DARREN W. DAHL and PAGE MOREAU*

Although both the academic and the trade literature have widely acknowledged the need to foster the development of more-innovative products, little empirical research has examined the cognitive processes underlying the creation of these novel product concepts. In this research, three empirical studies examine how analogical thinking influences the idea-generation stage of the new product development process. The first study uses the verbal protocols of real-world industrial designers to trace the role of analogy in the context of a new product development task, and the second and third studies use an experimental approach to assess the effectiveness of different ideation strategies and conditions. Findings from these studies indicate that the originality of the resulting product design is influenced by the extent of analogical transfer, the type of analogies used, and the presence of external primes. In addition, these studies reveal a positive relationship between the originality of the product concept and consumers' willingness to pay for it, an important measure in the concept-testing phase of product development.

The Influence and Value of Analogical Thinking During New Product Ideation

The idea-generation and concept-testing stages are often called the "fuzzy front end" of new product development because they typically lack well-defined processes, reliable information, and proven decision rules. The decisions made during these early stages, however, can lock in 75% to 85% of the subsequent costs for manufacturing and marketing support (Port 1998). Given these high stakes and the poor understanding of the fuzzy front end by most firms, there are substantial benefits to better understanding and improving these stages.

A few recent articles in marketing and management have examined these early stages in the product development process, making recommendations for process improvement, such as imposing financial screens (Reinertsen 1999), implementing electronic support technology (Montoya-Weiss and O'Driscoll 2000), and improving the integration of development activities (Khurana and Rosenthal 1997). Little research, however, has examined the influence of the cognitive strategies used by the product developers on the quality of the concepts produced in these stages. Two recent articles on product ideation and design are exceptions (Dahl, Chattopadhyay, and Gorn 1999; Goldenberg, Mazursky, and Solomon 1999). Although these studies have proposed better methods for product design and development, their contributions are limited primarily to straightforward design tasks such as product redesign and the development of incremental innovations. Little, if any, attention has been focused on the methods and cognitive processes that underlie the creation of more-original ideas and products (Marsh, Ward, and Landau 1999) that would defy straightforward classification into any existing product category (Gregan-Paxton and Roedder John 1997). Nonetheless, the Marketing Science Institute research priorities and the trade press identify a need for more-innovative and more-original product development (e.g., Curtis 1998; McMath 1998).

The design and marketing literature suggests several strategies for generating new product ideas, including such techniques as benchmarking (Ulrich and Eppinger 2000), user observation (e.g., empathic design; Leonard and Rayport 1997), lead user analysis (Von Hippel 1986), and analogical thinking (Srinivasan, Lovejoy, and Beach 1997). Of these techniques, analogical thinking has the greatest theoretical support as the driver of truly innovative thought (Boden 1994; Gentner et al. 1997; Perkins 1997; Polya 1954; Roukes 1988). Despite its importance, however, the evidence for analogy's role in creative thought is almost

*Darren W. Dahl is Assistant Professor of Marketing, Faculty of Management, University of Manitoba (e-mail: dahld@ms.umanitoba.ca). Page Moreau is Assistant Professor of Marketing, Edwin L. Cox School of Business, Southern Methodist University (e-mail: pmoreau@mail.cox.smu.edu). The authors are listed alphabetically and contributed equally to the research. The authors thank Amitava Chattopadhyay, Bill Dillon, Jacob Goldenberg, Amna Kirmani, Don Lehmann, Charles Lovas, Art Markman, Paul Packman, Charles Weinberg, and the three anonymous *JMR* reviewers for their comments on previous versions of the article. The financial support from the Social Sciences and Humanities Research Council of Canada is gratefully acknowledged.

Journal of Marketing Research
Vol. XXXIX (February 2002), 47–60

exclusively anecdotal in the design literature (Goel 1997). In psychology, the evidence is largely historical (Carlson and Gorman 1992; Genter et al. 1997; Rhodes 1986), analyzing analogy's role in the discoveries of Edison, Kepler, and Rutherford.

Although researchers in both disciplines accept the premise "that analogy plays a central role in innovation and creativity" (Goel 1997, p. 62), few empirical studies have examined how and to what extent analogical thinking influences creative thought. According to Amabile (1996, p. 3), "there are virtually no experimental studies of the effects" of environmental influences on creative performance. Therefore, the goal of our research is to gain a better understanding of how and under what conditions analogy facilitates originality in concept ideation and design.

Our investigation contributes to the existing literature on analogy and its role in the early stages of the product development process. First, we provide empirical evidence that analogy facilitates originality in the creation and design of new product concepts, and second, we define the conditions under which this relationship holds. Specifically, we examine the influence of benchmarking, a common design technique, on analogical processing, and we study the effects of different types of analogy on originality. Finally, we examine the influence of analogy and originality on consumers' willingness to pay for new product concepts, a typical measure used in concept testing to screen out unattractive concepts (Crawford and Di Benedetto 2000).

ANALOGY AND CONCEPT DEVELOPMENT

Researchers in cognitive psychology generally agree that creativity consists of reassembling elements from existing knowledge bases in a novel fashion to produce a new idea (Gagne and Shoben 1997; Hampton 1997; Ward 1994). Analogical thinking has been proposed as a basic mechanism underlying creative tasks, in which people transfer information from familiar, existing categories (i.e., base domains) and use it in the construction of their new idea (i.e., the target domain) (e.g., Finke, Ward, and Smith 1992; Gentner et al. 1997; Perkins 1997).

Evidence from the problem-solving literature suggests that people confronted with a creative task search through a "space of possibilities" in memory (Newell 1990; Perkins 1997), hoping to access useful information. This search process is described in the analogical transfer paradigm as the access stage, the first step in analogical thinking. The goal of the access stage is to activate information in one or more existing base domains (Gregan-Paxton and Roedder John 1997). When the information is accessed, people can map the similarities between the base and the target domains and transfer existing knowledge to the target. In following these steps, people can borrow both attributes and relations from existing base domains and use them in the creation of a novel target.

Practitioners in new product development recognize the importance of analogical thinking and actively encourage the use of multiple analogies in generating new product designs (Goel 1997). For example, IDEO, a product design consulting firm, uses formal brainstorming sessions to encourage design team members to access diverse knowledge bases during idea generation (Hargadon and Sutton 1997). The firm believes that the more knowledge bases accessed during the design process, the more original the product will be (Sutton 1997). Other practitioners also promote the use of multiple analogies during creative tasks. Sarlemijn and Kroes (1988) encourage the use of both functional and form analogies. Similarly, Gordon (1961) advocates the use of personal, direct, symbolic, and fantasy analogies in the synectic approach to design.

Despite the actual and advocated use of analogies in development and design, the effectiveness of these tactics has never been empirically tested. To explore the roles that analogy naturally plays in the early stages of the new product development process, we observed four pairs of new product development practitioners undertaking a new product design task.

STUDY 1

Four separate teams of new product development practitioners participated in this study by solving a specific design problem through the generation of an innovative design idea. We used verbal protocols of each session to trace the role of analogy in the idea generation process.

Method

New product development practitioners. Each team was composed of two professional product designers who were recruited from randomly selected industrial design firms that varied in size and product specialization. Participating designers worked primarily in a consumer product design capacity and had an average of 17 years of design experience. Design teams paralleled an actual product development assignment and provided the advantage of observable verbal communication.

Design problem. Given our research purpose, it was important to identify a consumer need that did not currently have a product solution available. Such a choice would avoid the potential for a straightforward redesign or product alteration. The need we selected was identified in *The Wall Street Journal* (Deveny 1994), and to our knowledge, there is no existing product available that meets this consumer need. The problem statement provided to the designers was as follows:

> A recent article in *The Wall Street Journal* identified the difficulties and problems inherent in eating in a moving vehicle while driving (e.g., inability in preparing food items, spillage of food and beverages, difficulty in food consumption, problems with temporary food storage). "Automotive dining" has created a new opportunity for a creative product introduction. You are asked to design a new product that will meet the needs/solve the problems of the commuting diner. The primary target market for this new product is business professionals making long commutes to the workplace. Secondary target markets include individuals employed in a transportation industry, automotive vacationers, and the casual recreational driver.
>
> Preliminary research with the primary target market indicates that the following criteria would be important in the realization of an innovative and effective product. The product should be practical and effective, safe to use, reusable, portable, [and] easy to assemble and use. Please disregard economic, material, and regulatory constraints when formulating your design idea.

