THE USE OF VISUAL MENTAL IMAGERY IN NEW PRODUCT DESIGN

by

DARREN W. DAHL

B. Comm., The University of Alberta, 1992

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY in

THE FACULTY OF GRADUATE STUDIES

Faculty of 
(Business Administration)

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

May 1998

© Darren W. Dahl, 1998
In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Commerce (Marketing)
The University of British Columbia
Vancouver, Canada

Date June 2/1998
THE USE OF VISUAL MENTAL IMAGERY
IN NEW PRODUCT DESIGN

Darren W. Dahl

Under the supervision of Professor Amitava Chattopadhyay and Professor Gerald J. Gorn at the University of British Columbia

ABSTRACT

This dissertation seeks to advance our understanding of how marketing principles can be used to improve the process of new product design. Specifically, it examines the potential of a specific cognitive process, visual mental imagery, as a tool to help designers maximize the appeal of new products in the eyes of their customers. A conceptual framework is presented that describes a process through which visual mental imagery might influence the customer appeal of a design output. This is followed by two experiments which test the hypotheses that flow from this model. The experiments manipulate both the type of visual imagery utilized, and the incorporation of the customer in the imagery invoked (content of the imagery), in order to examine their effects on the usefulness, originality, and customer appeal of the resulting design.

Consistent with the proposed framework and its hypotheses, visualization of the customer, as part of the imagery process, proved to enhance design usefulness when this imagery was imagination-based, but not when it was memory-based. Furthermore, use of imagination-based imagery resulted in more original designs than pure memory-based imagery. Finally, and most importantly, the use of customer visualization in combination with imagination-based imagery led to designs that were
significantly more appealing to the customer. An analysis of covariance subsequently revealed that this improvement in customer appeal was mediated both by the perceived usefulness of the design, and by its degree of originality. The dissertation concludes with the integration of the experimental findings, and a discussion of the potential of visual imagery as a tool in the new product design process.
# TABLE OF CONTENTS

ABSTRACT ........................................................................................................ ii

TABLE OF CONTENTS ....................................................................................... iv

LIST OF TABLES ................................................................................................ vi

LIST OF FIGURES .............................................................................................. viii

ACKNOWLEDGEMENTS .................................................................................... ix

CHAPTERS

ONE INTRODUCTION

The Nature of the Research Problem ............................................................ 1
Scope of this Research .................................................................................. 3
Contributions ................................................................................................. 4
Organization of this Document .................................................................. 6

TWO VISUAL MENTAL IMAGERY

Visual Mental Imagery Defined ..................................................................... 7
Visual Mental Imagery in Marketing ............................................................ 10
Visual Mental Imagery in Design ................................................................. 13
The Importance of Imagery Type ................................................................. 14

THREE PRODUCT DESIGN

The Design Process ....................................................................................... 18
Product Design and the Customer ............................................................... 22
Evaluating Product Design Output ............................................................ 26

FOUR THEORY AND HYPOTHESES

Design Usefulness ........................................................................................ 34
Design Originality ....................................................................................... 36
Creating Appealing Designs ....................................................................... 37
LIST OF TABLES

Table 5-1 Pretest Two: Table of Means ............................................................... 56
Table 5-2 Pretest Two: ANOVA for use of Customer Imagery ............................ 57
Table 6-1 Method: Demographics of Product Designers ..................................... 67
Table 6-2 Method: Elderly Judge Demographics .............................................. 68
Table 7-1 Manipulation Check: ANOVA for use of Memory Imagery .................. 78
Table 7-2 Manipulation Check: ANOVA for use of Imagination Imagery .......... 79
Table 7-3 Manipulation Check: ANOVA for use of Customer Imagery ............... 80
Table 7-4 Manipulation Check: ANOVA for Effort to use Imagery .................... 81
Table 7-5 Judge's Ratings Assessment: Reliability for Individual Items across Judges .............................................................................................................. 82
Table 7-6 Judge's Ratings Assessment: Reliability for Scale Indices within Judges .............................................................................................................. 83
Table 7-7 Judge's Ratings Assessment: Principal Component Analysis of Judged Items ............................................................................................................. 84
Table 7-8 Hypothesis Testing: Table of Means ................................................... 85
Table 7-9 Hypothesis Testing: Analysis of Variance for the Usefulness Variable ...................................................................................................................... 86
Table 7-10 Hypothesis Testing: Analysis of Variance for the Originality Variable ................................................................................................................... 87
Table 7-11 Hypothesis Testing: Analysis of Variance for the Customer Appeal Variable ........................................................................................................ 88
Table 8-1 Hypothesis Testing Follow-up Study: Table of Means .......................... 100
<table>
<thead>
<tr>
<th>Table 8-2</th>
<th>Hypothesis Testing Follow-up Study: Analysis of Variance for the Usefulness Variable</th>
<th>101</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 8-3</td>
<td>Hypothesis Testing Follow-up Study: Analysis of Variance for the Originality Variable</td>
<td>102</td>
</tr>
<tr>
<td>Table 8-4</td>
<td>Hypothesis Testing Follow-up Study: Analysis of Variance for the Customer Appeal Variable</td>
<td>103</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>The Product Design Process (Pahl and Beitz Model)</td>
<td>29</td>
</tr>
<tr>
<td>3-2</td>
<td>Linked Houses of Quality Function Deployment</td>
<td>30</td>
</tr>
<tr>
<td>3-3</td>
<td>The QFD House of Quality</td>
<td>31</td>
</tr>
<tr>
<td>3-4</td>
<td>Conceptual Framework of How Customer Incorporation and Imagery Type Drive Customer Appeal</td>
<td>32</td>
</tr>
<tr>
<td>4-1</td>
<td>Conceptual Framework and Hypotheses of How Customer Incorporation and Imagery Type Drive Customer Appeal</td>
<td>40</td>
</tr>
<tr>
<td>6-1</td>
<td>Procedure for Differing Experimental Conditions</td>
<td>66</td>
</tr>
<tr>
<td>7-1</td>
<td>Conditions for Mediation: Independent Variables have Significant Effect on Mediators and Ultimate Dependent Variable</td>
<td>89</td>
</tr>
<tr>
<td>7-2</td>
<td>Conditions for Mediation: Independent Variable’s Effects are Covaried Out - Effect on Ultimate Dependent Variable Disappears</td>
<td>90</td>
</tr>
<tr>
<td>7-3</td>
<td>Conditions for Mediation: Covariates are Significant</td>
<td>91</td>
</tr>
<tr>
<td>8-1</td>
<td>Follow-up Study - Conditions for Mediation: Independent Variables have Significant Effect on Mediators and Ultimate Dependent Variable</td>
<td>104</td>
</tr>
<tr>
<td>8-2</td>
<td>Follow-up Study - Conditions for Mediation: Independent Variable’s Effects are Covaried Out - Effect on Ultimate Dependent Variable Disappears</td>
<td>105</td>
</tr>
<tr>
<td>8-3</td>
<td>Follow-up Study - Conditions for Mediation: Covariates are Significant</td>
<td>106</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

In completing this dissertation I have benefited from the support, input and guidance of many individuals. Foremost are my two co-chairpersons, Amitava Chattopadhyay and Gerry Gorn, who have been incredible teachers, mentors—and friends—over the past number of years. Amitava has been a source of motivation and vision throughout the dissertation process, and has shown me how to succeed in all aspects of life. Gerry has provided me with inspiration by example, and has given me perspective on what is important in life. I am grateful to both for their patience and willingness to "jump in" with their advice, insights, and new ideas.

I wish to thank those who served on my dissertation research committee. Chuck Weinberg for providing critical feedback and challenging me to "raise the bar". He has shown me what an academic should be. Bruce Dunwoody for providing useful comments on my ideas and for assisting me in finding experimental subjects for my research.

I would like to thank the doctoral students and marketing group at UBC. Robin Ritchie for being a good friend and helping me with editing the final draft. Peter Darke and Asim Ansari for always being willing to discuss ideas and for providing good advice when I needed it. Anne Lavack for her encouragement and counsel in the early years. K.P, Sanjeev, Yong, Cindy, and the rest of the marketing group for their friendship and support.

I would also like to thank my parents, Gerry and Gloria, and the other members of my family for their support and concern throughout my tenure as a graduate student. I have always been able to count on them when I have needed their assistance. I am grateful for everything they have done for me and the things they continue to do.

Finally, I would like to thank Jennifer, both for her support and understanding, and for her patience during the many nights I have spent on this dissertation. She has helped me in innumerable ways - from the long hours spent assisting on data collection to her careful proof-reading of this final document. Perhaps most importantly of all, I thank her for the unwavering love and devotion along the way, and for her willingness to be there when I needed help.
CHAPTER ONE

INTRODUCTION

I. The Nature of the Research Problem

The failure rate for new products has remained steady at 35 to 45% for over 25 years (Business Week 1993; Crawford 1987). Recent research in marketing (e.g., Wind and Mahajan 1997) has sought to address this concern by highlighting the need for new marketing-oriented approaches. Research indicates that to be successful, new products must offer something novel to the customer (Angelmar 1990; Cooper and Kleinschmidt 1987). For example, the innovative Reebok “pump” design that inflates small pockets of air (air bag) in the heel of basketball sneakers has led to over $200 million in revenues (Dumaine 1991). The product’s originality helped it stand out from the crowd and created a competitive advantage (Kotler and Rath 1984). Originality, however, is not the only criterion for new product success. One need only consider the recent highly publicized failure of the Newton personal digital assistant (PDA) from Apple Computer Inc. (Elstrom 1996). Newton was the very first PDA to recognize hand-written characters, and achieved a high level of recognition accuracy for single characters. While Apple regarded this recognition ability as superior (Weiman and Moran 1992), it proved inadequate in the eyes of the customer (Johnson 1993; Orr 1993). Even assuming a 97% level of recognition accuracy at the character level, a 7-digit telephone number would be processed incorrectly about 20% of the time, with longer entries (names with addresses and phone numbers)
incorrect most of the time. Thus, to appeal to the customer and be successful, a new product must not only be original, as the Apple Newton undoubtedly was, but also useful, i.e., successfully meet some important need(s) of the customer (Baxter 1995; Pugh 1996); something the Apple Newton failed to do.

An important step in the new product development process is product design (Urban and Hauser 1993). When designing new products, the goal is to endow the product with physical and psychological attributes that will lead to success in the marketplace (Oakley 1990; Urban and Hauser 1993). This dissertation examines one way in which the design process can be managed to generate product designs that will appeal to the customer. In particular, it focuses on visual mental imagery, one of the central cognitive inputs into the design process (Lorenz 1990; Roozenburg and Eekels 1995). The design literature (c.f., Dym 1994; French 1994) indicates that product designers are encouraged to use visual mental imagery when developing a new design(s), with design courses explicitly training them in visualization. Downing (1992a) notes, however, that “…very little research has been conducted that directly explores the nature of the mental image and the implications for its use in design (p.442).” This research outlines a conceptual framework that enhances the understanding of the role of visual mental imagery in the design process. It provides insights on how visual mental imagery can be used as a design tool to facilitate the creation of product designs that will be successful in the marketplace.

1 The trade press reported word accuracy levels of 70-80% (Orr 1993; Strehlo 1993).
II. Scope of this Research

This dissertation takes as its' starting point the notion that visual mental imagery leads to improved designs, and expands on it in two ways: it proposes a conceptual model for how the type of visual imagery used and the content of the visual imagery can influence the design output. More specifically, it examines the effects on design output of: a) two types of visual mental imagery (memory imagery and imagination imagery), and b) whether or not the content of the imaging process incorporates the target customer.

The distinction between memory and imagination imagery type, long established in the psychology literature (e.g., Perky 1910; Richardson 1969), classifies mental images according to the nature of their composition. It is argued that the choice of imagery type, used during design, has direct implications on the design output. This research also seeks to establish the importance of visualizing the target customer when designing a new product. The marketing discipline has been successful in establishing the importance of bringing customer information into the design process (e.g., Griffin and Hauser 1993; Von Hippel 1978). This knowledge is built upon by demonstrating the importance of focusing the designer on the customer, during the design process, through the visual imagery content he or she utilizes.

