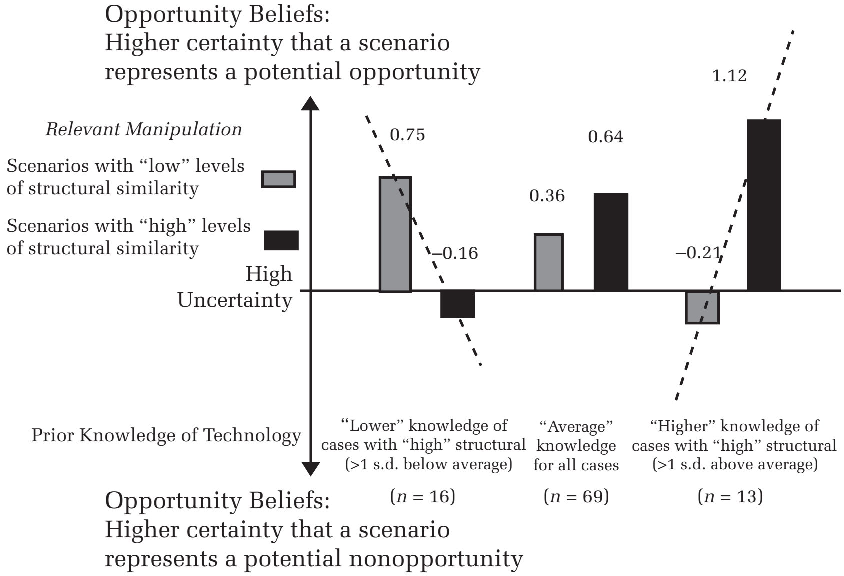


FIGURE 3B
Effects of Structural Similarity by Levels of Entrepreneurial Intent, Sample 2



tionship between structural similarity and opportunity beliefs is *positive* when participants have “high” levels of prior knowledge for the technologies in the “high” structural similarity scenarios (two columns on the right). In contrast, the relationship becomes *negative* when participants have “low” levels of prior knowledge for the technologies in the “high” structural similarity scenarios (two columns on the left). The significant findings for sample 1 (but not for sample 2) provide partial support for Hypothesis 5a. Here as well, the results from Table 3 provide additional explanations for the effects of prior knowledge of technologies in sample 1. More specifically, we observe that individuals with high prior knowledge of technologies distinguished opportunity ideas in which technologies and markets shared low levels of superficial but high levels of structural similarity from opportunity ideas with low levels of both superficial and structural similarity (model 5: $b = .46$, $p \leq .01$). In contrast, however, we did not observe a significant interaction be-

FIGURE 3C
Effects of Structural Similarity by Levels of Prior Knowledge of Technologies, Sample 1



tween prior knowledge of the markets and structural similarity (model 3b, $b = -.14$, $p = .25$; model 4b, $b = .07$, $p = .66$). Therefore, Hypothesis 5b was not supported.

Considerations of Effect Size

To explore whether the significant effects of increases in superficial and structural similarity are sufficiently important in magnitude to be meaningful, we calculated estimates of partial eta-square (η^2_p) and of the more conservative generalized eta-square (η^2_G) (cf. Olejnik & Algina, 2003; Pierce, Block, & Aguinis, 2004). Although qualifying effect sizes as "small" or "large" remains controversial, Cohen (1988) reported that measures of η^2_G in the social sciences typically range from .01 to .09. For samples 1 and 2, the effect sizes for superficial similarity were .05 and .11 for η^2_G ($\eta^2_p = .16$ and .28), respectively. For structural similarity, we observed effect sizes of .04 and .06 for η^2_G ($\eta^2_p = .16$ and .28). These effects are moderate in size. For their part, the η^2_G values for entrepreneurial intent were .01 and .04 for samples 1 and 2 ($\eta^2_p = .05$ and .19), and η^2_G for prior knowledge of technologies in sample 1 was .02 ($\eta^2_p = .07$). Importantly, observations that the relationships displayed in Figures 3B and 3C cross the midpoint of the scales are highly consequential for entrepreneurial action. These effects correspond to forming beliefs that a technology-market pair is likely a nonopportunity versus forming beliefs that a technology-market pair might indeed be an opportunity. In terms of an entrepreneurial action perspective (McMullen & Shepherd, 2006), this contrast might make all the difference between devoting more attention, effort, and other resources to evaluating whether applying a technology in a focal market is an opportunity worth personally pursuing instead of simply doing nothing about it.