Procedure. Each of the four teams was run individually. At the start of each session, designers were given the design problem statement, a pencil, and paper and were informed that they would have approximately one hour to develop a solution to the consumer problem.[1] The designers were asked to explain their thoughts and ideas both orally and through sketches as their ideas came to mind. Finally, the designers were told that at the conclusion of the design session, they would be required to provide a thumbnail sketch of their solution.

Before beginning, the designers read through the design brief, and after any necessary clarifications, the design session began. Each session was tape-recorded. The only experimenter involvement was reminding the designers to talk out loud. Upon completion of the session, the designers were debriefed and compensated for their participation.

Analysis

Customer judgments. Evaluations of each of the design team's solutions were obtained from a representative sample of target customer judges (i.e., commuters who drove to work or school). Judges (n = 19) were asked to judge each of the four designs in terms of their originality. Judges completed three seven-point scales measuring originality ("not at all original"/"very original," "not at all innovative"/"very innovative," "not at all creative"/"very creative") for each of the four designs. Scale items were drawn from previous research, and the three scores were averaged to form an overall originality index (all $\alpha > .70$).

Verbal protocols. An established coding scheme (Shah, Nico, and Kraver 1993) was used to classify the verbal protocols into the following activity states:

- Problem definition and clarification: when the design team referred back to the written task and the attributes required for the design;
- Focus of attention: when the design team discussed how to focus or what to focus on;
- Device function or specification: when the design team discussed the required function/configuration of the design independent of any generated idea;
- Incubation: when there was a distinct pause in the conversation;
- Idea generation: IGA = when an idea was generated in the form of an analogy, and IGD = when an idea was generated through assembly of mechanical design elements;
- Modification: when the design team evaluated an idea and decided to modify it to better meet the required attributes;
- Clarification/elaboration: when the design team asked one another questions about other ideas presented.
- Evaluation/arguments: when the design team passed verbal judgment on an idea; and
- Decision: when designs were selected at the end of the idea-generation phase.

Following previous protocol research in product design (e.g., Nagy, Ullman, and Dietterich 1992), we used a graphical approach in framing the relationships among activity states for idea generation. This involved the creation of a separate diagram for each of the four design teams, in which the flow from one design activity state to another was identified. The flow from activity to activity is identified by numbered paths representing the order of the designer's thought processes (i.e., changes from state to state). A description of each path facilitated interpretation.

Results

Customer judgments. We expected the variation in the number of analogies that the product development teams used to be positively related to the originality of their proposed design solutions. To test this relationship, we used a regression analysis in which each design's originality rating from each of the judges served as the dependent variable. The percentage of statements coded as IGAs and a set of 18 dummy variables for the individual judges served as the independent variables. This analysis indicated that the percentage of analogies used had a statistically significant effect on originality ($\beta = .24, p < .05$).[2] The moderate size of the standardized regression coefficient provides some evidence of a positive relationship between the number of analogies used by designers and the resulting originality. None of the judge dummy variables had a statistically significant effect on the originality ratings.[3]

Verbal protocols. An examination of the diagrams produced from the verbal protocols (see Figure 1) for each of the four design teams enabled us to draw conclusions about the general strategy a design team pursues in generating design ideas. Across the design teams, a fairly standard pattern of processes emerged. This is especially interesting given that the design teams were not instructed to choose a particular strategy or methodology for approaching the design problem, nor did they formally decide to do so.

At the start of the design exercise, each team spent the majority of its time in the problem definition, functional definition, and focusing states. Understanding and framing the design problem characterized this stage. Next, designers moved into an ideation stage, in which activities were centered on identifying and developing ideas: idea generation, modification, clarification, and evaluation. This process was extremely dynamic in nature, as the flow of activity moved among each of the four identified states. Finally, designers moved into a decision stage, in which clarification and modification led to a final decision. Incubation states were spread throughout the design process.

The verbal protocols also provided strong evidence for the importance of analogies as an idea source throughout the design process. The IGA state was shown to play a prominent role for each of the four design teams. In each case, the final design idea evolved from an IGA statement. For example, the design team represented in Figure 1 recommended a design idea that resembled a bib that could be worn while driving. This idea was developed from an initial IGA statement: "What if it's kind of just a restaurant roll-out bib that you put up here that rolls down into your lap?" Further IGA statements made by the team included "It could be like an airplane oxygen mask"; "Maybe it's like a plastic lid for a cup"; "Maybe it should be like that superabsorbent cloth....

[1] A one-hour time period is shorter than what designers would typically spend doing idea generation.

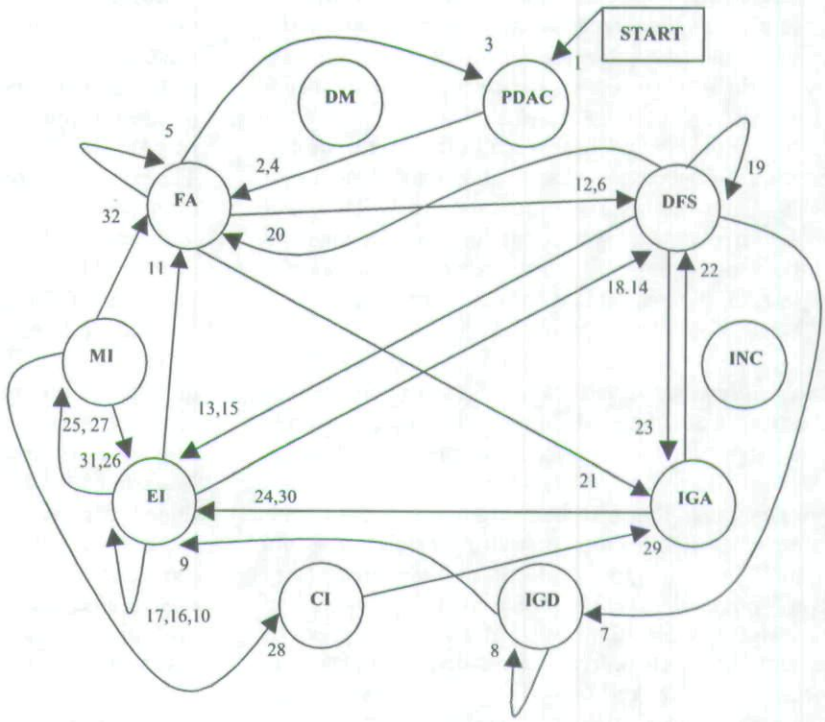
[2] The β reported here and those reported throughout the article are standardized unless otherwise specified.

[3] Regression analysis using the percentage of statements coded as IGDs indicated a statistically significant, moderately-sized negative effect on originality ($\beta = -.33, p < .01$). This negative relationship contrasts the findings for the IGA statements, thus further establishing the importance of analogical reasoning to idea generation.

Figure 1
DESIGN TEAM Y: STATE DIAGRAM

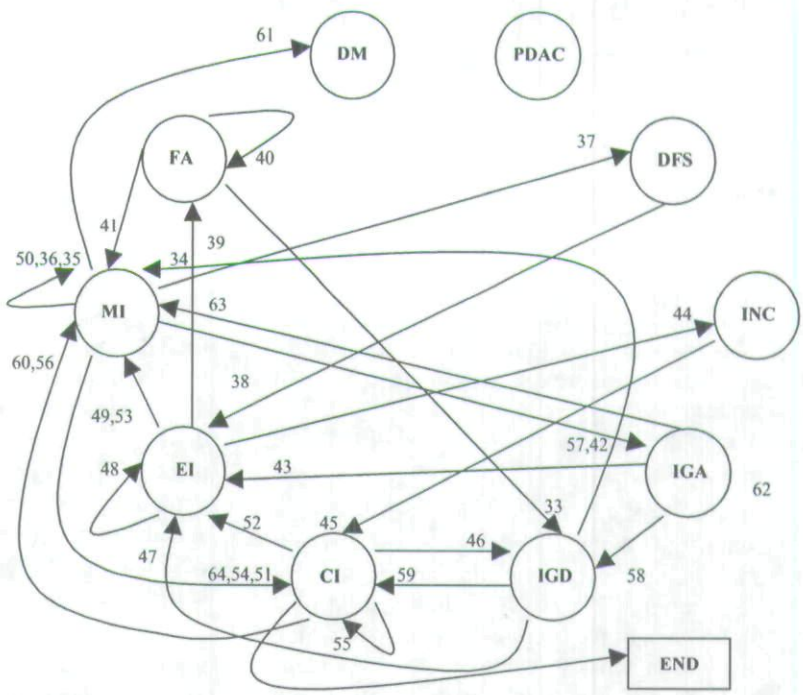
Activities 1 to 32

1. What is it?
2. Something simple …
3. People do many things in cars.
4. Primary target …
5. Someone may help hold …
6. Something that flattens …
7. Use an adapter …
8. Use an attachment …
9. What about older cars?
10. They aren't professionals …
11. Needs to be generic …
12. Test market …
13. But when …
14. Shadowing …
15. It wouldn't hurt to …
16. Yeah, that's true …
17. You'd really have to …
18. Backseat? Trunk?
19. What if …
20. Should be portable.
21. Plastic inserts …
22. One at a time …
23. Big cup plastic lid …
24. I don't know how it'd work …
25. Velcro …
26. What if you tip/hit it?
27. Attach to dashboard …
28. How big?
29. An armrest foldout tray …
30. That's what I think of …
31. Take whole or parts out …
32. Think of metaphors …