As alluded to in the previous section, two factors that impact the customer appeal of a product are the usefulness and originality of the product (Cooper and Kleinschmidt 1987; Song and Parry 1997). As will be shown, the effective management of imagery type and imagery content can foster the
production of product designs that are both useful and original. The resulting effects are shown to
produce customer appeal for the product design.

The scope of this research is constrained by the conditions and setting under which the product
design process is conducted. Foremost is the fact that the product design mission given to designers
will often vary (Bahrami and Dagli 1994). For example, Ulrich and Eppinger (1995) distinguish
between a designer's narrower mission of trying to build a better pneumatic nail tool for fastening
wood aimed at the high end consumer market, versus a broader one of trying to find better ways to
fasten wood together. In this research, the focus is on the former type of design situation where the
designer is asked for a product improvement that will meet the needs of a particular set of customers.
In addition, Bloch (1995; see also Yalch and Brunel 1996) has distinguished between aesthetic
performance goals and functional performance goals in product design. Aesthetic performance in
design refers to the artistic qualities and general appearance of the product. Functional performance in
design involves attributes that relate to the general physical performance of the product. This research
focuses on functional performance.

III. Contributions

From a theoretical perspective, this dissertation extends existing marketing and design
literatures on the role of visual mental imagery in two important ways: first, though prior research in
marketing has acknowledged the distinction between memory and imagination imagery (Childers and
Houston 1983; Ellen and Bone 1991), it has not examined the implications of this distinction. By
showing that these different types of imagery can have a very different impact on the design outcome, the value of this distinction is shown in the context of marketing and design research on new product development. Second, the investigation of customer incorporation during the process of design is new to the marketing and design literatures. Focusing on the customer is central to the marketing concept (e.g., Blattberg and Deighton 1996; Deshpande, Farley, and Webster 1993). As noted earlier, prior research has acknowledged the importance of incorporating information about the customer when designing a product (e.g., Griffin and Hauser 1993; Von Hippel 1978). This basic premise is supported and extended by specifically studying how visualizing the customer during the design process can impact the resulting design output.

This research also provides practical insights for marketing and design practitioners involved in new product design and development. It suggests potential ways in which the new product design process may be managed more effectively. For designers, a better understanding of visualization will create a more effective “design tool” which they can use when faced with new product design problems. For marketers, empirical evidence of the benefit of customer visualization would support their perspective on the importance of the customer. This research validates and potentially expands the role of the marketer in the design process. To visualize the customer effectively, the designer needs relevant insights about customer behavior, which the marketer can provide.
IV. Organization of this Document

The remainder of this document is organized into nine chapters. Chapter Two provides a review of the psychology literature, developing a working definition of visual mental imagery and establishing the importance of the distinction of imagery type. Chapter Three discusses product design and highlights the importance of the customer in the product design process. Chapter Four explores the relationship of customer incorporation in the visualization and the type of imagery used in design, and develops hypotheses regarding possible effects of these factors. Chapter Five goes on to report the results of four pretest studies, while chapter Six presents the research method used in the main study to test the hypotheses presented in chapter four. Chapter Seven reviews the findings of the main study. Chapter Eight describes a follow-up study that tests the generalizability of the results obtained in the main study. Chapter Nine concludes with a discussion of the research findings, implications for marketing theory and marketing practice, limitations of the research, and directions for future investigation.
CHAPTER TWO
VISUAL MENTAL IMAGERY

In this chapter, the literature on visual mental imagery is reviewed with a view towards understanding what visual mental imagery is and how it has been studied in the psychology, marketing, and design literatures. First, visual mental imagery is defined. Second, the study of visual mental imagery in marketing is reviewed. Third, the importance of visual mental imagery to the design process is reviewed in an examination of the design literature. The need for a better understanding of this relationship is also established. In the final section of the chapter, a distinction is made between two types of imagery -- imagination and memory imagery -- on the basis of the psychology literature, and the value of this distinction is highlighted.

I. Visual Mental Imagery Defined

The role of imagery in meaning and memory was first identified by early Greek philosophers and writers (Paivio 1971). Examples of this early theoretical development include Plato’s wax tablet model of memory which asserted that images are copies of perceptions and thoughts, and Simononides discovery of imagery’s role in mediational mnemonic techniques (Morris and Hampson 1983). Despite this early interest in imagery, it was not until the latter part of the nineteenth century that systematic study of mental imagery began. Researchers during this period (e.g., Galton 1883; Kulpe 1893) sought to define imagery as a cognitive process, and through introspective techniques, validate its existence
and identify individual differences in the ability to experience it. At this point in time, the imagery phenomenon was construed to be a consciously-experienced mental process, with distinctions drawn in terms of sensory modality (i.e., visual, auditory, kinaesthetic) of the image as revealed by introspection (Galton 1883).

Criticisms of initial work in mental imagery (e.g., Watson 1913) and the rise in behaviorist approaches to psychology resulted in a decline in imagery research and theoretical development during the early part of the twentieth century. It was not until authors like Miller, Galanter, and Pribram (1960) made a strong case for cognitive psychology that the “period of behaviourist induced scepticism” (Cooper and Shepard 1973, p.1) was dismissed in favour of a more open environment that facilitated imagery research. McKellar (1957), Richardson (1969), and Paivio (1971) were among the first to renew a systematic approach to imagery research. During this period visual mental imagery was defined to be a “quasi-sensory or quasi-perceptual experience, of which an individual is self-consciously aware, which exists in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts” (Richardson 1969, p. 2). These early authors affirmed that mental imagery was worth investigating, suggested methods by which imagery could be studied, and provided initial theoretic positions concerning the role of images in cognitive processing.

Today, mental imagery is recognized as a “basic form of cognition that plays a central role in many human activities - ranging from navigation, to memory, to creative problem solving” (Kosslyn 1994, p. 1). Imagery research has fostered theoretical and empirical progress in two distinct research directions (Kaufmann and Helstrup 1993). The first of these research paths is concerned with the
nature of the imagery construct. Research in this domain is concerned with understanding the composition of mental imagery and determining the processes involved in imaging and how they interact. Classification schemes for different imagery experiences (e.g., Richardson 1969; Cornoldi, De Beni, and Pra Baldi 1989), models of the general mechanics of the imagery process (e.g., Kosslyn 1980; 1994), neuropsychological research in image generation (e.g., Tippett 1992), and investigation of individual differences in imagery processes (e.g., Richardson 1994) are representative of this research track. The second research direction is concerned with the function of imagery. The functional role of imagery involves understanding the role and conditions under which imagery is involved in learning, memory, thinking, problem solving, and other cognitive processes. Paivio’s (1971; 1986) dual coding approach to mental representation, models of imagery and problem solving (e.g., Morris and Hampson 1983), and the function of imagery in affective processes (e.g., Singer and Pope 1978) are good examples of work in this area.

In this dissertation, the adopted definition of visual mental imagery follows the accepted psychological interpretation of this cognitive phenomenon. Visual mental images are functional, quasi-pictorial representations, the special properties of which can impact cognitive processing. Visual mental imagery enables the generation, interpretation, and manipulation of information through spatial representation (Kosslyn 1994). Effectively, visual mental imagery can be described as “seeing in pictures” and can be metaphorically compared to seeing with a “mind’s eye”. To get an intuitive feel for what mental imagery involves, Kosslyn (1980) suggests thinking about the shape of a German Shepard’s ears. In completing this cognitive task most individuals report that they picture a dog’s head
and “look at” its ears to assess the shape (see Kosslyn 1980 for an excellent discussion of mental imagery).

II. Visual Mental Imagery in Marketing

The concept of visual mental imagery was first introduced to the field of marketing as an information process utilized by consumers in an advertising context. Lutz and Lutz (1978; see also Childers and Houston 1983; Rossiter and Percy 1980) introduced the imagery paradigm to consumer research and outlined how imagery would impact the consumer in an advertising context. Empirical work (e.g., Alesandrini and Sheikh 1983; Childers and Houston 1984; Edell and Staelin 1983; Lutz and Lutz 1977; Rossiter and Percy 1980) showed that consumers experiencing imagery from an advertisement would show significantly higher rates of recall for the advertisement and would have a more positive attitude towards the ad. Early research also investigated individual differences in consumer information processing. Childers, Houston, and Heckler (1985) developed the style of processing (SOP) scale that indicates the preference of individuals for adopting visual versus verbal information processing styles.

In a seminal article, MacInnis and Price (1987) provided order and structure to the study of mental imagery in marketing. The authors defined mental imagery to be a “process by which sensory information is represented in working memory” (MacInnis and Price 1987, p. 473) and argued that this processing could vary in the amount of cognitive elaboration experienced. They identified low elaboration imagery processing to include the use of imagery as a mnemonic device and as a tool in
enhancing incidental learning. High elaboration processes include imagery's application to problem framing, its use in problem assessment and consumer satisfaction, imagery's role in purchase timing and intentions, and as a consumption experience in and of itself. The proposed framework (MacInnis and Price 1987) also identified antecedents, moderators, and consequences of imagery processing.

Subsequent research in imagery processing, in a marketing context, has been guided by the proposed framework and research directions identified by MacInnis and Price (1987). Unnava and Burnkrant (1991) investigated the interaction between concrete words and pictures in imagery processing and interpreted their impact on recall. They found that pictures enhance recall only when accompanying verbal information is not concrete. Bone and Ellen (1992; see also Bone and Ellen 1990) investigated the importance of content in imagery and how it affects attitudes and behavioral intentions. They show that the focal character and the plausibility of the imagined scene influence the degree of imagery evoked by an advertising message. The focal character of the evoked imagery is also shown to impact attitude towards the advertisement. Unnava, Agarwal, and Haugtvedt (1996) investigated the competition for mental resources between perception and imaging on the recall of advertising information. Other recent research efforts have investigated the importance of imagery processing in new product advertising (Oliver, Robertson, and Mitchell 1993), measurement of communication evoked imagery (Ellen and Bone 1991), consumer inferences about missing information in advertising (Smith 1991), shopping planning (Gould 1990), and whether advertising is processed by attribute or by brand characteristics (McGill and Anand 1988).
Applications of mental imagery processing in marketing has been primarily confined to cognitive processing in an advertising context. A modest suggestion to move imagery processing theory outside an advertising context has been made by a few authors (e.g., MacInnis and Price 1987), but little theoretical development and no empirical work has been directed towards this proposition. This dissertation seeks to expand the role of mental imagery theory in a marketing context by assessing its role in product design. Recently, marketing researchers have recognized the importance of marketing principles in product design and the new product development process, and have expressed a need for more research in this area (e.g., Bloch 1995; Wind and Mahajan 1997). As the next section highlights, visual mental imagery plays an important role in the design process, though a complete understanding of its potential in design is lacking. One of the contributions of this research is the extension of marketing visual mental imagery investigation into a product design context.

Imagery research in marketing has also largely focused on differences between imagery and non-imagery forms of mental processing. Little attention has been given to potential differences found in imagery processing itself. This dissertation investigates the importance of both the type and the content of visualization used during imagery processing. As will be seen in subsequent chapters, the type of visual imagery utilized and the content of the imagery invoked can be instrumental in producing product designs that appeal to the consumer.
III. Visual Mental Imagery in Product Design

In the product design literature, the identification of visual mental imagery as a technique that facilitates design has been made in a number of contexts. Textbooks addressing product design engineering (e.g., Dym 1994; French 1994) identify the importance of thinking visually during design tasks and advocate training with visual thinking techniques. In their text on product design methodology, Roozenburg and Eekels (1995) indicate that solutions to design problems are typically tried out in the mind - not in reality. Designers form mental images of a design and its effects and then evaluate those effects. Similarly, in the industrial product design literature, Lorenz (1990; see also Moggridge 1993) notes that the “skill of visualization is most frequently used by the industrial designer to synthesize other people’s ideas, and in particular to provide concreteness to marketing and engineering concepts” (p. 24). The facilitative use of mental imagery in the design process has also been identified in studies of invention heuristics for new products (e.g., Weber, Moder, and Solie 1990).

Evidence of the use of mental imagery in the design process extends beyond an engineering and industrial product design context. For example, the artistic design literature (Cheatham, Cheatham, and Haler 1983) identifies the importance of exploring design ideas visually through the use of two-dimensional and three-dimensional images. In addition, general discussions of architectural design (e.g., Akin 1986; Downing and Hubka 1979; Goldschmidt 1991) identify visual mental imagery as an important cognitive technique that facilitates the architectural design process. Downing (1987; 1992a; 1992b) develops the notion of using imagery in architectural design by promoting the idea of an “image
bank" that each architect has and draws upon when generating design ideas. He defines the image bank to be “the accumulation of an architectural designer’s mental imagery of memorable past place experiences” (Downing 1992a, p. 441).