DISCUSSION

Just as no two individuals or firms are the same, no two opportunities are the same. To our knowledge, our study is among the first to systematically investigate the independent effects of characteristics of opportunity ideas on opportunity beliefs and their contingent relationships with individual differences. In the paragraphs that follow, we discuss the contributions of our findings for studying opportunity identification, for efforts to identify multiple opportunities that are not always obvious, and for understanding the role of individual differences in this process.

Implications for Studying the Identification of Entrepreneurial Opportunities

The primary contribution of our results is to show that differences among opportunity ideas matter. Up to this point, extant research has primarily emphasized that when it comes to identifying entrepreneurial opportunities, it is people's cognitive abilities and resources that matter. In contrast, differences among opportunities have been largely ignored. By manipulating real cases of technology transfer to vary the superficial and structural similarities a technology shared with a potential target market, we showed that even in the early stages of mere possibilities (Davidsson, 2003), information differences about the underlying components of opportunity ideas affect the formation of opportunity beliefs. In doing so, we demonstrated that conceiving entrepreneurial opportunities as new supply-demand combinations is not only relevant for defining entrepreneurial opportunities theoretically, but also has practical implications for efforts to draw meaningful mental connections among various stimuli and spur the identification of promising entrepreneurial ideas. As such, our theoretical developments and findings have important implications for future research on opportunity identification.

To date, the few empirical studies that have addressed differences among opportunities have tended to focus on the performance implications of *exploitation-relevant differences*—as opposed to the effects of differences that are meaningful and important for the early identification of promising opportunity ideas. For instance, Samuelsson and Davidsson (2009) observed that the effects of human and social capital on new ventures' development activities were significant for new ventures pursuing *innovative opportunities* but not for those pursuing *imitative opportunities*. Similarly, Dencker and colleagues (2009) found that the number of jobs created by new ventures increases with the *sector-specific labor requirements* for different opportunities. More recently, Dahlqvist and Wiklund (2012) validated a measure of opportunity *newness* and observed that newness was correlated with intellectual property protection and patent application. By shifting attention away from the performance effects of exploitation-relevant differences to focus instead on the intrinsic characteristics of opportunity ideas for new supply-demand combinations, our study contributes a theoretically consistent approach for future studies of opportunity identification, an approach that in particular enables distinguishing the effects of differences among opportunity ideas from those of individual motivations, resources, and abilities.

Seen in this light, our findings encourage future research to investigate additional differences among entrepreneurial opportunities and the impact that such differences may have on opportunity identification. Though we provide evidence that the superficial and structural similarities characterizing different opportunity ideas can affect the initial formation of ex ante opportunity beliefs, future research could examine the effects of other differences, such as differences in the information complexity characterizing different opportunity ideas, the breadth of their market demand, their degree of urgency, or some other measure of their desirability. It would also be important to examine the extent to which variations in superficial and/or structural similarity influence perceptions of an opportunity's "radicalness," "innovativeness," or "novelty" (cf. Dahlqvist & Wiklund, 2012; Samuelsson & Davidsson, 2009)—and whether these effects are weaker or stronger for either dimension of similarity. Likewise, future studies could examine the effects of similarity differences not just on entrepreneurs' formation of opportunity beliefs but also on both their decisions to exploit particular opportunities and their efforts to communicate these opportunities to (and the response they obtain from) potential stakeholders.

Implications for Technological Innovation and Venturing

Another important contribution of our work is to cast light on cognitive reasons why some entrepreneurial opportunities may prove more difficult to identify than others. In this regard, Shane (2000) remarked that ideas for new technology-market combinations often appear "nonobvious" even to the inventors of new technologies or to entrepreneurs pursuing other opportunities (2000: 456). Furthermore, Gruber and his colleagues showed that only a minority of entrepreneurs (and firms) consider multiple market applications for the new technologies they exploit—despite the proven survival and performance benefits of doing so (cf. Gruber et al., 2008, 2010). These studies have stressed the pivotal importance of individual differences in knowledge and experience to explain the ability of some entrepreneurs to identify nonobvious and/or multiple opportunities for new technologies.