Activities 33 to 64

33. Little trays …
34. Fold down on seat …
35. A little deeper …
36. Put an air freshener on it …
37. Hard to drive and eat …
38. I know, but …
39. Here it says …
40. They're not defining design …
41. Clip back together …
42. Roll-out bib …
43. Not a bad idea …
44. Long pause
45. Something that …
46. Cloth over knees …
47. But, you see …
48. Yeah, but …
49. Cloth with a flap …
50. Adjustable straps …
51. I wonder …
52. I like the bib …
53. Come with plates …
54. How do they …
55. You fold it up …
56. Roll from behind seat …
57. Airplane tray …
58. From ceiling …
59. In front of you?
60. Elevate tray …
61. Bib idea is the best.
62. Superabsorbent sponge …
63. In a tube …
64. Easy storage …



Notes: CI = clarification/elaboration, DFS = device function or specification, DM = decision, EI = evaluation/arguments, FA = focus of attention, IGA = idea generation-analogy, IGD = idea generation-mechanical assembly, INC = incubation, MI = modification, PDAC = problem definition and clarification.

It comes in a tube." Other analogies identified and used by the four design teams included an airplane foldout table, bean bags, a dentist's swing light, a restaurant take-out tray, drink holders, and a lunchbox.

Separating the total number of coded activity states into quartiles enabled a comparison of IGA and IGD.[4] Across each of the design teams, analogies were primarily used at the end of the first quartile or at the start of the second quartile. These initial analogies were typically followed by evaluation, clarification, and modification. The IGD tended to follow IGA activity, occurring primarily in the second and third quartiles. The observed order of ideation (i.e., IGD following initial IGA) points to the importance of analogical processing as the starting point for the creative process. Across all design teams, further analogy ideation was observed in later quartiles, though not at the same frequency level as the initial IGA activity. We attributed this further use of analogy to the cyclical nature of the design process and used it as evidence that analogies are a relevant tool throughout the process.

Discussion

The verbal protocols collected in this preliminary study demonstrate that analogy plays an important role in the idea-generation stage of product development. All four pairs of designers incorporated information from existing base domains into their designs, and each team's use of analogy occurred without our prompting. According to consumers' ratings, the number of analogies used by each design team had a statistically significant, positive relationship to the originality of the resulting design. Although this study suggests that the use of more analogies in concept generation leads to more-original designs, the limited number of designers in the sample prevents us from making any definitive conclusions. Furthermore, this preliminary evidence does little to suggest the conditions under which the observed relationship holds.

Facilitating Access

The positive relationship between the number of analogies used and the originality of the resulting designs found in Study 1 suggests that it is important to understand how (and if) firms can actively encourage access to multiple knowledge bases. Though critical, the access stage can be difficult when the goal is to generate a truly novel product. In this case, potentially relevant information can often come from widely disparate domains, and researchers have shown that people often fail to access potentially valuable information in these situations (Gick and Holyoak 1980). As Perkins (1997) suggests, genuinely novel inventions are rare for this reason, because the search for the diverse information necessary to construct original ideas can be arduous.

Given peoples' relative inability to access relevant base domains spontaneously, research in analogical learning and problem solving has examined ways to improve the probability of success (e.g., Gentner, Rattermann, and Forbus 1993; Ross 1984). One straightforward tactic is simply to encourage people to search longer and harder during the access stage. Another factor has also been consistently shown to facilitate access: hints or cues that the experimenter provides. In these studies, however, the hint is provided to cue one specific base domain that alone contains the relevant information required to solve the problem or to learn about the target. Contrast this problem-solving objective with the objective of a new product design task, that of creative generation. In the latter case, relevant, useful information could be found in any number of base domains, not just one.

Nonetheless, the use of external cues as an ideation strategy has been encouraged in product design (e.g., Srinivasan, Lovejoy, and Beach 1997; Ulrich and Eppinger 2000). For example, the practice of benchmarking existing products—that is, studying an existing/competing product that is functionally similar—is advocated as an effective starting point for the creative process (Dumas 1994; Ulrich and Eppinger 2000). Similarly, searching established patents as a source of ideas has also been recommended (Glazier 1995; Ulrich and Eppinger 2000).

Although these strategies may be effective in routine and redesign tasks, research in creativity suggests that focusing on existing examples may inhibit the generative process when the goal is to create a truly innovative product (Jansson and Smith 1991; Marsh, Ward, and Landau 1999; Ward 1994). For example, students shown others' drawings before undertaking a creative task themselves are much more likely to incorporate specific features from the examples into their own work than are students who are not provided examples (Marsh, Landau, and Hicks 1996). Called "unconscious plagiarism" (Marsh, Ward, and Landau 1999), this phenomenon has proved robust across a variety of settings. Given our findings from Study 1 and the findings from the unconscious plagiarism studies, we propose the following:

H_1: More-original designs will be produced when no external cue is provided and there is encouragement to use as many analogies as possible.

Understanding Unconscious Plagiarism: Part-List Cueing and Form Fixation

Although we have predicted the effect of unconscious plagiarism on originality, little is known about the mechanisms underlying it. Specifically, how does an external cue influence cognitive processing and decrease originality? Although no definitive answers exist, at least two plausible explanations for the phenomenon are apparent. The explanations are not mutually exclusive; rather, unconscious plagiarism could result from either or both of the following explanations.

The first explanation is that the external example activates a previously stored representation, and the strength of this activation "may prevent the retrieval of new unrecalled material" (Finke, Ward, and Smith 1992, p. 150). Similar to the part-list cueing effect, the salience of the example would make the representation come to mind continually during attempts to access other potentially relevant domains (Alba and Chattopadhyay 1986). If this were correct, any incremental effort applied to an internal search would yield access to fewer knowledge bases and thus do little to improve the originality of the new idea. In this case, people who are shown a prime and encouraged to access many analogies (i.e., use a multiple access strategy) would access

[4]The first 25% of each team's data objects formed the first quartile, the second 25% formed the second quartile, and so on.

fewer knowledge bases than would subjects given the same instructions but not shown a prime. More formally,

> H_2: The presence of an external cue will moderate the relationship between access strategy and the number of analogies accessed. Specifically, when instructed to use a multiple access strategy, people viewing an external prime will access fewer base domains than will those who do not view an external prime.

The second explanation is that unconscious plagiarism arises because the external example specifies the form of the object to be created. For example, if people are given a task of imagining a piece of furniture that a handicapped person could use and are then primed with an example of an existing chair, the prime may dictate the form that the furniture should take (Finke 1990). The results from a series of experiments on creative invention motivate this prediction (Finke 1990). In this research, student subjects were given a set of randomly selected object parts (e.g., a sphere, a flexible tube, a handle) and were asked to combine the parts to create a new object or device. Some were told what function the new object should serve (e.g., a piece of furniture for a handicapped person), and others were told what specific type of object to make (e.g., a new kind of chair) (Finke, Ward, and Smith 1992). The results demonstrated that the most creative inventions came from student subjects for whom the function, but not the specific object type, was specified, which suggests that it is difficult for people to break away from basic object forms. Thus, an external cue may simply structure the form that the new product will take but do nothing to hinder access to multiple knowledge bases. If this mechanism is at work, we would expect the following:

> H_3: The presence of an external prime will increase the likelihood that the new design shares the same form as the prime.

Originality and Perceived Customer Value

More-original products are valuable to firms and their shareholders only if consumers are willing to pay for them. Therefore, a critical stage in the new product development process is that of concept testing when the firm attempts to evaluate the potential value of the product concepts before investing in their technological development (Crawford and Di Benedetto 2000). To test the influence of both analogical thinking and the use of primes on perceived customer value, we asked consumers to report their willingness to pay for the new product concepts developed.