Despite the relationship recognized between visual mental imagery and design processing, little research has been explicitly conducted to determine precisely how imagery facilitates design and how this putative facilitation can be managed (Chandrasekaran 1990). More generally, Roozenburg and Eekels (1995) indicate that an evaluation of the effectiveness of design methods and processes have scarcely been made. This dissertation seeks to address these deficiencies by investigating the relationship between visual mental imagery and design activities. Specifically, it introduces marketing and psychological perspectives to shed new light on the form and content of mental imagery used in product design, thereby facilitating the use of this form of cognition in design.

IV. The Importance of Imagery Type

The identification of differing types of visual mental imagery has a rich research tradition in psychology. Early authors sought to define a variety of imagery experiences according to the general conditions of their occurrence and through the content of their manifestations (e.g., Jaensch 1930; Ogden 1913). An important distinction articulated in this early research was the distinction between images based in imagination and images based in memory (Hicks 1924; Ogden 1913; Perky 1910). Memory images refer to events or occasions that one has personally experienced or observed (Perky 1910). An example of a visual memory image is the creation of a visual image of the contents of the
breakfast one ate yesterday. An imagination image differs from a memory image in that, instead of recalling a past experience for the image, the creation of a new, never before experienced event is constructed (Perky 1910). For example, a breakfast visual image could be imagined in which the contents of the breakfast were all colored blue. Note that the imagination image also relies on past memory (i.e., breakfast and the color blue), but it recombines these memory images in a new and previously unseen way.

The distinction between memory imagery and imagination imagery is reflected in more recent taxonomies of visual mental imagery. Richardson (1969; 1983; see also Holt 1972) identifies memory and imagination images as two of the four central classes of imagery type. Likewise, Horowitz (1970; 1983) uses a memory and imagination image distinction in his proposed imagery classification structure. Paralleling earlier research, memory imagery is described as a recollection of past experience that is always plausible and often autobiographical in nature (Horowitz 1983; Morris and Hampson 1983; Richardson 1969). Imagination images are described as a construction of past experience that is recombined to form a new construct that has not previously been perceived (Horowitz 1983; Morris and Hampson 1983; Richardson 1969). Recently, Kosslyn (1994) provided support for the memory-imagination imagery distinction in his discussion of image generation. He suggested that images are generated through either a direct recollection of previously seen objects or events, or a rearrangement of memory components into a novel pattern. These two forms of image generation are synonymous with the definitions of memory imagery and imagination imagery.

2 The other two identified imagery types are after-images (images that immediately follow and replicate actual sensory stimulation) and eidetic (vivid perception-like images that differ from after-images by persisting for a longer period of time).
The differences between memory and imagination imagery, while conceptually distinct, represent the extreme positions imagery type can sustain. Morris and Hampson (1983; see also McKellar 1957) suggest that memory images and imagination images form the ends of an imagery continuum rather than distinct types of images. They argue that most memory images represent some form of reconstruction rather than an accurate reproduction of a remembered scene. Likewise, as indicated previously, imagination images are dependent on remembered experience and are not isolated in their generation. Visual mental images, at some level, utilize aspects of both imagination and memory in their formation (Morris and Hampson 1983).

Differentiating between types of imagery has been found to be important in problem-solving (e.g., Adeyemo 1990; 1994), learning (e.g., Levin, Ghatala, DeRose, and Makoid 1977), mood and affect (e.g., Richardson and Taylor 1982; Vrana and Lang 1990), and neuropsychology (e.g., Chen 1991). Surprisingly, little attention to an imagery type distinction has been made in either the marketing or design literature. In marketing, some scholars (Burns, Biswas, and Babin 1993; Childers and Houston 1983; Ellen and Bone 1991) have referenced Richardson’s (1969) taxonomy of types of imagery from the psychological literature. However, their empirical research focuses only on one of these types of imagery, namely memory imagery. In design research, no formal identification of a memory-imagination imagery distinction has been made, although the importance of both memory and imagination in imagery design processing has been articulated (e.g., Downing 1992a; 1992b; Lorenz 1990).
This dissertation argues that a distinction between the use of imagination imagery and memory imagery is important in a product design context. As noted above, by definition, imagination imagery is novel, as it involves the creation of previously unseen images. Previous research in psychology (e.g., Adeyemo 1990) has demonstrated the capacity for imagination imagery to facilitate innovative problem solutions. This capacity would stem from a broadened product design solution space when imagination imagery is used. By contrast, memory imagery is confined to previous experience, and while images based in memory can provide a reference point for design (Downing 1992a), it is argued that an exclusive focus on memory imagery will limit the full potential of visual imagery as a beneficial tool in design. This research contributes to both the marketing and design literature by identifying this type distinction, and as will be seen, by showing its relevance to the effective interaction of marketing and design principles in producing appealing new products. In the next chapter, we expand on our thesis by examining the process of product design more closely, and by investigating the importance of the customer to successful product design.
CHAPTER THREE
PRODUCT DESIGN

The literature reviewed in the second chapter defined visual mental imagery and indicated its importance as a cognitive process in product design. The third chapter builds on this established relationship by providing a better background of what product design is and why it is relevant to marketing researchers. This chapter first seeks to define the design process and identify what aspects are central to this research. The second section of the chapter identifies the importance of the customer in the design process and traces the history and evolution of the application of marketing principles in design. The chapter concludes with a discussion of what factors lead to successful product design and an identification of the constructs used in this research to evaluate product design success.

I. The Design Process

The systematic study of the design process, across all design disciplines, was first addressed in the design methodology movement of the early sixties (Goel and Pirolli 1992). This research attempted to understand the commonalties among the various design professions (e.g., architecture, engineering, industrial design, urban design), and develop systematic methods and tools to assist the design professional (Cross 1984). A direct result of these efforts was a better understanding of the core components of the design process that are characteristic in all design scenarios. These components can be described as analysis, synthesis, and evaluation (Asimow 1962; Luckman 1967;
Markus et al. 1972). Bahrami and Dagli (1994) explain these identified components as follows: “analysis refers to the defining and understanding the “whats” that must be translated by the designer into an explicit statement of functional requirements (goals)” (p. 12). An example of this stage is the collection and interpretation of market research data that defines the specific product needs of the customer. “The synthesis component involves finding the feasible solution among derived alternatives” (p. 12). An example of synthesis is a design team’s development process in producing a product prototype that attempts to meet design goals. Finally, “the evaluation phase is concerned with assessing the validity of the solutions relative to the original functional requirements” (p. 12). For example, in the evaluation phase, one might undertake a focus group to obtain feedback. These basic phases of design form a cyclical loop that revises and improves through iteration until an appropriate solution is obtained. Coyne et al. (1990) argue that these three phases of design form the basis of the framework for design activity and coincide with many types of design methodologies, design principles, and specific discipline based design theories.

The design process has often been linked to problem solving theory (e.g., Coyne et al. 1990; Mitchell 1990; Newell 1973). Design is seen as a problem solving process of searching through a problem state space, where the differing states represent differing design solutions (Newell 1973; Simon 1969). The design problem space is defined by the goals and constraints specific to each design situation. For example, in product design, functional performance goals, stipulated by the consumer, provide definition to potential and appropriate solution states that constitute the design problem space. The basic design components, identified above, reflect the problem solving approach (Coyne et al.
The analysis stage of design involves defining the problem space according to specified goals and constraints. Design synthesis involves searching the constructed design problem space for a feasible solution. The evaluation component of design is the test of appropriateness assigned to each potential solution. As will be seen, visual mental imagery can be managed as an effective tool in navigating the solution space for product design problems.

Formal models of "product" design have much in common with both the generic component model of design and problem solving theory. A number of authors (e.g., French 1985; Hubka 1989; Pahl and Beitz 1986; Pugh 1961; Ullman 1992; Ulrich and Eppinger 1995) have outlined specific models that incorporate the core design components in a product design context. For example, Pahl and Beitz (1986; see Figure 3-1) describe the phases of product design as: clarification of the task, conceptual design, embodiment design, and detail design. Clarification of the task involves discovering and defining the design problem. The completion of this phase results in a design specification that defines the functions and properties that are required for the new product, as well as the constraints placed upon the solution and design process itself. Design synthesis is fulfilled through the conceptual and embodiment phases. Conceptual design involves the development of broad solutions, called concepts, that meet the design specifications. Embodiment design is the elaboration of a chosen concept into a definitive design. It involves the continual refinement of the concept. Finally, detail design completes the process by achieving a fully specified product through production, assembly, testing, and evaluation. It is important to note that in models of product design, the stages and phases
articulated do not necessarily follow rigidly one after the other. They are often carried out iteratively, with the problem solving process continually being applied throughout the design cycle.

In this dissertation, the focus is on the synthesis component of the design process. Specifically, this research is centered in the concept generation stage of product design. Noted above, this stage is concerned with exploring thoroughly the solution space of product concepts that may be applied to successfully meet the outlined customer specifications. Concept design includes a mix of external search, creative problem solving, and systematic exploration of various solution fragments (Ulrich and Eppinger 1995). The result of this activity is an approximate description of the technology, working principles, and form of the product. Usually, when completing the concept design stage of a product design problem, a set of 10 to 20 concepts are developed, each typically represented by a sketch and brief descriptive text. Concept design is commonly seen to be one of the most important phases of the design process because the decisions made at this stage strongly bear upon all subsequent phases of product design (Roozenburg and Eekels 1995).

The creative problem solving that is a central part of the idea generation in conceptual design provides a good opportunity to understand the role and potential of visual mental imagery in the design process. Previous research (e.g., Lorenz 1990) has indicated that visualization is an important part of conceptual design. In fact, Roozenburg and Eekels (1995) note that the potential solutions developed during conceptual design are evaluated in the mind by forming images of the product idea. This research seeks to build on this understanding by clarifying what types of imagery and what visualization strategies are most conducive to realizing success at this stage of the product design process.
II. Product Design and the Customer

Over the past decade, the study of issues involving product design and the customer have received increased attention from marketing researchers. These efforts can be divided into two distinct research streams. The first involves consumer response to the exterior form of a product’s design (e.g., Bloch 1995), i.e., its aesthetic aspects. The second stream involves understanding the customer’s functional wants and needs and effectively communicating these interests during the design process (e.g., Griffin and Hauser 1993).

Consumer response to those aspects of a product that relate specifically to its design has been identified as an important factor in consumer purchase behavior. Recently, Bloch (1995) introduced a conceptual model and several propositions that describe how the exterior form of a product relates to consumers’ psychological and behavioral responses. Model components include product form development, consumers’ cognitive and affective responses, and consumer behavioral responses to the product form. Bloch (1995) develops propositions from his proposed structure and identifies potential managerial implications. Bruce and Whitehead (1988) also investigate the role of product design in consumer purchase behavior. They show how product design can act as a strategic tool in facilitating desired consumer responses. Other authors (e.g., Veryzer 1993; Yalch and Brunel 1996) have sought to define specific characteristics of the product design and consumer response relationship. The effect of visual attributes and consumer characteristics on consumer judgements of product design attractiveness (Eckman and Wagner 1994), aesthetics and product preference (Veryzer 1993), and
need hierarchies in consumer judgements of product design (Yalch and Brunel 1996) have been investigated.

The second research stream that links product design and the customer has been concerned with the effective involvement of the customer and use of the customer information in the initial stages of the design process. This body of research has emphasized that the central role of marketing in the design process is to provide an understanding of the customer for the designer (e.g., Urban and Hauser 1993). Traditionally, marketing's involvement has focused on finding out the target customers' needs and wants (Bailetti and Litva 1995). These needs and wants form customer requirements which in turn define the goals and direction of the new product development. More recently, marketing researchers have articulated new approaches to better use customer information and thereby bring the customer more fully into the design process.

One of the first suggestions for more active customer involvement in the design process was Von Hippel's (1978) customer-active paradigm. In the context of industrial products, Von Hippel introduced the idea that customers can play an important role in the new product development process by being an instigator for new product design. Rather than being a respondent that "speaks only when spoken to," in this paradigm, product design is implemented through a direct request by the customer. The author notes that this type of customer involvement in the new product development process is probably limited to specific types of industrial products.