By drawing attention to the similarity characteristics of different technology-market combinations, we provide a complementary explanation that augments scholarly research on innovation and technological venturing. In spite of the human mind's documented reliance on structural considerations for interpreting ambiguous stimuli and drawing creative insights, we found that on average, entrepreneurs remained ambivalent about opportunity ideas that present divergent types of similarities—such as the case in which the superficial elements of a new technology are dissimilar to the superficial elements of a target market, despite high structural similarity between the new technology's core capabilities and the underlying causes of latent demand in that target market. Because the perception and processing of structural similarities in the absence of superficial similarities is cognitively demanding (Catrambone & Holyoak, 1989; Gentner, 1989), such technology-market combinations appear particularly difficult to identify. At the same time, cognitive scientists and management scholars alike have documented that making this kind of mental connection often lies at the basis of powerful creative insights (cf. Dahl & Moreau, 2002; Dunbar, 1993; Gavetti et al., 2005; Holyoak & Thagard, 1995). This observation has two important implications for future research on innovation and technological venturing—and for the efforts of entrepreneurs, inventors, and technology transfer officers to identify multiple technology-market opportunities.

First, our results raise questions as to whether, when, and why some individuals are able to lift the veil of doubt caused by superficial dissimilarity to form positive beliefs about technology-market combinations that are structurally sound. In this regard, our analyses revealed that individuals' abilities to distinguish between nonobvious opportunities (low superficial but high structural similarity) and technology-market pairs with high superficial similarity but low structural similarity were positively related to their entrepreneurial intent. As such, this finding augments scholarly understanding of the positive effects that entrepreneurial intention may have in efforts to identify opportunities. In addition, and complementing Gruber and colleagues' (2010) finding that high levels of specialized knowledge can sometimes constrain the identification of opportunities for new technologies, we also found evidence that higher levels of prior knowledge of technologies could sometimes override the effects of structural similarity on opportunity identification. In practice, this latter observation raises the question of whether prior knowledge of technologies simply dominates the formation of positive opportunity beliefs (regardless of matches or mismatches in structural similarities), or whether it instead enables some participants to imagine how the mismatches might be corrected or overcome. Although preliminary, these findings provide an empirical basis for further investigation of the role of individual differences in fostering the identification of nonobvious opportunities.

Second, our results also have normative implications for practice. Specifically, they reinforce the notion that the competitive advantage of entrepreneurial strategies is not only about capabilities to implement strategies for new product development and commercialization; important advantages may also proceed from abilities to identify opportunities *ahead of competitors*. To the extent that some opportunities are cognitively more difficult to identify, however, strategists face a nontrivial challenge; they must be able to zero in on the structural match between the core capabilities of a new technology and the root causes that explain market problems, even when the superficial elements of that technology do not match those of different target markets. Although breadth and depth of experience will facilitate this task (cf. Gruber et al., 2010), our research suggests that important benefits could follow from better understanding the specific reasons why some opportunities appear more difficult to identify than others. Therefore, we suggest that innovation managers, entrepreneurs, inventors, and technology transfer officers could greatly benefit from a deeper understanding of these issues. Building on our findings, one could develop training exercises to foster the abilities of individuals to identify multiple opportunities—notably by focusing on abilities to perceive, understand, and communicate the core structural reasons underlying the key capabilities of new technologies, and on abilities to imagine the *transfer* of such capabilities to cognitively distant markets that may not have superficial elements in common with the technologies (for the general benefits of training managers to think more "structurally," see Gavetti and Rivkin [2005]).

Implications for the Roles of Individual Differences in Opportunity Identification

An additional contribution of our research is to expand the scholarly understanding of the role of individual characteristics, abilities, and resources at the opportunity-individual nexus. Prior studies have tended to define this role in terms of main effect relationships with opportunity identification or exploitation without sufficiently considering the effects of differences among opportunities. In contrast, our research provides empirical evidence of contingent relationships—wherein individual differences (in entrepreneurial intent and prior knowledge) moderate the effects that variations in the structural characteristics of opportunity ideas have on the formation of opportunity beliefs.