STUDY 2

To test H_1–H_3, we manipulated two experimental factors (access strategy and external prime) in a between-subjects design. The access strategy factor had two levels (access to a single base and access to multiple bases), as did the external prime factor (prime and no prime). A single control condition that received neither manipulation also was included. Thus, the design had five cells ([2 access strategy × 2 external prime] + 1 control).

Design Problem

Participants in the study were 106 undergraduate engineering students who were randomly assigned to an experimental condition. They all had completed coursework in design fundamentals and were recruited through announcements that offered $10 for participation. Although previous research in product design has used engineering students (e.g., Dahl, Chattopadhyay, and Gorn 1999; Jansson and Smith 1991), we note that students lack both the training and experience of actual product development team members. Students received a problem statement identical to that in Study 1.

Independent Variables

Manipulation of access strategy. The number of base domains a student was encouraged to access was manipulated through written instruction. These instructions were developed through pretesting. The instructions for the single (multiple) base conditions were as follows:

> In tackling new design problems, many designers find that using a single (multiple) analogy (analogies) to one (several) existing product can help them produce more original designs. New products can be like an existing product in both (1) how they look and (2) how their specific parts or components work. On the following page, you will read a design brief about a specific design problem. After you read the design brief, think of one existing product (as many different types of products) that this new product or its components could look like or work like. Take a minute or so to identify an analogy (these analogies) and please write down the analogy (analogies) in the space provided below. After generating your analogy (analogies), you are asked to use it (them) to develop an innovative and effective design concept that solves the design brief problem.

Manipulation of external prime. Directly following the manipulation of access strategy, students in the two prime conditions received a sketch of a "drive-in window food tray" and were told that this example was provided to help them get started and that it might be useful in solving the design problem. The example was identified through analogies generated in Study 1, and its applicability was verified through pretesting. The control group was not given any instruction regarding the use of analogies, nor were members shown an external prime before the exercise.

Procedure

Student subjects were tested individually. At the start of the design session, students in the manipulated experimental conditions were given the appropriate experimental manipulation, the design problem statement, a pencil, and paper and were informed that they would have approximately one hour to develop a solution to the design problem. After exposure to the assigned manipulations, the students were asked to read the problem statement and were told to produce a thumbnail sketch of their ideas. Students in the control condition received similar instructions, minus the experimental manipulations. After completing the design task, all students filled out a short questionnaire, were debriefed, and were paid for their participation.

Manipulation Check Measures

The questionnaire the students completed started with an open-ended measure that asked them if they had been provided with an example and, if so, to name the example. Students were next asked to write down what they thought the purpose of the study had been (the suspicion probe). Finally, sex, age, and language spoken were indicated;

responses to these items had no effect on the results reported subsequently and therefore are not discussed further.

Dependent Measures

Measures of base domain access. Before completing the questionnaire, students were asked to write down all the analogies they used during the design session.

Measures of design form. Two research assistants, blind to the purpose of the experiment, rated each resulting design on the extent to which it contained and relied on the form that the example made salient (i.e., a tray). Each design was rated on three seven-point scales that indicated the extent to which the design relied on the use of a tray ("does not rely on a tray at all"/"relies completely on a tray"), the extent to which a tray was incorporated into the design ("strongly disagree"/"strongly agree"), and the extent to which a tray was integral in the overall design ("not at all integral"/"very integral"). Higher scores indicated more reliance and use of a tray. The three scores were averaged to create a measurement index of design form (all $\alpha > .85$).

Measures of originality. Following the methodology that Goldenberg, Mazursky, and Solomon (1999) employed, we invited three senior product design professionals to participate as expert judges in the evaluation of the resulting designs. All three professionals currently held positions as product designers and had extensive training and experience in consumer product design. The judges were blind to the students' identity, to one another's identity, and to the purpose of the experiment.

Three separate booklets were prepared, each with a different random order of the 104 designs. Judges were randomly assigned to one of the booklets and worked individually at their own speed in their ratings. Judges were asked to rate each design on the three-item originality index used in Study 1. The three items were averaged to form an originality index for each design solution (all $\alpha > .80$). After completing the ratings, the judges were thanked and compensated for their participation.

Perceived customer value. To assess potential customers' perceived value for each of the resulting designs, we asked a sample of four potential customers (i.e., commuters), blind to the purpose of the experiment, to indicate their willingness to pay for each design. We prepared four separate booklets, each with a different random order of the 104 designs. Judges were randomly assigned one of the booklets and were asked to rate each design individually at their own speed. Judges were asked to indicate how much they would be willing to pay for the design on a scale anchored by $10 and rising by $10 increments to a high of $150. After completing the ratings, the judges were thanked and compensated for their participation.

Results

Manipulation checks. The external prime manipulation was effective. Students in the external prime condition reported receiving an example and successfully named it. Students' responses to the suspicion probe were examined by a trained research assistant and one of the principal investigators. In no instance did subjects indicate awareness of the true intent of the study.

Hypothesis tests. H_1 states that more-original designs will be produced when students are not shown an external prime but are encouraged to access multiple base domains. An analysis of variance (ANOVA) was used to test this hypothesis with access strategy and external prime serving as independent factors and each judge's originality ratings as the dependent variable (for cell means, see Table 1 and Figure 2). Two dummy variables were also included as predictors to control for potential interjudge variance among the three expert judges. In addition, four interaction terms between each of the dummy variables and the experimental factors were included as predictors. This analysis revealed four statistically significant main effects (access strategy: $p < .0001$, $\omega^2 = .07$; prime: $p < .0001$, $\omega^2 = .10$; expert judge 1: $p < .0001$, $\omega^2 = .22$; expert judge 2: $p < .0001$, $\omega^2 = .16$) and the predicted interaction between access strategy and the exter-

Figure 2
STUDY 2 RESULTS: ORIGINALITY MEANS BY CONDITION

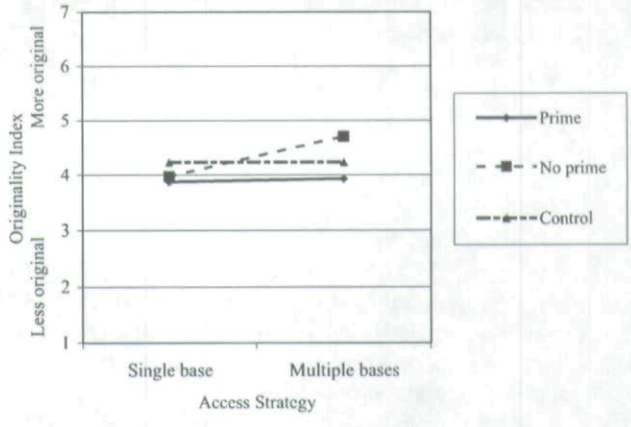


Table 1
EXPERIMENT 2: CELL MEANS AND STANDARD DEVIATIONS

	Prime		*No Prime*		
Dependent Measures	*Single Base*	*Multiple Bases*	*Single Base*	*Multiple Bases*	*Control*
Originality index	3.87	3.93	3.97	4.70	4.23
	(.60)	(.63)	(.93)	(.77)	(.83)
Number of analogies used	2.82	6.19	3.24	7.73	3.33
	(1.65)	(4.55)	(1.64)	(4.99)	(1.98)
Design form index	5.68	5.01	4.62	3.90	4.27
	(1.80)	(2.09)	(2.51)	(2.14)	(2.02)

nal prime ($p < .05$, $\omega^2 = .03$). None of the other interaction terms was statistically significant.[5]

To interpret the direction and magnitude of these results, recall that the originality scores were assessed on a 1 to 7 scale index, where 7 was the most original. On average, student subjects in the no prime/multiple base condition ($\bar{x} = 4.70$) produced designs that were statistically more original than those in each of the other cells (no prime/single base $\bar{x} = 3.97$, $p < .01$; prime/multiple base $\bar{x} = 3.93$, $p < .01$; prime/single base $\bar{x} = 3.87$, $p < .01$; control $\bar{x} = 4.23$, $p < .05$).[6] Thus, H_1 was supported statistically. These results provide some indication that instructing people to access multiple base domains and showing them no example before an ideation session may result in the creation of more-original concepts. However, the magnitude of these effects appears to be rather small, and despite the statistical differences across conditions, the means themselves are close to the midpoint on the scale.