In later research, Von Hippel (1986; see also Urban and Von Hippel 1988) also identified the importance of identifying and focusing on lead users during product design. Lead users are defined as
“users whose present strong needs will become general in a marketplace months or years in the future” (Von Hippel 1986, p. 791). Since lead users are familiar with conditions which lie in the future for most others, they can serve as a need forecasting laboratory that can provide new product concept and design data. Von Hippel (1986) explores how lead users can be identified, and how their perceptions and preferences can be incorporated into the design process.

Perhaps the most influential customer orientated approach that has been applied to new product design is the design tool known as quality function deployment (QFD). QFD originated in Japan in 1972 and has been used successfully by manufacturing companies world-wide (e.g., Toyota, Xerox). QFD is a kind of conceptual map that brings customer wants in line with engineering abilities (Hauser and Clausing 1988). It provides a means for interfunctional planning and communications. Essentially, QFD uses a visual data-presentation format, composed of four “houses” of data, that both engineers and marketers can understand and act upon (see Figure 3-2). The first house, sometimes called the “house of quality” (see Figure 3-3), links identified customer needs (customer attributes) to engineering measures of product performance (engineering characteristics). The resulting matrix relates a list of the customer attributes, rated by their importance, to the engineering characteristics and abilities (Hunter and Van Landingham 1994). The second house of QFD links the identified design relationships to actions that the company can take. The third and fourth houses link actions to implementation decisions and implementation to product planning respectively. Griffin and Hauser (1993) have traced the ability of QFD and the “house of quality” to give the customer a voice
throughout the design process. They provide practical insights on how to obtain accurate customer attributes and demonstrate the effectiveness of using this algorithm in product design.

The identification of the above approaches are good examples of how marketers have been able to establish the importance of the customer in the design process and bring the customer's needs and wants to the attention of the designer. While this has led to the successful development of many new products, as Bailetti and Litva (1995) note "despite all best efforts, the design process often leads to the introduction of products that do not meet customer expectations," (p. 3). Recently, an editorial in the *Journal of Marketing Research* (Wind and Mahajan 1997) called for new approaches and paradigms that improve the effectiveness of marketing's contribution to new product development. The authors indicate new approaches should involve the customer because centering the design process on the customer increases the likelihood of new product success. This dissertation seeks to highlight and explore a new approach to incorporating the customer in the concept design stage of the product design process.

One possible difficulty in product design, is that when designing products, designers are not always able to incorporate effectively information about the customer. Bailetti and Litva (1995) indicate that when designers receive information about the customer that they deem is inadequate for their purposes, they must supplement this by creating their own insights. Rifkin (1994; see also Leonard and Rayport 1997; March 1994; Nussbaum 1993) has suggested designers can do this by moving towards "empathic design," where the voice of the customer "comes out of understanding users' needs through empathy with their world rather than from what users themselves tell developers
they want" (p. 10). Empathic design promotes customer understanding by trying to see customers interacting with a product in a natural usage environment (Leonard and Rayport 1997).

This research proposes that one potential strategy to increase empathy and understanding of the customer is to incorporate images of them in the content of the visual mental imagery used when designing a product. Incorporating the customer in design imagery refers to the actual imaging of a customer with the product imagery. This form of imaging could involve images of the customer as an "actor": utilizing product prototypes, interacting with specific aspects of a design, or utilizing previous designs that the designer is attempting to build upon. It is reasoned that including images of the customer in the visual mental imagery utilized during the product design process affects the design output. Further, it is proposed that the impact of including the customer in the visualization depends on the type of visual mental imagery invoked. These propositions are developed more fully in Chapter Four.

III. Evaluating Product Design Output

So far, the discussion has focused on major inputs into the design process, the type of visual imagery that is used by the designer (memory vs. imagination) and the content of the imagery (whether or not the customer is incorporated). These inputs into the design process cannot, however, be discussed in isolation. In order to establish a context for their role in product design, it is necessary to provide an understanding of what constitutes a "successful" new design. By developing key
dependent variables, the impact of manipulating imagery type and imagery content, on product design output, can be assessed.

The central goal of the product design process is to create products that appeal to the end-user (Bloch 1995; Kotler and Rath 1984). Research in new product development has highlighted the importance of numerous factors in new product success (i.e., technological synergy, proficiency of product development activities, top management support), but ultimately, success depends on whether the product appeals to the customer and they are willing to purchase it. The question then becomes, what factors does customer appeal depend on?

Cooper and Kleinschmidt (1987; 1990; see also Song and Parry 1997) have identified the importance of creating product advantage to build customer appeal. They indicate that one aspect of product advantage is innovation. Products that are unique and are the first of their kind are more successful in the marketplace. This suggests that products that are original - i.e., ones that provide a degree of difference between new and old - facilitate the creation of customer appeal. This idea is consistent with other research in new product design (e.g., Angelmar 1990). Anecdotes from the trade literature have also indicated the importance of originality in producing customer appeal for products (e.g., Lorenz 1990; Nussbaum 1988; 1993). For example, the Gillette Sensor razor, was a successful new product introduction because it used an innovative design that distinguished it from throw-away blade systems (Nussbaum 1993).

A second important aspect of product advantage is the ability of a new product to meet customer needs by solving customer problems (Cooper and Kleinschmidt 1987). A useful product is
one that provides benefits to the consumer by meeting their needs. The usefulness of a product design to the consumer - i.e., the ability to meet his or her needs and wants - is a critical factor in achieving customer appeal (Cooper and Kleinschmidt 1987; 1990). Product usefulness acts as a summary construct of the criteria (e.g., ease of use) used by a consumer in determining the ability of the product to solve their problems. Identified in Chapter One, the Apple Newton illustrates the importance of product usefulness as it was unsuccessful in the marketplace because it did not successfully solve a customer problem or fill an important need. As a route to increasing customer appeal, the focus in this research is on the influence of the perceived usefulness and originality of a new product design. Figure 3-4 presents a conceptual model of how imagery type and imagery content influence these constructs. In the subsequent chapter, the relationships in the conceptual framework presented are explored, and hypotheses underlying the model are developed.

Given the stage of the product design process studied in this research, measures of usefulness and originality were chosen as the central drivers of customer appeal. At later stages of the new product development process, other variables may also be important in generating customer appeal. For example, Garvin (1984; see also Bralla 1996) has identified a number of attributes (e.g., durability, serviceability, reliability, upgradability, economic cost) that may be important to consumers when purchasing a finished product. The focus of this research, however, is on concept design during new product development, and at this point in the design process only a sketch of the concept is available for evaluation. In the next chapter, hypotheses are developed that link imagery type and imagery content with the resulting usefulness, originality, and customer appeal of a product design.
Figure 3-1

The Product Design Process (Pahl and Beitz Model)

Source: Modified from Roozenburg and Eekels (1995)
Figure 3-2

Linked Houses of Quality Function Deployment

Source: Modified from Hauser and Clausing (1988)
Figure 3-3

The QFD House of Quality

List of customer wants | Customer importance ranking | Relationships of wants and hows
---|---|---
| | | ◇ ○ △

Voice of the customer

List of design hows | Voice of the engineer
---|---

Source: Modified from Hunter and Van Landingham (1994)
Figure 3-4

Conceptual Framework of How Customer Incorporation and Imagery Type Drive Customer Appeal

* The solid lines represent direct relationships. The effects of customer incorporation and imagery type on customer appeal are mediated by usefulness and originality. A dotted line is used to represent this relationship.
CHAPTER FOUR

HYPOTHESES

In the preceding chapters, the conceptual foundation of the proposed research was established. It was argued that visual mental imagery is an important part of the product design process and the potential for this form of cognition in product design has not yet been fully realized. In Chapter Two, the distinction of imagery type was made. Specifically, differences between imagination visual mental imagery and memory visual mental imagery were articulated. In Chapter Three, the importance of the customer to the product design process was documented. A new approach to achieving a customer focus in product design, by incorporating images of the customer in the content of the design visualization, was presented.

In this chapter, a series of hypotheses are outlined that pertain to the effect of two independent variables - imagery type and imagery content - on the dependent variables of interest. The chapter is divided into three sections. In each section, hypotheses drawn from the conceptual framework established in Chapter Three are presented. The first section delineates the effect of imagery type and imagery content on the usefulness of the design output. In the second section, the effect of the manipulated variables on the originality of the product design is hypothesized. In the final section, the customer appeal of a product design is hypothesized to directly result from its usefulness and originality.
I. Design Usefulness

For a new product to achieve usefulness in the eyes of the customer it must successfully meet their needs. As Cooper and Kleinschmidt (1987) note, a new product entering the market must be superior to existing products in meeting customer needs if it is to survive and remain on the market. It is argued that imagination imagery can provide an advantage to the designer in identifying new design approaches that better meet customer needs. Previous research in imagery (e.g., Finke and Slayton 1988; Finke, Ward, and Smith 1992; Roskos-Ewoldsen 1993) indicates that imagination and its playful imagery manipulations are likely to lead to a numerically large and more diverse set of images as solutions to design problems. Finke, Ward, and Smith (1992) indicate that imagination imagery, through what they describe as creative cognition, provides a medium for the detection of unexpected relations, the possibility of realizing new interpretations, and the testing of numerous image combinations.

The positive benefits provided by using imagination imagery may, however, be mitigated by the potential danger of losing the interests of the customer during visualization. Logically, the freedom provided by imagination imagery may lead to “flights of fantasy” and result in new approaches that have no relevance to the consumer. It is argued that the manipulation of imagery content can provide an appropriate constraint that ensures the benefits provided by imagination imagery while still retaining a focus on the customer.

Simply stated, by actually putting images of the customer into the content of the design process imagery, one can ensure that all design activity remains centered on the customer. Previous discussions
of customer involvement in design (e.g., Bailetti and Litva 1995; Palmiter et al. 1994) have indicated a need for designers to "keep the customer in their thoughts as they design ... the product," (Palmiter et al. 1994, p.129). Including the customer in the imagination imagery will constrain the large solution space provided by imagination imagery. It brings realism by providing relevant boundaries and guidelines that focus the designer's imagination. The resulting design process is better able to fulfil customer requirements and create a product that is useful and appealing to the end-user (Bailetti and Litva 1995).

It is anticipated that incorporating the customer in memory imagery will have less of a beneficial effect. Previous research in design has shown that relying on memory during the design process may lead to sub-optimal outcomes (Jansson and Smith 1991; Purcell, Gero, Edwards, and Matka 1994; see also Smith, Ward, and Schumacher 1993). Jansson and Smith (1991) asked subjects to come up with new product designs, giving subjects, in what they called the fixation group, some example solutions. They found that, relative to the control group, those given example solutions tended to fixate on the examples and stuck closely to them in the designs they came up with. It is expected that memory forms of visual mental imagery will create a fixation point. Including images of the customer in what is already a more constrained solution space, should have less of an effect on the usefulness of the design output.

Additionally, designs in the marketplace are likely to have at least some usefulness, or they would not likely be on the market. Hence, even without instructions to visualize the customer, the product designs retrieved by designers from memory are likely to have some customer utility, thus
reducing the scope for improvement through customer incorporation in the visualization. This, of course, would be more true for established products that have been in the marketplace for a long time, rather than really new products. In this research, the focus of the design mission is on such a product. It is hypothesized that:

**H1:** Including the customer in imagination visual imagery during the product design process will have a bigger effect on the usefulness of the design produced, than including the customer in memory visual imagery.

**II. Design Originality**

The distinction of imagery type also has implications for the perceived originality of the product design. As discussed above, imagination imagery is likely to lead to a more diverse set of images (e.g., Finke and Slayton 1988; Finke, Ward, and Smith 1992; Roskos-Ewoldsen 1993). The principles of creative cognition indicate that when images are mentally synthesized or transformed, they often end up having properties and characteristics that result in creative discovery (Finke, Ward, and Smith 1992). This should lead to more original designs. Supporting this idea, Adeyemo (1990) showed that in a creative problem solving exercise, the use of imagination imagery led to subjects developing more creative and original solutions to the experimental problem. Other experimental studies have also shown that imaginative visual images benefit and enhance the creative process (e.g., Finke 1990; Isaken, Dorval, and Kaufmann 1991/1992).
By contrast, the dependence of memory imagery on previous experiences constrains playful imagery manipulations and reduces the diversity of images generated and therefore, the originality of design solutions (Jansson and Smith 1991). Further support for this notion is provided by the early research in problem solving (e.g., Adamson 1952; Birch and Rabinowitz 1951; Duncker 1945; Luchins 1942). Experimental research in this area has shown that subjects who use an object, or see it used, in a familiar way are blocked from using that object in a novel way during problem solving tasks. Thus, it is hypothesized that:

H2: When designing a product, the use of imagination visual imagery compared to the use of memory visual imagery, will result in product designs that are more original.