In doing so, our observations provide a useful complement to prior research and refine the role of cognitive resources in the understanding of opportunity identification. Instead of simply conceiving of this role in terms of an individual's use of prior knowledge (e.g., Shane, 2000; Shepherd & DeTienne, 2005) or existing prototypes of opportunities to identify meaningful patterns or issues from the environment (cf. Baron, 2006; Dutton & Jackson, 1987), we theorized that an important cognitive challenge for identifying opportunities was that of perceiving/interpreting similarity matches and mismatches between new means of supply and market contexts in which to apply these new means of supply. Developing this argument further, we documented that individual differences in entrepreneurial intent (and to some degree, in prior knowledge of technologies) could facilitate the processing of cognitively demanding structural similarities—even in the absence of superficial similarities. As such, our research highlights that an important effect of cognitive resources is to help individuals perceive, process, and/or interpret relevant information about the integral components of an entrepreneurial opportunity; these resources can enable individuals to identify different *kinds* of opportunities, including, for instance, opportunities that are cognitively more demanding to identify because they call for transferring the application of new technologies across contexts that share low levels of superficial similarity but high levels of structural similarity.

In similar fashion, our findings invite further research on the role of individual differences in cognitive abilities. In a series of recent studies, for instance, Baum and Bird (2010, 2011) documented significant relationships between entrepreneurs' practical intelligence and the growth of their firms. Although we did not observe significant effects for the control variables of education, experience, and self-efficacy, our observation that entrepreneurs with higher levels of entrepreneurial intent were able to form more positive opportunity beliefs for nonobvious technology-market combinations (low superficial similarity, high structural similarity) suggest the importance of studying whether individual differences in intelligence or other cognitive abilities can enable some individuals to make insightful but cognitively demanding mental connections that spur the identification of promising opportunities.

Limitations and Conclusion

No empirical studies are ever perfect. In addition to discussing the choices we made regarding what variables to include, critics could object to our deriving results from hypothetical evaluations of arbitrarily manipulated scenarios that have little in common with real-life efforts to identify opportunities. Likewise, critics could object that our results are not about "objective" characteristics of opportunity ideas but are based on how we "framed" the technologies and markets presented to participants. Similarly, our choice to conduct the studies with individuals who were unfamiliar with and unconcerned about these technologies and markets (and who were already engaged in other entrepreneurial pursuits) necessarily limited the variance in individual differences. In practice, this could explain the partial support we obtained for the effects of prior knowledge of technologies in sample 2 and for the effects of prior knowledge in both samples.

From a scholarly standpoint, however, a relevant validity question is to ask whether the results we report above would be weaker or stronger if we had conducted the study with fewer design constraints. In the maelstrom of day-to-day events, would-be entrepreneurs rarely have much control over the opportunity-relevant information they encounter, nor do they control how rich and complete this information really is. In technology transfer, for instance, the first encounter with a technology is often limited to snapshot descriptions on a website, in a journal article, or in patent documents. Furthermore, evidence from other studies suggest that when people are free to think of any potential market in which to apply new technologies, they not only rely on their prior knowledge of these markets (cf. Gruber et al., 2008, 2010; Shane, 2000), but also use this knowledge to zero in on key structure-level connections between the capabilities of new technologies and the root causes of particular market problems they know about (cf. Grégoire, Barr, & Shepherd, 2010). Thus, we suggest that the constraints noted above were part of our methodological strategy for ruling out alternative explanations and helped separate the effects of opportunity ideas from the effects of individual differences known to foster opportunity identification. Conjointly studying the effects of opportunity ideas and individual factors offers significant advances in understanding the drivers of opportunity identification and furthering knowledge of the early stages of entrepreneurial action—and of processes that are pivotal for broader organizational efforts toward innovation, economic growth, and strategic renewal.

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APPENDIX A

Measurement Items for Dependent Variable (Opportunity Beliefs)

Table A1 reports the instructions, items, and scale anchors for the measure developed and validated by Grégoire, Shepherd, and Lambert (2010). The five-item instrument captures participants' level of certainty that a market-technology scenario does (or does not) suggest a potential opportunity. Participants answered on a nine-point scale anchored on the left by "NO, certainly not" and on the right by "YES, certainly." Given the wording of the items and anchors, answers to the left of the scale (negative numbers) correspond to beliefs that a scenario *is not* an opportunity, whereas answers to the right of the scale (positive numbers) correspond to beliefs that a scenario *is* an opportunity. Conversely, answers at the midpoint of the scale indicate that participants are uncertain about whether a scenario is an opportunity or a nonopportunity.