Nonetheless, the statistical differences raise an interesting question. Specifically, how did the external prime inhibit the originality of subjects in the multiple base condition? H_2, the part-list cueing hypothesis, suggests that originality of the designs produced by students in the prime/multiple base condition may have been reduced because they could not access as many base domains as did students in the no prime/multiple base condition. A two-way ANOVA, with access strategy and external prime as the two independent factors, showed a statistically significant main effect for access strategy on the number of analogies used ($p < .001$, $\omega^2 = .22$), an effect considered large in experimental research (Cohen 1977, pp. 284–88; Keppel 1991). Because no statistically significant interaction emerged, however, there is no support for H_2. Students' ability to access multiple domains was not influenced by the presence of an external prime to any meaningful degree.

Another possible explanation for unconscious plagiarism, proposed in H_3, is that the external prime imposed a structure or form on the design, thus reducing its originality. To test this hypothesis, the design form index served as the dependent variable, and a three-way ANOVA was used, with access strategy, the external prime, and a dummy variable for one of the two judges serving as the independent factors. The results revealed statistically significant main effects for each of the experimental factors (prime: $p < .0001$, $\omega^2 = .31$; access strategy: $p < .0001$, $\omega^2 = .20$), both of which are considered large in experimental research (Keppel 1991).

Students who saw the prime and were instructed to access only one domain relied on the prime heavily ($\bar{x} = 5.68$), whereas those who saw no prime and accessed multiple base domains relied on it the least ($\bar{x} = 3.90$). Students in the control condition ($\bar{x} = 4.27$) did not differ from the others who were not exposed to the prime ($\bar{x} = 4.26$) but differed statistically from those who were exposed to it ($\bar{x} = 5.34$, $p < .05$) (see Table 1 and Figure 3). Taken together, these findings support H_3, demonstrating that the external prime reduced design originality by structuring the form of the design.

[5]In subsequent analysis for both Studies 2 and 3, when appropriate, we tested regression models that included interactions between judges and experimental factors. These models did not statistically outperform those reported in the manuscript.

[6]For the planned contrasts, to obtain a better estimate of within-cell error, we use data from all five experimental conditions (Keppel 1991).

Figure 3
STUDY 2 RESULTS: DESIGN FORM INDEX MEANS BY CONDITION

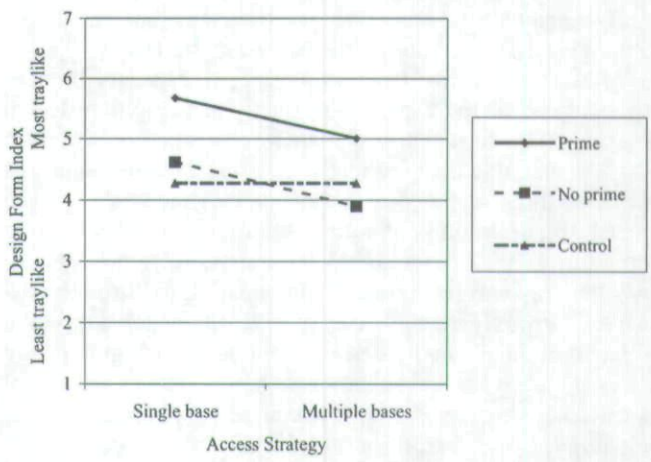


Table 2
STANDARDIZED REGRESSION COEFFICIENTS FOR STUDY 2

	Dependent Variable	
Independent Variables	*Originality*	*Willingness to Pay*
Prime	−.10**	−.17**
Access strategy	.18**	.16**
Prime × access strategy	−.11*	−.05
Design form index	−.22**	−.27**
Originality		−.08
Expert judge 1	−.44**	−.09*
Expert judge 2	.27**	.00
Design form judge	.11	.04
Commuter judge 1		.29
Commuter judge 2		.05
Commuter judge 3		−.11*
R^2	.30**	.25**

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

Accessing multiple base domains also independently reduced students' reliance on a tray.

Given that both of the experimental factors and the design form index influenced originality, we ran a regression to assess their relative effects. In the analysis, the predictors included the experimental factors, their interaction, the design form index, and dummy variables for both sets of judges. The results, presented in Table 2, show a positive influence of the multiple access condition, a negative influence of the prime, and a negative influence of the interaction of access strategy and the prime on originality. The design form index was also negatively related to originality.

Perceived customer value. To assess the effects of the experimental factors and the measured variables on consumers' willingness to pay for each design, we ran an additional regression that included as additional predictors the originality index and three dummy variables for the commuter judges (see Table 2). The presence of a prime had a statistically significant, negative presence on commuters' willingness to pay for a design ($\beta = -.17$), and encouraging

Table 3
PREDICTED WILLINGNESS TO PAY BY CONDITION FOR STUDY 2

	Manipulated Variables				*Measured Variables*		*Expert Judges*	*Expert Judges*	*Expert Judge*	
Willingness to Pay	*Intercept*	*Prime*	*Access Strategy*	*Prime × Access Strategy*	*Design Form Index*	*Originality*	*EJ1 & EJ2*	*CJ1–CJ3*	*DF1*	*Predicted Values*
Betas	74.12	–12.71	6.93	–3.02	–4.58	–2.24	–4.14	10.96	3.62	
Condition										
No prime/multiple bases	1	0	1	0	3.90	4.70				$63.10
One prime/multiple bases	1	1	1	1	5.01	3.93				$44.01
No prime/single base	1	0	–1	0	4.62	3.97				$47.58
One prime/single base	1	1	–1	–1	5.68	3.87				$33.26
Control	1	0	0	0	4.27	4.23				$55.53

Notes: Average beta (for a list of the individual judge betas, see Table 2).

the use of multiple analogies had a positive influence (β = .16). Furthermore, the higher the design's rating on the design form index (i.e., the more the design relied on a tray), the lower was the commuters' willingness to pay (β = –.27). These standardized coefficients, however, appear relatively small in magnitude. Thus, the following analysis better elucidates their practical implications.

Predicted willingness to pay. To provide a more comprehensive interpretation of our results, we used the regression equation described previously to predict the commuters' average willingness to pay for the designs in each of the experimental conditions (see Table 3). The purpose in doing this analysis was also to aid in our interpreting the statistically significant but relatively small differences across the conditions on both the originality and the design form index measures. Recall that the range in originality means was only from 3.87 to 4.70 on a seven-point scale, and the range on the design form index was only from 3.90 to 5.68 on a seven-point scale. For easier interpretation, we used the nonstandardized regression coefficients in this exercise.

The predicted value for the designs produced by students in the no prime/multiple base condition was $63.10, compared with $44.01 for the prime/multiple base condition, $47.58 for the no prime/single base condition, $33.26 for the prime/single base condition, and $55.53 for the control group. This analysis indicates that the small changes in originality may have some meaningful influence on an innovation's value to a firm.

Discussion

These results indicate that the use of multiple base domains in a design task can facilitate a more-original design if no example is provided before the design task. Instead of enhancing originality, the presence of an example negated the benefits associated with accessing multiple base domains during concept generation. This study also enhanced our understanding of the mechanisms underlying unconscious plagiarism. Although the prime did not constrain students' access to multiple base domains, it reduced originality by influencing the structure of the new design. This important finding suggests that during a generative task, the salient properties of an external example may serve as a starting point for the overall design. Finally, this study tested our implicit assumption that firms can benefit from even small increases in the originality of their new product concepts.

However, a key question remains: What would have happened if multiple external cues had been provided simultaneously at the beginning of the design task? This is arguably a more realistic scenario, yet the predicted effects of multiple primes on originality are not obvious. When multiple primes are provided, it could be that the increased accessibility of multiple bases increases design originality, particularly if the bases would have otherwise been relatively inaccessible. If students are able to map and transfer attributes and/or relations from these domains to their designs, providing multiple external primes may increase overall design originality.

Conversely, the multiple primes could more completely dictate the form that the design should take, resulting in designs rated as less original than those produced when students view only one external prime. If students can map and transfer the concrete properties from many different base domains, they may have little incentive to search for more-original information contained in nonprimed domains. Thus, providing multiple primes may further inhibit creativity rather than enhance it, because the concrete properties of the examples are compelling and difficult to ignore.

To assess how multiple primes affect cognitive processing, we could again examine their influence on the number of different base domains accessed during a generative task. This process-tracing measure, however, implicitly assumes that all analogies are created equal, whereas recent research in analogy suggests that there are distinct types of analogies. In the following section, we describe the different types of analogies and propose that analogy type interacts with the external primes to influence creative task performance.