Unfortunately, previous research does not provide a clear picture of how the incorporation of the customer in the visual imagery used in design will affect the originality of the resulting design. Hence, no formal hypotheses regarding this potential relationship is offered, although such effects are examined empirically.

III. Creating Appealing Designs

The central goal of the product design process is to create products that appeal to the end-user (Bloch 1995; Kotler and Rath 1984). According to the conceptualization presented, at the early stages of the product development process, the appeal of a new product will depend on the perceived usefulness and perceived originality of the product design (Cooper and Kleinschmidt 1987; 1990; see Figure 4-1). Products that are useful to the customer, i.e., satisfy their needs, are more appealing
It is therefore expected that the perceived usefulness of a product design will have a direct effect on the appeal generated by the design.

It is argued that, unlike usefulness, originality in isolation does not lead to customer appeal. Products that are original are more liked only if they are useful as well. As the case of Apple Newton, referred to in Chapter One exemplifies, products that are original, but not useful, do not appeal to the customer. Thus, a product that is useful in addition to being original, will be very well liked (Cooper and Kleinschmidt 1987; 1990). Hence, it is expected that the interaction of the usefulness and originality of a product design will have a significant effect on customer appeal. A direct effect of originality on customer appeal is not expected.

The conceptualization also suggests that originality and usefulness, in turn, depend on the type of imagery and whether the customer is incorporated in the visualization (see Figure 4-1, Hypothesis 1, and Hypothesis 2). Given this relationship, one would expect that the interaction of imagery type and customer incorporation would have an effect on customer appeal. Taken together, the above suggests that the customer appeal of a product design depends on the interaction of imagery type and customer incorporation, and this effect is mediated by the usefulness and originality of the design. More specifically:

**H3:** The most appealing designs will be produced when both imagination imagery is used and the customer is incorporated in the imagery.

**H4a:** The effects of imagery type and customer incorporation on customer appeal will be mediated by a direct effect of usefulness.
H4b: The effects of imagery type and customer incorporation on customer appeal will be mediated by an interactive effect of usefulness and originality.
Figure 4-1
Conceptual Framework and Hypotheses of How Customer Incorporation and Imagery Type Drive Customer Appeal

* The solid lines represent direct relationships. The effects of customer incorporation and imagery type on customer appeal are mediated by usefulness and originality. A dotted line is used to represent this relationship.
CHAPTER FIVE
PRETESTS

To assess the hypotheses presented in Chapter Four, an experimental study was planned in which two experimental factors would be manipulated (Chapter Six details the full research methodology). Specifically, these manipulations involved the type of imagery and the content of the imagery (i.e., whether or not the customer was incorporated) used by a designer during product design. In the study, participating designers would receive these manipulations before completing a product design task. Resulting designs would then be evaluated by consumer judges from the target customer segment. Before completing and implementing the experimental design however, it was necessary to address a number of conceptual and methodological issues.

In this chapter, a set of four pretests is described that address these issues. The first pretest examined the nature of visualization in product design and determined the imagery type manipulation. The second pretest dealt with the development of an effective training technique that would ensure customer incorporation in the imagery used during design. The pretest also dealt with the choice of product category to be used. Pretest three sought to determine the appropriate time required to generate a new product idea and prepare a sketch of the idea. The fourth pretest examined the ability of senior citizens to evaluate a large number of designs and the time required for evaluation.
I. Nature of Visualization in Product Design

The purpose of this pretest was three-fold. First, the pretest sought to confirm that designers use visual mental imagery when generating ideas. The design literature (e.g., Roozenburg and Eekels 1995) indicates that designers rely on visual mental imagery when they are producing new designs. The first pretest was used to verify this proposition. Second, the pretest was used to develop the manipulation of imagery type. Instructions that encouraged the designer to rely on images based in memory or images based in imagination were tested for their effectiveness. Finally, the pretest was used to investigate whether designers would spontaneously visualize the customer when designing a product. Before developing a customer incorporation manipulation, it was important to determine the extent of customer visualization that occurred in the absence of instruction that specifically focused the visualization on the customer.

Research Design

The pretest used three separate experimental conditions. Designers in the first condition received no instructions to use visual mental imagery when designing (control condition). Designers in the second condition were instructed to use their memory to create visual images that would assist in creating a new design (memory condition). Designers in the third condition were told to form visual images using their imagination (imagination condition).
Product Designers

Designers participating in the pretest were 27 undergraduate engineering students from the main study population. They had all completed coursework in design fundamentals and were offered $10 for their participation.

Procedure

Participating individually, designers received a written sheet of instructions that asked them to design a clothes drying rack for a young adult. They were told to produce a “thumbnail sketch”\(^3\) of the central aspects of their design idea. After receiving the initial design task, designers received additional instruction according to their assigned condition (designers in the control condition received only the design task.). Those in the memory imagery condition were instructed as follows:

"In solving design problems, many designers find that using past memories to form visual images (pictures in the mind) of potential designs can help them produce innovative and effective designs. Digging deep into your memory and visualizing clothes drying racks that you have previously seen may help in the development of design solutions. In producing your design please try to use this type of visual strategy."

In the imagination imagery condition, designers were given instructions that encouraged them to go beyond previously seen images:

"In solving design problems, many designers find that using imagination to form visual images (pictures in the mind) of potential designs can help them to produce innovative

\(^3\) A “thumbnail sketch” is an industry term for a simple sketch of a design concept (Ulrich and Eppinger 1995).
and effective designs. Using imagery that goes beyond clothes drying racks that you would normally see, can help in the development of design solutions. In producing your design please try to use this type of visual strategy."

The designers were then given 20 minutes to develop their design. After completing the design task, they completed a short questionnaire. They were then debriefed and paid for their participation.

Dependent Variables

The dependent measures were contained in the short questionnaire that designers completed after finishing the design task. The designers were first asked to indicate if they used visual mental images when producing their designs, and if so, to briefly describe the images they experienced. Next, the designers were asked to indicate to what degree they used visual mental images in producing their design (not very much (1) - very much (5)). They were then asked to indicate to what degree they used images of past memories in producing their design (not very much (1) - very much (5)) and to what degree they used images that went beyond a "normal" drying rack in producing their design (not very much (1) - very much (5)).

Results

As expected, all designers across each of the three experimental conditions indicated that they did use visual mental imagery when completing the design task. Further, the scale measuring the degree to which they used visual imagery provided additional evidence that designers across all three conditions were using visual mental imagery to produce their design idea (F (2, 24) = 1.45, p > .10,
These findings support the idea that visual mental imagery is an important and widely used tool in design.

To assess the effectiveness of the imagery type manipulation, the scale measures investigating memory imagery and imagination imagery use were examined. The use of memory images was shown to be equivalent across both the memory imagery and imagination imagery conditions (t (1, 20) < 1, p > .10, means: memory = 4.08, imagination = 3.90). The use of memory images was expected in both imagination and memory conditions so the equivalence in the usage of memory images is not surprising. Contrasting this result, a difference between conditions in the use of imaginative images was significant. Designers in the imagination condition indicated they relied more on mental pictures that went beyond previously seen drying racks than designers in the memory condition (t (1, 20) = 1.87, p < .05, means: memory = 2.67, imagination = 3.60). This finding verified the manipulation of imagery type would be effective in focusing designers on using either imagination or memory images.

To discern if the designers were visualizing the customer during the design task, the description of the experienced imagery was examined. Across all conditions, only two designers reported using images of the customer. Interestingly, both of these designers were in the imagination imagery condition. The small incidence of customer images adds support for the relevance and validity of a customer incorporation manipulation.
II. Visualizing the Customer during Product Design

The second pretest was conducted to develop the customer incorporation manipulation. The first pretest provided some evidence that designers do not “automatically” visualize the customer when designing. The current pretest sought to replicate this finding and test two separate approaches of encouraging the designer to include the customer in the imagery used in product design. The first approach involved instruction to the designer to include the customer in visualization. The second approach involved a short visualization training exercise that was used in conjunction with instruction to incorporate the customer. The pretest also was used to assess two separate product forms for potential use in the main study. It was important to select a product that had both relevance to the target customer population and that could be translated into an understandable design task.

Research Design

The pretest used a 2 x 3 between subjects factorial design. The first factor consisted of two separate product design tasks. Informal discussions were held with senior consumers (age 60+) to identify products that they had difficulty with, and that they felt could be improved. A car jack and a can opener were two products that were frequently mentioned. These two products represented the two levels of the first factor. The second manipulated factor tested approaches to customer incorporation. Acting as a control, the first level of this factor consisted of no specific instructions to incorporate the customer. The second level of the factor sought to encourage the incorporation of the customer through written instruction. The third level of the factor used a guided imagery training
exercise in conjunction with written instruction to facilitate the incorporation of the customer in the visual imagery used by the designer.

*Product Designers*

Designers participating in the pretest were 31 undergraduate engineering students from the main study population. They had all completed coursework in design fundamentals and were offered $10 for their participation.

*Procedure*

Participating individually, designers received a written sheet of instructions that asked them to produce a product design (car jack or a can opener) for a senior customer (age 60+). Designers were told to produce a “thumbnail sketch” of the central aspects of their design idea. After receiving the design task, designers then received the customer incorporation manipulation. As mentioned above, in the first condition, designers received no instructions to visualize the customer. In the second condition, designers received written instruction as follows:

"A useful strategy in design involves visualizing the potential customer of the product. Seeing in your mind, an elderly person being involved with, and interacting with, the proposed product design can assist the development of the design solution. In producing your design please try to use this visual strategy."

In the third condition, designers received a training exercise before receiving both the design task and the customer visualization instructions. The training exercise utilized a guided imagery procedure (see Appendix A). This involved reading a short story about a young adult putting together
a new TV stand. As the designers read the short story, they were instructed to stop after reading each sentence in the story and try to picture in their minds the events they had just read about. The training exercise took approximately 5 minutes to complete.

It is important to note that the training exercise involved a customer segment that differed significantly from the target customer segment of the design task. A different customer segment was chosen for the training exercise to ensure that experimental conditions that received training did not have an unfair advantage over other conditions. The training task simply created a better awareness for the designer of what “visualizing a customer” could involve.

In all conditions, designers were given 20 minutes to develop their design. After completing the design task, they filled out a short questionnaire. They were then debriefed and paid for their participation.

Dependent Variables

The designers were asked to describe the visual mental images they used when producing their designs. The cognitive responses provided by the designers were coded by the experimenter. Coding consisted of identifying the number of distinctly different images involving the customer that the designer utilized during the design process. The experimenter also examined the general nature and completeness of the designs to assess the ability of the designer to comprehend the design task instructions. Additionally, during debriefing, designers were asked to indicate their feelings about the ease and clarity of the product design task.
Results

The mean scores of the number of customer images used by the designer, for each of the experimental conditions, are presented in Table 5-1. Analysis of variance of the customer image scores indicated a marginal main effect for the customer focus manipulation (F (2, 25) = 3.13, p < .10, means: no instruction = 0.5, instruction = 1.45, instruction and training = 1.65). None of the other effects reached statistical significance (see Table 5-2). Given the small sample size, the marginal main effect provides reasonable support for the success of the customer focus manipulations. The addition of the training segment to customer incorporation instructions resulted in a slight increase in the number of customer images, though the difference was not significant. The effect of the customer incorporation manipulations was consistent across both product design tasks.