TABLE A1

Items (and Underlying Dimension)	Scale Anchors								
INSTRUCTIONS: Please select the circle (no.) that most closely corresponds to your evaluation of the following statements.			NO certainly not					YES certainly	
	−4	−3	−2	−1	0	1	2	3	4
The technology can be used to solve the problems of the market described (fit)									
The technology has the capabilities to answer the needs of the market described (fit)									
There is a "match" between what the technology does, and what the market described demands (fit)									
Applying the technology with individuals/firms in the market described does constitute a feasible opportunity (feasibility)									
The technology is sufficiently developed to be applied profitably with individuals/firms in the market described (feasibility)									

APPENDIX B

Source Technologies and Experimental Manipulations of Opportunity Scenarios

In order to develop opportunity scenarios that reflect real-life cases of technology transfer, we identified a series of cases in which (a) a technology had been developed by a university or other research institution, (b) where that technology had been offered for licensing, (c) where there were documented attempts at exploiting the new technology, and (d) where the relevant markets and technologies of the exploited opportunities shared low levels of superficial similarity but high levels of structural similarity. Such conditions mirror observations made in the literature (e.g., Dougherty, 1992; Katila & Ahuja, 2002; Shane, 2000). We identified several such cases from various technology transfer websites associated with universities and other institutions. We selected four technologies among these, including that studied in Shane (2000). Table B1 describes the four selected technologies and associated markets, along with the specific parameters we manipulated for superficial and structural similarity. We created descriptions that are similar in length and content to the press releases communicated by technology transfer offices in their efforts to entice external firms and individuals to license and commercialize new technologies. We worked with a linguist to ensure that the descriptions were easy to read and comparable in length and complexity.

TABLE B1
Source Technologies and Experimental Manipulations of Opportunity Scenarios

Technology	Exploited Opportunity	Summary of Manipulations	
NASA's EAST™ (extended attention span training) technology, a training system originally developed to increase the concentration abilities of shuttle pilots http://www.sti.nasa.gov/tto/spinofff2003/spin03.pdf	Cyberlearning LLC, of Plymouth Meeting, PA, has licensed the technology from NASA and is developing its application as an alternative to medication in the treatment of attention deficit disorder. The technology is commercialized as SMART™ (Self-Mastery and Regulation Training).	*Target market*	ADHD children lack alternative to medication in the treatment of ADHD.
		High superficial similarity between technology and market	• Video game system/car-driving game system • Developed as a joint project between the Division of Child and Adolescent Psychiatry and the Department of Biomechanical Engineering • Teenage drivers
		Low superficial similarity	• Flight simulator • Developed at NASA's Langley Research Center • Pilots operating the space shuttle
		High structural similarity	• Tool designed to improve the concentration of teenage drivers/pilots
		Low structural similarity	• Tool designed to improve to help teenage drivers / pilots control their level of stress and anxiety

Continued

TABLE B1
(Continued)

Technology	Exploited Opportunity	Summary of Manipulations	
MIT's 3DPTM three-dimensional printing, the particular technology studied by Shane (2000), but also described at http://web.mit.edu/tdp/www	Among several applications, the technology has been applied to domain of presentation models by Z corporation, now established in Burlington, MA. http://www.zcorp.com	*Target market*	Until architecture firms can acquire capabilities to make models in-house, they must continue to use outside firms (costs + delays).
		High superficial similarity	• Rapid-prototyping technology • Makes concept prototypes and models • Works directly from computer drawings of engineers/designers
		Low superficial similarity	• Manufacturing technology • Makes industrial parts and tools, such as forms and molds used in plastic injection moldings
		High structural similarity	• Can make finished models/parts without aid of skilled technicians
		Low structural similarity	• Skilled technicians are needed to finish models/parts
Georgia Institute of Technology's patented radio frequency vibrometer, a technology found in a radar microsensor developed jointly with NASA's Dryden Flight Research Center http://www.sti.nasa.gov/tto/spinofff2003/spin03.pdf	Atlanta-based Radatec has developed applications of the technology to detect mechanical failure in fast-rotating turbines, and for use in active suspension systems for moving vehicles. http://www.radatec.com	*Target market*	Car manufacturers have been unable to develop active suspension systems for lack of small/cost-effective technology to monitor changes in road.
		High superficial similarity	• Developed at Georgia Tech department of mechanical engineering • Automotive industry • Joint tests with Ford
		Low superficial similarity	• Developed by NASA's Dryden Flight Research Center • Airline industry • Joint tests with Boeing
		High structural similarity	• Radar system to monitor minute changes in surface
		Low structural similarity	• Radar system to avoid collisions
NASA's Marshall Space Center's VISAR™ software resolves image distortions in atmospheric and solar videos, in which the movements of recording devices and/or of the objects being studied introduce "blurs" in the images. http://technology.msfc.nasa.org	One of the first field applications of the technology was by the FBI, which used it to analyze video footage from surveillance cameras in connection with the 1996 Atlanta terrorist bombing. Integraph Solutions Group (Madison, AL) licensed the technology and integrated it in its video analyst software suite. http://www.solutions.intergraph.com	*Target market*	Video surveillance equipment is limited by distortions induced by movement of camera.
		High superficial similarity	• UCLA's School of Theater, Film and Television • Independent digital movies • Video cameras
		Low superficial similarity	• NASA's physicist and computer engineer • Distant stars and planets from movie spacecrafts • Radar and detectors
		High structural similarity	• Software to correct from movement blurs
		Low structural similarity	• Software to boost the contrast in low-light conditions