Near Versus Far Analogies

Whereas some analogies may be drawn from knowledge bases that are similar to the target, other analogies may be drawn from bases that are "wildly discrepant" (Ward 1998, p. 221). Consequently, analogies are often described by their position on a continuum, ranging from "near" at one extreme to "far" at the other (Gentner et al. 1997; Perkins 1997). For example, when designing a new freeway system, designers could draw a near analogy from a closely related base domain, such as a freeway system in another city. However, they could also draw a far analogy from a more distant base domain, such as the human circulatory system. This distinction is important because the type of information mapped and transferred from near analogies is different from that transferred from far analogies.

When near analogies are drawn, both surface-level attributes (e.g., roads) and the relations among the attributes (e.g., the flow of cars through the freeway system) are mapped and transferred. However, when far analogies are drawn, few surface-level attributes can be mapped, leaving the mappings to occur between common relations (Gentner 1989; Ward 1998). Because near analogies often fall into the category of "literal similarity" (Gentner 1989), they represent smaller conceptual distances between the old and the new ideas and may be viewed as less original (Ward 1998). Far analogies are considered the main drivers of truly innovative thought, serving as the basis for "mental leaps" (Holyoak and Thagard 1995; Ward 1998). However, far analogies require the identification of similarities in the relational (not surface) structure between the base and the target domains, and when the target and base domains share few surface similarities (e.g., freeway systems and the human circulatory system), access is often difficult (Gentner, Ratterman, and Forbus 1993). Nonetheless, new concepts based on far analogies are likely to be more creative than those based on near analogies (Perkins 1997; Ward 1998). Therefore,

H_4: The higher the proportion of far analogies used in a design task, the greater is the originality of the resulting design.

Predicting the Use of Far Analogies

To explain how people use their existing knowledge in a creative task, Ward and colleagues have proposed the path-of-least-resistance (POLR) model (Ward 1998). Because generating new ideas is cognitively demanding, the POLR model suggests that people will simplify the task by using analogies that come readily to mind.

In analogical thinking, access is largely determined by the nature of the similarity between the surface-level attributes of the base and target domains (Gentner, Ratterman, and Forbus 1993), and the POLR is often found between a base and a target with many common surface attributes. When a base and the target share these superficial qualities, they often come from the same or close conceptual domains and thus are typically near analogies (Ward 1998). Far analogies, however, are less accessible than near analogies because the nature of the similarity between the base and the target domains is at the more abstract, relational level. To discover these far analogies requires more cognitive effort. Therefore, we would expect that people encouraged to access multiple base domains would access a higher proportion of far analogies in a creative task than would people who are encouraged to access only one.

H_5: When the use of multiple base domains is recommended, a greater proportion of far analogies is accessed.

The accessibility of different bases can also be manipulated, as is demonstrated in Study 2, by using an external prime. The priming of a specific base makes the path between that base and the target the one of least resistance. Students who saw the prime subsequently used it in structuring the form of the new product. The primes may have a tendency to create a focus on concrete attributes, facilitating the ability to draw near analogies. To access far analogies, however, there would be a need to think in a more abstract fashion in order to perceive similarities among abstract relations. Thus, we hypothesize the following:

H_6: The greater the number of external primes provided, the lower is the proportion of far analogies accessed.

STUDY 3

We conducted Study 3 to experimentally test H_4–H_6 and to examine the effect of those factors on perceived customer value. The number of external primes shown to students before the design task was manipulated between subjects (no prime, one prime, or several primes). Access strategy was held constant across these three cells: Students in all the prime conditions were encouraged to access and use as many analogies as possible. For the purpose of comparison, however, we also included an additional "several primes" cell, in which students were encouraged to access and use only one analogy. Thus, the design had four cells.

Design Problem

The study's participants were 119 engineering students who were randomly assigned to an experimental condition. Participants were senior students who had completed at least two courses in design and were paid $10 for their participation. The task and procedure were identical to that used in Study 2.

Independent Variables

Manipulation of access strategy. Access strategy was manipulated in the same way as described in Study 2.

Manipulation of external primes. The external prime manipulation occurred at the start of the design exercise. In the single prime condition, students received a sketch of a "drive-in window food tray" and were told that this example was provided to help them get started. In the multiple prime conditions, students received this sketch plus three additional sketches (a cup holder, a lunch box, and an airplane foldout table). As in Study 2, the primes chosen were identified through analogies generated in Study 1, and their applicability was verified through pretesting. In the no prime condition, no external prime was provided.

Dependent Measures

Measures of base domain access. Again, students were asked to write down all the analogies they used during the design session.

Near versus far analogies. Two independent coders, blind to the purpose of the experiment, coded each analogy as either a near or a far analogy. We instructed the coders to consider any vehicle accessory/attachment or portable eating equipment a near analogy (e.g., car compact disc player, cup holder, tray table) and any nonvehicle/non–eating-related analogy (e.g., bean bag chair, dentist's lamp, hammock, space arm) a far one. The initial agreement between the two coders was 95%, and disputes were resolved through discussion with one of the authors.

Customer judgments. To assess the originality and perceived value of the resulting designs, we solicited responses from potential customers (Dahl, Chattopadhyay, and Gorn 1999). We used the same judging protocol as in Study 2 with a sample of 16 potential customers (i.e., commuters). We obtained ratings of originality (summed as an originality index [all $\alpha > .82$]) and willingness to pay.

Results

Manipulation checks. The external prime manipulations were effective. Students in the three external prime condi-

tions reported receiving examples and were successful in naming the given primes. Furthermore, using the same methodology as described in Study 2, we determined that none of the study participants were aware of the experimental hypotheses.

Design originality. An ANOVA was used to test for differences in design originality among the four cells. Included as additional predictors were 15 dummy variables used to control for potential differences across the 16 judges. The results reveal small but statistically significant differences across conditions ($p < .0001$, $\omega^2 = .03$) and statistically significant effects for 9 of the 15 judge dummy variables. Consistent with our findings from Study 2, students who were not shown a prime and were encouraged to access multiple base domains produced designs that, on average, were rated as statistically more original than those in the other conditions (no prime $\bar{x} = 4.45$ versus one prime $\bar{x} = 3.87$, several primes $\bar{x} = 4.07$, one analogy $\bar{x} = 4.09$; all $p < .01$). Again, we highlight the relatively small differences across these four cells and note that all four means are relatively close to the midpoint of the seven-point scale. Given the potential importance of small differences in originality on perceived customer value, however, we test H_4–H_6 to better understand why students in the no prime condition produced designs that were rated as statistically more original than those produced in other conditions.

Far analogies and originality. H_4 states that the higher the proportion of far analogies used in a design task, the greater is the originality of the resulting design. We used regression analysis to test this hypothesis. The judge's rated originality for each design served as the dependent variable, and the percentage of far analogies, the experimental factors, and a set of 15 dummy variables for the individual judges served as the independent variables. The results, shown in Table 4, reveal that the percentage of far analogies had a statistically significant, but small, positive effect on originality ($\beta = .05$, $p < .05$), in support of H_4. In addition, the presence of a single prime and the presence of multiple primes had statistically significant, negative effects on originality (single prime $\beta = -.16$, multiple primes $\beta = -.13$). Nine of the judge variables also had statistically significant effects on originality.

Table 4
STANDARDIZED REGRESSION COEFFICIENTS FOR STUDY 3

	Dependent Variable	
Independent Variables	*Originality*	*Willingness to Pay*
One prime	−.13*	−.14*
Multiple primes	−.16**	−.15**
Access strategy	.01	−.03
Percentage of far analogies	.05*	.11**
Originality		.44**
Expert Judge Dummies		
1	−.18**	−.10**
2	.05*	−.10**
3	.04	.01
4	.03	−.15**
5	.01	.05*
6	.11**	−.11**
7	.02	.03
8	−.06*	−.16**
9	.18**	−.19**
10	.09**	−.15**
11	−.14**	.12**
12	−.09**	−.04
13	.10**	−.14**
14	−.03	.10**
15	−.03	−.18**
R^2	.16**	.39**

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

Predicting the use of far analogies. H_5 and H_6 predict that both access strategy and the presence/absence of external primes will influence the proportion of far analogies accessed during the design task. A one-way ANOVA, with the four different conditions serving as the independent factors, revealed a statistically significant, medium-sized effect of the variables ($p < .01$, $\omega^2 = .13$). H_5 states that student subjects who are encouraged to access multiple base domains in the design task will access a higher proportion of far analogies than will those who are encouraged to access only one domain. A planned contrast between the single-base access cell and the three multiple-base access cells revealed a statistically significant difference in the proportion of far analogies accessed (single-access $\bar{x} = .48$ versus multiple-access $\bar{x} = .61$, $p < .05$). In addition, a contrast between the two cells within the multiple primes condition was statistically significant (single-access $\bar{x} = .48$ versus multiple-access $\bar{x} = .74$, $p < .05$). Both of these contrasts provide support for H_5.