The resulting designs, produced by the designers, were examined for their completeness and clarity. Across both product conditions, designers were able to complete a design of the assigned product and these designs were legible and recognizable. Designs for the car jack design task, however, showed greater variability in design outcomes. Discussion with designers during debriefing supported this observation. Designers in the car jack condition indicated that they found a large number of options available to them when completing the design task. Designers in both conditions found their respective design tasks easy to understand and complete. Given favorable designer response, and the larger number of design outcomes possible, the car jack design task was selected for the main study.
III. The Impact of Time on Product Design

The third pretest was used to determine the appropriate amount of time required by designers to complete the design task. Previous experimental work in the design literature (e.g., Jansson and Smith 1991; Shah, Nico, and Kraver 1993) that has used timed design tasks has employed a range of time periods. Three different time periods were selected for testing. It was important that the selected period provide the designer sufficient time to realize the visualization manipulation and fully develop a design idea.

Research Design

The pretest used three separate experimental conditions. Designers in the first condition were told they had up to fifteen minutes to complete the design task (15 minute condition). The second condition provided the designer with up to thirty minutes to complete the design task (30 minute condition). In the third condition the designer was given up to forty-five minutes to complete the design task (45 minute condition).

Product Designers

Designers participating in the pretest were 15 undergraduate engineering students from the main study population. They had all completed coursework in design fundamentals and were offered $10 for their participation.

Procedure

Participating individually, designers received a written sheet of instructions that asked them to design a car jack for a senior customer (age 60+). They were told to produce a "thumbnail sketch" of
the central aspects of their design idea. The designers were also randomly given one of the imagery strategies that were to be used in the main study. After receiving the instructions, the designers were given up to 15, 30, or 45 minutes to develop their design, depending on their assigned condition. After completing the design task, they filled out a short questionnaire. They were then debriefed and paid for their participation.

**Dependent Variables**

The dependent measure was contained in the short questionnaire that designers completed after finishing the design task. The questionnaire asked the designers to indicate if they had enough time, too much time, or just the right amount of time to develop images and fulfil the design task. They were also asked to briefly explain their answer. As an additional measure, the experimenter recorded the time taken by the designer to complete the design task.

**Results**

Each of the designers in the fifteen-minute condition indicated they did not have enough time to finish the design task. Representative comments from this condition included: “the time is enough to develop the images, but not enough to fulfil the design task”, “the general idea was developed with the time, but to be a little more specific with the design, one needs more time” and “the general idea was developed with the time, but to be a little more specific with the design, one needs more time”. All designers in this condition used the full fifteen minutes to complete their designs.

In the thirty-minute experimental condition, each of the designers indicated they had sufficient time to complete the design task. Comments from this condition included: “just the right time”, “had
time to consider, draw a diagram, and describe it verbally”, and “I had enough time to fulfil the design task”. Three out of five of the designers in this condition used the full thirty minutes to finish the task and the remaining two designers finished early.

The designers in the forty-five-minute experimental condition varied in their response to the sufficiency of time provided for design task completion. Four out of five of the designers indicated that forty-five minutes to complete the design task was too much time. The remaining designer indicated that the time provided was the right amount. Comments included: “too much time”, “had a pretty clear idea of how it had to work right away”, and “I finished early”. Interestingly, all five of the designers in this condition finished the design task early with the majority finishing before thirty minutes had expired.

Given the results of the pretest, the thirty minute time period was chosen as the time frame for the design task in the main study. The results indicate that thirty minutes is a sufficient period for a designer to produce a thumbnail sketch of a car jack for senior consumers.

IV. Evaluating Product Designs

The fourth pretest was used to determine the feasibility of obtaining evaluation ratings of the produced designs from the target population of the design task. Following the methodology used by Olney, Holbrook, and Batra (1991), customer judges would be asked to evaluate each of the developed designs on one of the dependent variables of interest. Given the age of the target population it was important to discern if judges could rate a total of 140 designs (the number of designs to be
produced in the main study). The pretest also sought to determine what form of instructions and procedural steps would be most effective in facilitating reliable judgements.

**Target Customer Judges**

Judges participating in the pretest were 10 seniors (age 60+) recruited from local senior citizen centers. To participate, judges had to have a valid driver’s license and had to have driven in the past year. They were offered $20 for their participation.

**Procedure**

Participating individually, judges received a book of designs (n = 140) and were randomly assigned to evaluate the designs on one of the dependent variables of interest (originality, usefulness, or customer appeal). Judges were asked to provide an evaluation of each individual design on three, 7-point scale items that have been used in previous research (Andrews and Smith 1996; Besemer and O'Quin 1986; Kardes 1986; Mano and Oliver 1993). The three items composing the originality scale were unique (7) - ordinary (1), original (7) - commonplace (1), and fresh (7) - routine (1). Items for the usefulness scale were useful (7) - useless (1), effective (7) - ineffective (1), and worthwhile (7) - worthless (1). The customer appeal scale was composed of appealing (7) - unappealing (1), likeable (7) - not likeable (1), and desirable (7) - undesirable (1). Scale item ratings were completed in an evaluation booklet. After finishing the ratings exercise, judges were questioned about their experience and the evaluation process. They were then debriefed and paid for their participation.
Dependent Variables

Judges were asked to give their thoughts on the evaluation exercise. Specifically, they were asked if judging the complete set of 140 designs was manageable? Did they feel that they had remained consistent in their judgements across all 140 designs? What would they change about the evaluation process? What was their overall reaction to the experience? Additionally, the experimenter recorded the time taken by the judges to complete the evaluation exercise and visually inspected the evaluation booklets.

Results

The entire sample of judges felt that judging 140 designs on a 3-item scale was a reasonable task. The judges indicated that they felt confident in the reliability of their judgements. They noted that across the entire set of designs there were similar patterns and some replication in the designs. They felt that this made the evaluation task easier and helped maintain consistency in their judgements. The majority of judges indicated that they enjoyed the experience and found it interesting. Specific comments included: “that was interesting, will those designs be made?”, “it was fun”, and “if you need help doing this again just let me know”. The judge’s responses and attitudes suggested that the evaluation of 140 designs was both a feasible and reasonable task to complete.

The judges also provided a number of suggestions to improve the evaluation task. First, some of the judges indicated that it was important to take short breaks when evaluating. They felt that short breaks helped reduce fatigue. Second, some of the judges felt that the instructions and evaluation booklet needed to have a larger font type. A larger font would make instructions and rating scales
clearer and easier to understand. Finally, all of the judges emphasized the importance of having good instructions. They found the design task to be more enjoyable and easier when they had a clear understanding of what was required. Each of these suggestions were implemented in the customer evaluation procedure used in the main study.

Observation by the experimenter indicated that the evaluation task took between one and a half and two hours to complete, including breaks. An inspection of the evaluation booklets indicated that judges had completed the entire exercise and had provided an evaluation for each of the designs. These observations lend support to the conclusions regarding the feasibility of the evaluation task that were made previously.
Table 5-1

Table of Means

Customer Incorporation

<table>
<thead>
<tr>
<th>Product</th>
<th>No Instruction</th>
<th>Instruction</th>
<th>Instruction and Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car jack</td>
<td>0.40</td>
<td>1.50</td>
<td>1.80</td>
</tr>
<tr>
<td>Can opener</td>
<td>0.60</td>
<td>1.40</td>
<td>1.50</td>
</tr>
</tbody>
</table>
Table 5-2

Analysis of Variance for the use of Customer Imagery

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>1</td>
<td>0.34</td>
<td>0.03</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>7.61</td>
<td>3.13*</td>
</tr>
<tr>
<td>Product x Customer incorporation</td>
<td>2</td>
<td>0.32</td>
<td>0.13</td>
</tr>
<tr>
<td>Error</td>
<td>25</td>
<td>30.40</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>30</td>
<td>38.39</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .10 level.
In this chapter, a research study is proposed that evaluates the hypotheses presented in Chapter Four. This chapter has five sections. First, the research design is presented. Second, the participating subjects (designers) are identified and the product to be studied is reviewed. Third, the independent variable manipulations, identified in the preceding chapter, are reviewed. Fourth, the procedure used in the study is described. Fifth, the manipulation checks and dependent variables are identified, and the evaluation process used in their measurement is described.

I. Research Design

The study used a between subjects factorial design that involved the manipulation of two experimental factors: imagery type and customer incorporation in visualization during the design process. There were two levels of imagery type (memory imagery vs. imagination imagery). Since previous research has indicated that it is difficult for the designer to focus on the customer (e.g., Baletti and Litva 1995), two operational manipulations of customer incorporation were used. Thus, there were three levels of customer incorporation (no customer incorporation instruction vs. customer incorporation instruction vs. customer incorporation training and instruction). An additional control condition that received neither the imagery type nor the customer incorporation manipulations was also
included in the design. Thus, the design had 7 cells ((2 imagery type x 3 customer incorporation) + 1 control = 7).

II. Product Designers and Product

*Product Designers*

Designers participating in the study were 140 undergraduate engineering students (see Table 6-1 for a demographic description of participating designers). They had all completed coursework in design fundamentals and were recruited in design engineering classes through announcements offering $10 for participation. Previous research investigating cognitive processes in design suggests that engineering students are a viable sample population for investigation (e.g., Jansson and Smith 1991; Purcell, Gero, Edwards, and Matka 1994).

*Product*

As indicated in the preceding chapter, the product chosen for the design task was a car jack for senior customers (age 60+). Seniors were chosen as the target customer group because they represented a customer population that was distinctly different from the designers. This was done to represent the real life situation where designers are typically designing products for customers different from themselves.
III. Independent Variables

Manipulation of Imagery Type

Visual mental imagery type was manipulated by instructing designers to rely on images based on either imagination or on memory, during the design task. These instructions were developed through the pretesting (see Chapter Five for complete manipulation text). In the memory imagery condition, designers were instructed to "dig deep into their memory" and visualize car jacks that they had previously seen when developing their design solution. In the imagination imagery condition, designers were instructed to "go beyond" car jacks that they would normally see and use other image forms to develop their design solutions.

Manipulation of Customer Incorporation

In the no customer incorporation condition, designers did not receive any instructions to visualize the customer. As mentioned previously, two approaches to encourage customer incorporation during visualization were used. These were developed on the basis of the pretesting described in Chapter Five. In the first approach, designers were instructed to incorporate the customer in their visualization by imaging the customer being involved with and interacting with the proposed product design (see Chapter Five for complete manipulation text).

In the second customer incorporation condition, designers were given a training exercise before receiving either the imagery or customer incorporation instructions. As indicated in Chapter Five, the training exercise (see Appendix A) involved reading a short story about a young adult putting together a new TV stand. To prevent bias, the training exercise used a customer
segment and a product that were different from those used in the actual design task (see Chapter Five). Designers were asked to try to visualize the story as they read. After completing the training exercise, designers were given the appropriate imagery instructions, depending on the condition they had been assigned to, as well as the instructions to visualize the customer in the design task.

Control Group

The control group was not given any instructions to use visual imagery. Given their academic training and the results of the pretesting, it was expected that the designers would spontaneously use visual mental imagery and that this visual imagery would primarily be memory imagery, rather than imagination imagery. If this turned out not to be the case, any differences that might be found between the imagination imagery and memory imagery conditions might be attributed to the memory imagery treatment hurting the production of appealing designs, rather than the imagination treatment encouraging the production of more appealing designs, which is the thesis. A control group provided a way to ensure that the memory manipulation was not a limiting condition that had little relevance and merely set up the designer to fail.

IV. Procedure

Designers participating as subjects were run individually. The group that received the training exercise (customer incorporation with instruction and training) received the training first. Designers in all conditions then received the instructions for the design task. Designers were
asked to design a car jack for elderly adults (age 60+), and were told to produce a "thumbnail sketch" of the central aspects of their design idea. Consistent with industry practice for this stage of the design process, they were told to disregard any constraints (e.g., economic, material, regulatory) as they developed their idea. They were given 30 minutes to develop their design. Pretesting indicated this time frame was appropriate (see Chapter Five). Designers in the control condition proceeded to the actual design task at this point. All the remaining designers received the imagery type (imagination or memory) treatment. One third of the subjects in each of the imagery type conditions, who had been assigned to the no customer incorporation condition, proceeded to the design task. The remaining two thirds received the customer incorporation instructions, followed by the design task. Half of these subjects had received the prior training in customer incorporation noted above. Figure 6-1 provides a procedural flow diagram of the differing experimental conditions. Note that the customer visualization training exercise, which involved visualizing a young customer setting up a TV stand was given before the main task of designing a jack was introduced. This was done to preclude the possibility that during the training period, subjects would be thinking of the design they would later have to do, possibly leading to them having more experience with designing car jacks than those in the other conditions. After completing the design task, designers filled out a short questionnaire. They were then debriefed and paid for their participation.
V. Manipulation Check and Dependent Variable Measures

Manipulation Check Measures

To investigate the success of the manipulations, a short questionnaire containing a number of manipulation checks was completed by the designers (see Appendix B). The questionnaire started with an open-ended measure. The designers were asked to describe any mental pictures they had during the design exercise. These responses were coded and used to check the success of the customer incorporation manipulation. Next, the designers were asked to complete three, 7-point scales that also sought to determine the nature and form of their visualization. Designers were asked how hard they were trying to use visual imagery in producing their design (not very hard (1) - very hard (7)), to what degree they used mental pictures of previously seen car jacks (not very much (1) - very much (7)), and to what degree they used mental pictures that went beyond a "normal" car jack (not very much (1) - very much (7)). Designers then completed an open-ended question that asked what they thought was the purpose of the study. Finally, designers indicated their age, gender, and study major.