APPENDIX C

Example of Experimental Manipulations: Description of the Target Market for MIT's 3DP™

Architects seeking capability to make presentation models in-house

Not everyone can read and understand the technical drawings used by architects. The same way, it is sometimes hard to visualize how a project will feel like in three dimensions from simply looking at a computer simulation or a nice sketch depicting it. Because of that, architects often make presentation models to more effectively communicate their ideas to their clients.

However, good presentation models are generally time-consuming, expensive and difficult to make. But since most architecture firms do not have the in-house equipment, resources or skilled employees required to make high-quality models, they must outsource their fabrication to specialized model-making firms. Until architecture firms can acquire the capabilities to make presentation models in-house, however, outsourcing the fabrication of these models will continue to lengthen the design process, and to raise the costs of architectural services.

High Degree of Superficial Similarity High Degree of Structural Similarity	Low Degree of Superficial Similarity Low Degree of Structural Similarity
MIT develops new rapid-prototyping technology. MIT is proud to introduce its new three-dimensional printing technology (3DP™ for short)—a technology devised to facilitate the fabrication of small-scale concept prototypes directly from engineers' computer drawings. The 3DP™ machine works by building prototypes in layers, out of any material available in powdered form (such as ceramics, metals, plasters, plastics, etc.). The process begins by compressing a precise quantity of powdered material on the surface of the machine's "building floor." using a technology similar to ink-jet printing, a mechanical arm moves over the loose powder and deposits a binding material at specific points—where the prototype is to be built. Once a layer is glued, the floor supporting the prototype is lowered a short distance, so that a second layer of powder can be spread, compressed, and glued. This layer-by-layer process is repeated until all layers have been glued. Any unglued powder is then removed, revealing the finished prototype. Because it is designed to work with several kinds of powder materials, the 3DP™ technology can produce high-quality prototypes of different composition, strength characteristics, surface textures, colors and finishes. Better yet, the technology can do that entirely on its own, without the aid of skilled technicians, operators or artisans.	MIT develops new manufacturing technology. MIT is proud to introduce its new Three-Dimensional Printing technology (3DP™ for short)—a technology devised to facilitate the making of custom-made industrial parts and tools, such as the forms and molds used in plastic injection molding. The 3DP™ machine works by building molds in layers, out of any material available in powdered form (such as ceramics, metals, plasters, etc.). The process begins by compressing a precise quantity of powdered material on the surface of the machine's "building floor." Using a technology similar to ink-jet printing, a mechanical arm moves over the loose powder and deposits a binding material at specific points—where the mold is to be built. Once a layer is glued, the floor supporting the mold is lowered a short distance, so that a second layer of powder can be spread, compressed, and glued. This layer-by-layer process is repeated until all layers have been glued. Any unglued powder is then removed, revealing the finished mold. Because it is designed to work with several kinds of powder materials, the 3DP™ technology can produce high-quality industrial molds of different composition, strength characteristics, surface textures and finishes. Better yet, the technology can do that entirely on its own, without the aid of skilled technicians, operators or artisans.

Denis A. Grégoire (dgregoire@syr.edu) is an assistant professor of entrepreneurship and emerging enterprises at the Whitman School of Management, Syracuse University. He received his Ph.D. from the University of Colorado–Boulder. His research examines the cognitive processes that support entrepreneurship and strategic decision making.

Dean A. Shepherd (shepherd@indiana.edu) is the Randall L. Tobias Chair in Entrepreneurial Leadership and a professor of entrepreneurship at the Kelley School of Business, Indiana University. He earned his Ph.D. at Bond University. His research focuses on entrepreneurial decision making, emotions, and failure.