H_6 states that the more external primes provided to students before the design task, the lower is the proportion of far analogies accessed. To test this hypothesis, we again used planned contrasts that compared the proportions of far analogies accessed by those who viewed no, one, or four primes. Of the analogies used by students who viewed no prime, 74% were considered far analogies, a proportion statistically greater than the 49% used by students who viewed one prime ($p < .01$) and the 55% used by students who viewed multiple primes ($p < .01$). Therefore, it appears that the existence of any concrete example inhibits the use of far analogies in the design task, in partial support of H_6.

Originality and perceived customer value. As in Study 2, our final tests in this study were designed to assess the influence of the experimental conditions, the percentage of far analogies, and rated originality on perceived customer value. The regression model used to test this relationship included as predictors the originality index and a set of dummy variables for the judges. The results are presented in Table 4. As in Study 2, the presence of a single prime had a statistically significant, negative effect on judges' willingness to pay for a design ($\beta = -.14$), as did the presence of multiple primes ($\beta = -.15$). Originality had the largest effect on willingness to pay ($\beta = .44$), but encouraging the use of multiple analogies had no statistically significant influence on perceived value. The benefits of that manipulation, however, are evident in the positive effect of the percentage of far analogies ($\beta = .11$).

Predicted willingness to pay. As in Study 2, we used the nonstandardized regression coefficients from the regression described previously to predict the judges' average willingness to pay for the designs in each condition, because the magnitudes of the βs were largely in the small-to-moderate range. The results are provided in Table 5. The predicted value for designs in the no prime/multiple base condition was $45.54, compared with $28.34 for the one prime/multiple base condition, $33.22 for the multiple prime/multiple

Table 5
PREDICTED WILLINGNESS TO PAY BY CONDITION FOR STUDY 3

		Manipulated Variables			*Measured Variables*		*Judges*	
Willingness to Pay	*Intercept*	*One Prime*	*Multiple Primes*	*Access Strategy*	*Proportion of Far Analogies*	*Originality*	*J1–J15 Dummy Variables*	*Predicted Values*
Betas	8.12	–9.66	–7.71	–1.84	9.72	8.81	–7.14	
Condition								
No prime/multiple bases	1	0	0	1	.74	4.45		$45.54
One prime/multiple bases	1	1	0	1	.49	3.87		$28.34
Multiple primes/multiple bases	1	0	1	1	.61	4.07		$33.22
Multiple primes/single base	1	0	1	0	.48	4.09		$33.97

Notes: Average beta (for a list of the individual judges' betas, see Table 4).

base condition, and $33.97 for the multiple primes/single base condition.

Discussion

This study demonstrates that exposing student subjects to many, as opposed to one, external prime does little to enhance the originality of the resulting design. The external primes limited the proportion of far analogies used in the design task. Because we found this proportion to be a positive predictor of both design originality and perceived value, we better understand how the external primes dictate the structure and reduce the originality of the resulting design. In this study, the external primes appeared to focus the students on more concrete, near analogies. In their absence, students were able to access and use more abstract, far analogies, thus making "mental leaps" rather than "mental hops" to increase originality (Holyoak and Thagard 1995).

Consistent with Study 2, we also found that encouraging the access of multiple base domains during the idea-generation stage can improve design originality in the absence of an external prime. When students were encouraged to use multiple analogies and received no external prime, they were able to use a higher proportion of far analogies during the task to increase design originality. Finally, as in Study 2, this study demonstrated that a firm may benefit financially from creating products with higher levels of perceived originality.

GENERAL DISCUSSION

By documenting the influence of analogical thinking during the ideation stage of new product development, these three studies have theoretical and practical implications for the marketing, psychology, and product development literature.

Theoretical Implications

Although the relationship between analogical thinking and originality has both anecdotal and historical support in the literature, the studies presented here are the first to examine and test empirically how analogy influences originality. By understanding the way in which analogical thinking affects concept generation, this research has enabled us to identify the conditions under which originality can be enhanced.

In Study 1, we found a positive relationship between the number of analogies used and the originality of the resulting design. In Studies 2 and 3, we examined the conditions under which people use analogical thinking to access and use information from multiple domains. We found that simply instructing students to use many (as opposed to one) base domains during the idea generation stage increased the number of analogies drawn. However, the relationship between the number of analogies used and the resulting originality of the product concept was qualified by other factors.

Specifically, when an external prime was present during ideation, increasing the number of analogies used did not enhance originality. This strategy, often referred to as benchmarking, is frequently encouraged for new product development. When developing a new category of products (not redesigning products within an existing category), the presence of an external prime hindered students from producing, rather than helped them produce, original ideas. We not only documented this phenomenon, called unconscious plagiarism, but also took steps to identify its underlying cause. Our analyses provided evidence that form fixation was driving the effect. Whether one or many in number, external primes appear to focus people on concrete attributes. Students exposed to one or several primes used a lower proportion of far analogies (analogies to distant domains) than did those who received no prime. This finding is important given the empirical evidence from Study 3, which shows that the proportion of far analogies used by the subject was a strong indicator of both the originality of the resulting design and consumers' perceptions of its value. Taken together, our studies demonstrate that originality can be enhanced during idea generation by encouraging the extensive use of analogies and providing no external benchmarks.

It is important, however, to qualify the generalizability of our priming results. A limitation of Studies 2 and 3 is that all the primes promoted the use of near analogies. To compare the effects of the single prime to those of the multiple primes in Study 3, we held the type of prime (near versus far) constant across all the priming conditions. Our results, then, may hold only when the primes represent near analogies. When far analogies are primed, such priming may encourage, rather than hinder, more abstract and original thought.[7]

Practical Implications

Should originality, however, be a critical goal in new product development? Although more research is needed to fully answer this question, our results revealed that con-

[7]We thank one of the reviewers for pointing out this possibility.

sumers were willing to pay more for more-original product concepts. This finding suggests that more-original products may be an important source of revenue growth for the firm and its shareholders.

To foster more-original designs, firms may find that encouraging the use of analogies from several disparate knowledge bases is a superior strategy. With further examination and replication, our findings may present opportunities for education and training programs for successful ideation practice. That our control group in Study 2, which was not exposed to either of the experimentally manipulated factors, underperformed the group exposed to the recommended ideation approach highlights the applicability of our findings.

Limitations and Further Research

As with any experimental research, our results are subject to several potential limitations. Despite the statistical significance of our manipulations, the mean differences of originality observed in our research were relatively small. It remains to be seen whether, in a less-controlled setting, the differences identified are meaningful in a practical sense. In addition, the nature of the design task (i.e., time provided and scope of design mission) and the product being designed might have influenced the relationships observed in this research.

As indicated previously, the participants in our laboratory studies were design students, not professional designers. This distinction could also limit the generalizability of the findings. Professional designers might have been less susceptible to priming than the students used in this research. In addition, the students' compensation was not dependent on the quality of their output, nor was the magnitude of their compensation comparable to that of professional designers. Finally, as noted previously, the primes used in this research encouraged the use of near analogies rather than far ones. These limitations, however, provide opportunities for further research.

For example, testing the external validity of these findings represents an opportunity. This research could be accomplished by a test of our methods using professionals in the new product development process and/or proceeding further along the product development process by obtaining consumer reactions to physical product prototypes. Indeed, our results provide some initial evidence that suggests that companies might find it worthwhile to conduct field tests to evaluate the actual economic worth of these findings. Quasi-experimental field investigations, similar to those conducted by Simester and colleagues (2000) to test quality improvement programs, would provide the opportunity to externally validate our conclusions.

Theoretically, additional research is needed to examine the influence of far primes on originality and understand if their use is effective in developing both incremental and radical innovations. Whereas we compared the influence of near and far analogies, other taxonomies have also been proposed (e.g., Gordon 1961). Future research could examine whether further refinement of analogy type would provide additional benefits to the concept-generation stage. Finally, factors such as the developer's category involvement, motivation (intrinsic and extrinsic), and product type (industrial versus consumer) may also influence both analogical thinking and its effect on design originality.

REFERENCES

Alba, Joseph W. and Amitava Chattopadhyay (1986), "Salience Effects and Brand Recall," *Journal of Marketing Research*, 23 (November), 363–69.