Dependent Variable Measures

Target Customer Judges. When designing new products, the goal is to appeal to a potential user. Hence, responses to the dependent measures were obtained from judges belonging to the user segment for whom the product was designed. A sample of elderly judges (age 60+) was recruited from local senior citizen centres (see Table 6-2 for a demographic description of participating judges). As in the pretest, judges participating in the study were required to have a valid driver's license and to have driven a vehicle in the past year. A separate sample of judges
was utilized to evaluate all of the 140 designs created by the designers, for each of the dependent variables of interest (originality n = 14 judges, useful n = 16 judges, appeal n = 12 judges). Separate judges were used for each dependent variable to eliminate shared method variance (see Olney, Holbrook, and Batra 1991).

Pretesting indicated that evaluating the entire set of designs (n = 140) on only one variable was a reasonable task for an individual judge to complete, and took between one and a half and two hours, including breaks (see Chapter Five). Before starting the rating exercise, judges received an instruction sheet that asked them to rate the designs on the assigned variable of interest only. Judges were instructed to omit things like cost, present availability, or the artistic merits of the design from their evaluations (See Appendix C). Twenty booklets were prepared, each with a different random order of the 140 designs. Judges were randomly assigned one of the booklets. Judges were paid $20 for their participation.

**Target Customer Judgements.** The judges were asked to rate each of the car jack designs on the constructs of either originality, usefulness, or appeal. As indicated in Chapter Five, each of these constructs was represented by 3-item, 7-point semantic differential scales drawn from previous research (Andrews and Smith 1996; Besemer and O'Quin 1986; Kardes 1986; Mano and Oliver 1993). The three items composing the originality scale were unique (7) - ordinary (1), original (7) - commonplace (1), and fresh (7) - routine (1). Items for the usefulness scale were useful (7) - useless (1), effective (7) - ineffective (1), and worthwhile (7) - worthless (1). The customer appeal scale was
composed of appealing (7) - unappealing (1), likeable (7) - not likeable (1), and desirable (7) - undesirable (1).
Figure 6-1

Procedure for Differing Experimental Conditions
### Demographics of Product Designers

<table>
<thead>
<tr>
<th>Total Judges</th>
<th>140</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>117</td>
</tr>
<tr>
<td>Female</td>
<td>23</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>19.36</td>
</tr>
<tr>
<td>Std Dev</td>
<td>2.04</td>
</tr>
<tr>
<td>Max</td>
<td>32</td>
</tr>
<tr>
<td>Min</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 6-2

**Elderly Judge Demographics**

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Originality</th>
<th>Usefulness</th>
<th>Appeal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Judges</td>
<td>14</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Female</td>
<td>6</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>70.08</td>
<td>68.75</td>
<td>69.36</td>
</tr>
<tr>
<td>Std Dev</td>
<td>9.34</td>
<td>6.74</td>
<td>5.08</td>
</tr>
<tr>
<td>Max</td>
<td>86</td>
<td>84</td>
<td>78</td>
</tr>
<tr>
<td>Min</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>
CHAPTER SEVEN

RESULTS

In this chapter, the results of the study described in Chapter Six are presented. The chapter consists of two sections. The first section deals with preliminary analyses. Manipulation checks for the study, the reliability and validity of the consumer judgements, and the relationship of the control group to the other experimental conditions are discussed. In the second section, tests of the hypotheses presented in Chapter Four are conducted.

I. Preliminary Analyses

Manipulation Checks

Designers' responses to scales assessing the form and nature of the visual mental imagery used during the design task were examined. The type of imagery utilized during the design process was examined with a scale measure of memory image usage and a scale measure of imagination image usage. The memory image usage scale assessed to what degree the designer experienced mental pictures of previously seen car jacks. As noted earlier, since memory would be involved in the memory and the imagination conditions, significant differences between these conditions on the memory image usage scale was not expected. A two-way ANOVA with imagery type and customer incorporation as the two independent factors showed that there was no significant main effect for imagery type (F (1,
Contrasting this result, a two-way ANOVA for the imagination image usage scale, with imagery type and customer incorporation as the two independent factors, revealed only a main effect for imagery type, with those in the imagination condition using imaginative images to a greater extent ($F(1, 134) = 8.17, p < .01$, means: memory = 4.30 and imagination = 5.11, see Table 7.2). For both of these scale measures, the control condition was not significantly different from the memory condition (memory use scale: $F(1, 138) = 1.74, p > .10$, means: memory = 5.13 and control = 4.5; imagination use scale: $F(1, 138) < 1$, means: memory = 4.30 and control = 3.90).

The open-ended responses that provided a description of the visual images that the designers used during the design exercise were examined to assess the success of the customer incorporation manipulation. Designers were asked to describe any mental pictures that they had, had during the design exercise. Coding of the cognitive responses was completed by a research assistant blind to the experimental conditions and hypotheses. Coding consisted of identifying the number of distinctly different images involving the customer, that the designer utilized during the design process. As expected, a two-way ANOVA indicated a significant main effect for the customer incorporation manipulation ($F(2, 130) = 30.37, p < .001$). None of the other effects reached statistical significance (see Table 7-3). The designers that received no instructions to incorporate the customer used fewer images of the customer ($mean = 0.59$) than those in the customer incorporation conditions: the number of images used in the customer incorporation instruction condition was 1.50 and was even higher in the

---

* For the ANOVAs and planned contrasts, to obtain a better estimate of within cell error, data from the control condition in addition to the data from the six experimental conditions is used (Keppel 1991). Using the error term from just the 6 experimental conditions does not substantively change the results.
condition in which both instructions and training (mean = 2.69) were used (contrasts: no instructions vs. instruction, F (1, 134) = 10.12, p < .01, instruction vs. instruction plus training, F (1, 134) = 17.31, p < .001). The control condition did not significantly differ from the condition that received no instructions to incorporate the customer (F (1, 134) < 1, means: no instructions = 0.59 and control = .60).

It was also considered important to establish that the designers across all conditions made an equal effort on the visualization task. The two-way ANOVA on the scale assessing how hard the designers tried to use imagery indicated there were no significant differences across the experimental conditions (see Table 7-4). Additionally, the control condition did not differ from the manipulated conditions in effort to visualize (F (1, 138) < 1, means: manipulated conditions = 4.64 and control = 5.05).

Finally, designers' responses to the question related to the perceived purpose of the study were examined. No designers were aware of the experimental hypotheses, and none suspected that the study had anything to do with differences in the nature of visualization during the design process.

*Reliability Assessment of Judge's Ratings*

Coefficient alpha was utilized to assess the reliability of the ratings produced by the consumer judges. This analysis was conducted to ensure that the judges provided consistent and dependable evaluations of the car jack designs across each of the scale items. Following Olney, Holbrook, and Batra (1991), reliability was assessed for individual items across judges, scale indices within judges,
within-judge scale indices across all judges, and the aggregate scale index composed of the mean of all judges on each item.

The alphas for single-item interjudge reliability on each of the 9 scale items were .70 for fresh, likeable, desirable, and appealing, .71 for unique, .74 for original, and .77 for useful, effective, and worthwhile (see Table 7-5). Scale indices for each of the forty-two individual judges ranged from .75 to 1.00 (see Table 7-6). The index formed by summing the 3-scale items for each construct within each judge and then calculating the interjudge reliability on that sum produced reliabilities of .75 for original, .78 for useful, and .71 for appeal. Finally, the aggregate scale index composed of the average of the scale indices across all the judges was .98 for the three original items, 1.00 for the three usefulness items, and .99 for the three appeal items. The averaged multi-item indices benefit from the variance-reducing tendencies inherent in taking averages of averages (Olney, Holbrook, and Batra 1991).

As a check on the structure of the three construct measures, the mean scores across the judges for each of the nine items that make up the three constructs were subjected to principal component analysis, followed by varimax rotation (see Table 7-7). The items measuring appeal, “appealing,” “likeable,” and “desirable,” loaded on one factor (appeal: loadings = .94, .95, .95). The items measuring originality, “unique,” “original,” and “fresh,” loaded on a second factor (original: loadings = .97, .96, .96). The items measuring usefulness, “useful,” “effective,” and “worthwhile,” loaded on a third factor (usefulness: loadings = .92, .91, .91). The three factors accounted for 98% of the variance in the data. Follow-up confirmatory factor analysis revealed that the three factor model provided an
acceptable fit (Bentler-Bonett Normed Fit Index = .964, Comparative Fit Index = .973, $\chi^2 (25) = 99.85, p < .001$), as the fit indices exceeded .90, the benchmark for acceptable fit (Bentler and Bonett 1980). As well, the three-factor model fit the data better than a single factor model (Bentler-Bonett Normed Fit Index = .421, Comparative Fit Index = .423, $\chi^2 (27) = 1629.78, p < .001$), or a two-factor model in which the items for the usefulness and customer appeal constructs were combined to form a single factor (Bentler-Bonett Normed Fit Index = .641, Comparative Fit Index = .645, $\chi^2 (26) = 1010.26, p < .001$). For the test of hypotheses below, the mean score across the three items used to measure each construct was used as the operational measure.

Memory Versus Control

As discussed earlier, it was expected that those in the control condition would spontaneously use primarily memory images rather than imagination images in their visualization. This should result in designs produced being similar to those produced in the memory condition in terms of originality, usefulness, and customer appeal. A series of planned contrasts compared those in the control condition to those in the memory imagery no customer incorporation condition. The results showed that they used the same amount of memory and imagination type images (memory imagery, $F (1, 138) < 1$, means: control = 4.50 and memory = 5.05, imagination imagery $F (1,138) < 1$, means: control = 3.90 and memory = 3.95), and the designs produced did not differ in terms of originality ($F (1, 138) < 1$, means: control = 3.96 and memory = 3.82), usefulness ($F (1, 138) < 1$, means: control = 3.10 and memory = 3.12), and customer appeal ($F (1, 138) < 1$, means: control = 3.32 and memory = 3.27). Thus, the findings with respect to the main hypotheses below are driven by the superiority of giving
explicit instructions/training to use imagination imagery and not because the memory imagery condition
led to a situation in which an artificial constraint was placed on what designers might intuitively do.

II. Test of Hypotheses

In this section, tests of the four hypotheses offered earlier are presented. The mean scores for
each of the dependent variables along with standard deviations and cell sizes are presented in Table 7-8.

_Hypothesis 1: Effect of Customer Incorporation and Imagery Type on Usefulness_

Consistent with the first hypothesis, the ANOVA\(^5\) results for the usefulness variable revealed
an interaction effect (F (2, 134) = 3.03, p < .05, omega square = .032). None of the other effects
reached statistical significance (see Table 7-9). Additionally, a planned contrast indicated that the
designs produced in the imagination imagery customer incorporation conditions were rated as more
useful than the designs produced in the imagination imagery no customer incorporation condition (F (1,
138) = 6.33, p < .01, means: imagination customer incorporation = 3.14 and imagination no customer
incorporation = 2.64). A contrast between those in the memory imagery customer incorporation
conditions and memory imagery no customer incorporation condition was not significant (F (1, 138) <
1, means: memory customer incorporation = 3.02 and memory no customer incorporation = 3.12).
Thus the data are consistent with hypothesis 1: customer incorporation enhanced the usefulness of the

\(^5\) A 2 x 3 ANOVA design was used for all hypotheses.
designs produced more when imagination imagery was used than when memory imagery was used. In fact, including the customer in memory visualization did not significantly change the outcome.