Amabile, Teresa M. (1996), *Creativity in Context*. Boulder, CO: Westview Press.

Boden, Margaret A. (1994), *Dimensions of Creativity*. Cambridge, MA: MIT Press.

Carlson, W. Bernard and Michael E. Gorman (1992), "A Cognitive Framework to Understand Technological Creativity: Bell, Edison, and the Telephone," in *Inventive Minds: Creativity in Technology*, R.J. Weber and D.N. Perkins, eds. New York: Oxford University Press, 48–79.

Cohen, Jacob (1977), *Statistical Power Analysis for the Behavioral Sciences*. New York: Academic Press.

Crawford, C. Merle and Anthony Di Benedetto (2000), *New Products Management*. Boston: Irwin/McGraw-Hill.

Curtis, James (1998), "In Search of the Big Idea," *Marketing*, (October 22), 30–31.

Dahl, Darren W., Amitava Chattopadhyay, and Gerald J. Gorn (1999), "The Use of Visual Mental Imagery in New Product Design," *Journal of Marketing Research*, 36 (February), 18–28.

Deveny, Kathleen (1994), "Neat Tricks: Inventors Tidy Up Automotive Dining," *The Wall Street Journal*, (February 1), B1.

Dumas, Angela (1994), "Building Totems: Metaphor-Making in Product Development," *Design Management Journal*, 5 (Winter), 71–82.

Finke, Ronald (1990), *Creative Imagery: Discoveries and Inventions in Visualization*. Hillsdale, NJ: Lawrence Erlbaum Associates.

———, Thomas Ward, and Steven Smith (1992), *Creative Cognition: Theory, Research, and Applications*. Cambridge, MA: MIT Press.

Gagne, C. and E.J. Shoben (1997), "The Influence of Thematic Relations on the Comprehension of Nonpredicating Combinations," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 23 (1), 71–87.

Gentner, Dedre (1989), "The Mechanisms of Analogical Transfer," in *Similarity and Analogical Reasoning*, Stella Vosniadou and Andrew Ortony, eds. Cambridge, UK: Cambridge University Press, 99–124.

———, Sarah Brem, Ron Ferguson, Philip Wolff, Arthur B. Markman, and Ken Forbus (1997), "Analogy and Creativity in the Works of Johannes Kepler," in *Creative Thought*, Thomas B. Ward, Steven M. Smith, and Jyotsna Vaid, eds. Washington, DC: American Psychological Association, 403–59.

———, Mary Jo Rattermann, and Kenneth Forbus (1993), "The Roles of Similarity in Transfer: Separating Retrievability from Inferential Soundness," *Cognitive Psychology*, 25 (4), 524–75.

Gick, Mary and Keith Holyoak (1980), "Analogical Problem Solving," *Cognitive Psychology*, 12 (3), 306–55.

Glazier, Stephen C. (1995), "Inventing Around Your Competitors' Patents," *Managing Intellectual Property*, 51 (July/August), 10–14.

Goel, Ashok K. (1997), "Design, Analogy, and Creativity," *IEEE Expert*, 12 (June), 62–70.

Goldenberg, Jacob, David Mazursky, and Sorin Solomon (1999), "Toward Identifying the Inventive Templates of New Products: A Channeled Ideation Approach," *Journal of Marketing Research*, 36 (May), 200–10.

Gordon, William J.J. (1961), *Synectics: The Development of Creative Capacity*. New York: Harper and Row.

Gregan-Paxton, Jennifer and Deborah Roedder John (1997), "Consumer Learning by Analogy: A Model of Internal Knowledge Transfer," *Journal of Consumer Research*, 24 (December), 266–84.

Hampton, James A. (1997), "Conceptual Combination: Conjunction and Negation of Natural Concepts," *Memory and Cognition*, 25 (6), 888–909.

Hargadon, Andrew and Robert Sutton (1997), "Technology Brokering and Innovation in a Product Development Firm," *Administrative Science Quarterly*, 42 (4), 716–49.

Holyoak, Keith J. and Paul Thagard (1995), *Mental Leaps: Analogy in Creative Thought*. Cambridge, MA: MIT Press.

Jansson, David G. and Steven Smith (1991), "Design Fixation," *Design Studies*, 12 (1), 3–11.

Keppel, Geoffrey (1991), *Design and Analysis: A Researcher's Handbook*, 3d ed. Englewood Cliffs, NJ: Prentice Hall.

Khurana, Anil and Stephen Rosenthal (1997), "Integrating the Fuzzy Front End of New Product Development," *Sloan Management Review*, 38 (2), 103–20.

Leonard, Dorothy and Jeffrey Rayport (1997), "Spark Innovation Through Empathic Design," *Harvard Business Review*, 75 (6), 102–12.

Marsh, Richard, Joshua Landau, and J.L. Hicks (1996), "How Examples May (and May Not) Constrain Creativity," *Memory and Cognition*, 24 (5), 669–80.

———, Thomas Ward, and Joshua Landau (1999), The Inadvertent Use of Prior Knowledge in a Generative Cognitive Task," *Memory and Cognition*, 27 (1), 94–105.

McMath, Robert (1998), "What Do Consumers Really Want?" *Marketline*, 1 (30), 6–7.

Montoya-Weiss, Mitzi and Tony M. O'Driscoll (2000), "From Experience: Applying Performance Support Technology in the Fuzzy Front End," *Journal of Product Innovation Management* 17 (2), 143–61.

Nagy, Richard L., David G. Ullman, and Thomas G. Dietterich (1992), "A Data Representation for Collaborative Mechanical Design," *Research in Engineering Design*, 3 (4), 233–42.

Newell, Allen (1990), *Unified Theories of Cognition*. Cambridge, MA: Harvard University Press.

Perkins, David N. (1997), "Creativity's Camel: The Role of Analogy in Invention," in *Creative Thought*, Thomas Ward, Steven Smith, and Jyotsna Vaid, eds. Washington, DC: American Psychological Association, 523–38.

Polya, George (1954), *Mathematics and Plausible Reasoning*. Princeton, NJ: Princeton University Press.

Port, Otis (1998), "Making Complexity Look Simple," *BusinessWeek*, (May 18), 166.

Reinertsen, Donald G. (1999), "Taking the Fuzziness out of the Fuzzy Front End," *Research-Technology Management*, 42 (6) 25–31.

Rhodes, Richard (1986), *The Making of the Atomic Bomb*. New York: Simon & Schuster.

Ross, Brian (1984), "Remindings and Their Effects in Learning a Cognitive Skill," *Cognitive Psychology*, 16 (3), 371–416.

Roukes, Nicholas (1988), *Design Synectics: Stimulating Creativity in Design*. Worcester, MA: Davis Publications.

Sarlemijn, Andres and Peter A. Kroes (1988), "Technological Analogies and Their Logical Nature," in *Technology and Contemporary Life*, Paul T. Durbin, ed. Dordrecht, The Netherlands: Reidel, 237–55.

Shah, Jami J., Jill A. Nico, and Theodore C. Kraver (1993), "Non-intrusive Protocol Study of Design Idea Generation," *Design Theory and Methodology ASME*, 53, 213–22.

Simester, Duncan I., John R. Hauser, Birger Wernerfelt, and Roland T. Rust (2000), "Implementing Quality Improvement Programs Designed to Enhance Customer Satisfaction: Quasi-Experiments in the United States and Spain," *Journal of Marketing Research*, 37 (February), 102–12.

Srinivasan, V., William S. Lovejoy, and David Beach (1997), "Integrated Product Design for Marketability and Manufacturing," *Journal of Marketing Research*, 34 (February), 154–63.

Sutton, Robert (1997), "A Culture of Knowledge Brokering: Innovation at IDEO," presentation at Marketing Science Institute, Boston (May 6).

Ulrich, Karl T. and Steven D. Eppinger (2000), *Product Design and Development*, 2d ed. New York: McGraw-Hill.

Von Hippel, Eric (1986), "Lead Users: A Source of Novel Product Concepts," *Management Science*, 32 (7), 791–805.

Ward, Thomas B. (1994), "Structured Imagination: The Role of Category Structure in Exemplar Generation," *Cognitive Psychology*, 27 (1), 1–40.

——— (1998), "Analogical Distance and Purpose in Creative Thought: Mental Leaps Versus Mental Hops," in *Advances in Analogy Research*, Keith Holyoak, Dedre Gentner, and Boicho Kokinov, eds. Sofia, Bulgaria: New Bulgarian University Press, 221–30.