It is also noteworthy that within the imagination imagery customer incorporation conditions, a contrast between those who were trained to incorporate the customer and those who received only instructions to incorporate the customer was significant (F (1, 138) = 3.60, p < .05). As might be expected, those that received instruction and training produced designs that were judged to be the most useful (means: imagination customer incorporation instruction = 2.92 and imagination customer incorporation instruction plus training = 3.35).

**Hypothesis 2: Effect of Imagery Type on Originality**

Hypothesis 2 states that those in the imagination imagery condition would produce more original product designs than those in the memory imagery condition. Consistent with hypothesis 2, the ANOVA results for originality reveal a significant main effect for imagery type (F (1, 134) = 23.35, p < .001, omega square = .159, means: memory imagery 3.81 and imagination imagery = 4.40). None of the other effects reached statistical significance (see Table 7-10).

**Hypothesis 3: Effect of Customer Incorporation and Imagery Type on Appeal**

The ANOVA results for the appeal variable revealed an interaction effect (F (2, 134) = 3.22, p < .05, omega square = .035). None of the other effects reached statistical significance (See Table 7-11). As expected, the designs produced by those in the imagination imagery customer incorporation condition were judged to be the most appealing. The planned contrast between this condition and all of the other experimental conditions combined was significant (F (1, 138) = 11.63, p < .001, means:
imagination customer incorporation = 3.74 and other experimental conditions = 3.19). Thus, hypothesis 3 was supported.

Hypotheses 4a and 4b: The Effect of Usefulness and Originality on Appeal

The interaction effect produced by the manipulations of imagery type and customer incorporation on customer appeal (H3) was hypothesized to be mediated by a main effect of usefulness (H4a) and an interaction between originality and usefulness (H4b). According to Baron and Kenny (1986), three conditions need to be met to infer mediation: First, the independent variables must have a significant effect on the mediator(s) and the ultimate dependent variable. Second, when the effects of the independent variables, on the mediator variable(s), are covaried out, the effects of the independent variables on the dependent variable should either diminish or disappear. Third, the covariate(s) used in the analysis should be significant.

As shown above, the independent variables have significant effects on both the mediators (H1 and H2) and the ultimate dependent variable (H3) (see Figure 7-1). To satisfy the second and third criterion for mediation (Baron and Kenny 1986) an analysis of covariance with imagery type, customer incorporation, their interaction, and the hypothesized mediator variables as the covariates was conducted. When an interaction term is hypothesized as a mediator, as in this case, Aiken and West (1990) recommend that, a) one should incorporate all of the direct effects; in this case it means including the direct effect of originality over and above the hypothesized effects, and b) given that all of the effects have to be included, the mediator variables should be mean centered to reduce

---

6 When done separately, the contrasts between this condition and the other conditions were all significantly different at the .05 level. Moreover, the other conditions did not differ significantly from each other.
multicollinearity. Following their recommendations, the raw usefulness and originality scores were mean centered and the ANCOVA model estimated included the direct effect of usefulness, the direct effect of originality, and their interactive effect as covariates.

Consistent with the criterion proposed by Baron and Kenny (1986), the analysis of covariance revealed that the previously significant interaction effect (F (2, 114) = 3.06, p < .05) of imagery type and customer incorporation on customer appeal disappeared (F (2, 111) = 2.32, p > .10) (see Figure 7-2). Further, usefulness, as a covariate, was significant (F (1,111) = 57.76, p < .001), as was the interactive effect between usefulness and originality, albeit at a p < .10 level (F (1,111) = 2.93, p < .10) (see Figure 7-3). Originality, as a covariate, was not significant (F (1,111) < 1, p > .10). Thus, all three criteria required to infer mediation are met, providing support for both hypotheses 4a and 4b.
Table 7-1

Analysis of Variance for the use of Memory Imagery

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>1.63</td>
<td>0.48</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>14.47</td>
<td>2.12</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>0.47</td>
<td>0.07</td>
</tr>
<tr>
<td>Error</td>
<td>134</td>
<td>455.80</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>139</td>
<td>472.37</td>
<td></td>
</tr>
</tbody>
</table>
Table 7-2

Analysis of Variance for the use of Imagination Imagery

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>19.60</td>
<td>8.17*</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>2.45</td>
<td>0.51</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>12.40</td>
<td>2.58</td>
</tr>
<tr>
<td>Error</td>
<td>134</td>
<td>321.49</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>139</td>
<td>355.94</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .01 level.
Table 7-3

Analysis of Variance for the use of Customer Imagery

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>0.19</td>
<td>0.13</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>87.08</td>
<td>30.37*</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>0.94</td>
<td>0.33</td>
</tr>
<tr>
<td>Error</td>
<td>130</td>
<td>186.36</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>135</td>
<td>274.57</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .001 level.
Table 7-4

Analysis of Variance for the Effort to use Imagery

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>3.01</td>
<td>0.93</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>7.92</td>
<td>1.23</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>2.22</td>
<td>0.34</td>
</tr>
<tr>
<td>Error</td>
<td>134</td>
<td>432.63</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>139</td>
<td>445.78</td>
<td></td>
</tr>
</tbody>
</table>
Table 7-5

Reliability for Individual Items across Judges (Coefficient Alpha)

<table>
<thead>
<tr>
<th>Originality</th>
<th>Usefulness</th>
<th>Customer Appeal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique</td>
<td>.71</td>
<td>.77</td>
</tr>
<tr>
<td>Fresh</td>
<td>.70</td>
<td>.77</td>
</tr>
<tr>
<td>Original</td>
<td>.74</td>
<td>.77</td>
</tr>
</tbody>
</table>
### Table 7-6

**Reliability for Scale Indices within Judges (Coefficient Alpha)**

<table>
<thead>
<tr>
<th>Judge Number</th>
<th>Usefulness</th>
<th>Originality</th>
<th>Customer Appeal</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>.9783</td>
<td>.9901</td>
<td>.8943</td>
</tr>
<tr>
<td>Two</td>
<td>.9479</td>
<td>1.000</td>
<td>.9781</td>
</tr>
<tr>
<td>Three</td>
<td>.9891</td>
<td>.9666</td>
<td>.9940</td>
</tr>
<tr>
<td>Four</td>
<td>.9834</td>
<td>.9682</td>
<td>.9787</td>
</tr>
<tr>
<td>Five</td>
<td>.9771</td>
<td>1.000</td>
<td>.9735</td>
</tr>
<tr>
<td>Six</td>
<td>.9826</td>
<td>.8524</td>
<td>.9916</td>
</tr>
<tr>
<td>Seven</td>
<td>1.000</td>
<td>.9327</td>
<td>.9976</td>
</tr>
<tr>
<td>Eight</td>
<td>1.000</td>
<td>.9719</td>
<td>1.000</td>
</tr>
<tr>
<td>Nine</td>
<td>1.000</td>
<td>.8332</td>
<td>1.000</td>
</tr>
<tr>
<td>Ten</td>
<td>1.000</td>
<td>.9862</td>
<td>.9968</td>
</tr>
<tr>
<td>Eleven</td>
<td>.9543</td>
<td>.7524</td>
<td>1.000</td>
</tr>
<tr>
<td>Twelve</td>
<td>1.000</td>
<td>.8982</td>
<td>.9665</td>
</tr>
<tr>
<td>Thirteen</td>
<td>1.000</td>
<td>.8775</td>
<td>1.000</td>
</tr>
<tr>
<td>Fourteen</td>
<td>.9281</td>
<td>.9651</td>
<td></td>
</tr>
<tr>
<td>Fifteen</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sixteen</td>
<td>.9904</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Note: Independent sample of judges for each variable.
Table 7-7

Principal Component Analysis of Judged Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appealing</td>
<td>.9433</td>
<td>.0130</td>
<td>.3123</td>
</tr>
<tr>
<td>Likeable</td>
<td>.9480</td>
<td>.0004</td>
<td>.3024</td>
</tr>
<tr>
<td>Desirable</td>
<td>.9461</td>
<td>.0106</td>
<td>.3081</td>
</tr>
<tr>
<td>Unique</td>
<td>-.0520</td>
<td>.9661</td>
<td>-.1659</td>
</tr>
<tr>
<td>Original</td>
<td>.0553</td>
<td>.9648</td>
<td>-.1421</td>
</tr>
<tr>
<td>Fresh</td>
<td>.0020</td>
<td>.9608</td>
<td>-.1896</td>
</tr>
<tr>
<td>Useful</td>
<td>.3352</td>
<td>-.1981</td>
<td>.9161</td>
</tr>
<tr>
<td>Effective</td>
<td>.3325</td>
<td>-.2233</td>
<td>.9118</td>
</tr>
<tr>
<td>Worthwhile</td>
<td>.3494</td>
<td>-.1961</td>
<td>.9126</td>
</tr>
</tbody>
</table>

Variance Explained 56.7% 31.0% 10.4%
Table 7-8

Table of Means

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Imagery Type</th>
<th>Customer Incorporation Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Customer Incorporation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Customer Incorporation</td>
</tr>
<tr>
<td>Usefulness</td>
<td>Control</td>
<td>3.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.61) (^b)</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>3.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.82)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.68) (0.73, 0.64)</td>
</tr>
<tr>
<td></td>
<td>Imagination</td>
<td>2.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.71)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.77) (0.64, 0.84)</td>
</tr>
<tr>
<td>Originality</td>
<td>Control</td>
<td>3.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.69)</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>3.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.46)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.80) (0.89, 0.71)</td>
</tr>
<tr>
<td></td>
<td>Imagination</td>
<td>4.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.74)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.52) (0.50, 0.52)</td>
</tr>
<tr>
<td>Customer Appeal</td>
<td>Control</td>
<td>3.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.69)</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>3.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.67)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.72) (0.76, 0.69)</td>
</tr>
<tr>
<td></td>
<td>Imagination</td>
<td>3.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.86) (0.80, 0.93)</td>
</tr>
</tbody>
</table>

\(^a\) Cell sizes are n = 20.

\(^b\) The standard deviations for each reported mean is contained in parentheses ({}).

\(^c\) The means for the customer incorporation instruction and customer incorporation instruction plus training are contained in parentheses ({}).
Table 7-9

Analysis of Variance for the Usefulness Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>0.18</td>
<td>0.35</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>2.20</td>
<td>2.12</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>3.14</td>
<td>3.03*</td>
</tr>
<tr>
<td>Error</td>
<td>134</td>
<td>69.41</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>139</td>
<td>74.93</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .05 level.
Table 7-10

Analysis of Variance for the Originality Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>10.17</td>
<td>23.35*</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>0.40</td>
<td>0.45</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>0.50</td>
<td>0.57</td>
</tr>
<tr>
<td>Error</td>
<td>134</td>
<td>58.29</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>139</td>
<td>69.36</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .001 level.
Table 7-11

Analysis of Variance for the Customer Appeal Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>2.16</td>
<td>3.12</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>2</td>
<td>2.71</td>
<td>1.97</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>4.44</td>
<td>3.22*</td>
</tr>
<tr>
<td>Error</td>
<td>134</td>
<td>92.46</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>139</td>
<td>101.77</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .05 level.
Figure 7-1

Conditions for Mediation: Independent Variables have Significant Effect on Mediators and Ultimate Dependent Variable
Figure 7-2

Conditions for Mediation: Independent Variable's Effects are Covaried Out - Effect

on Ultimate Dependent Variable Disappears
Figure 7-3

Conditions for Mediation: Covariates are Significant

- Customer Incorporation
- Imagery Type
- Usefulness
- Originality
- Customer Appeal

Significant (p<.001)
Significant (p<.10)
CHAPTER 8
FOLLOW-UP STUDY

Since an experimental approach was taken in the first study, choices had to be made about the variables to include, and it was not possible to study all of the variables upon which the results might potentially be contingent. The product design context and the design task chosen for the main study potentially limit the generalizability of the conclusions that can be drawn from the research reported in the last chapter. In a product design context, one might expect that the characteristics of the designer (e.g., their level of experience, ability to visualize, working individually or in a team), the designer-market interface (e.g., the similarity between the designer and the target segment), the product being designed (e.g., product for an end consumer {i.e., a can opener} vs. a component {i.e., a ball bearing}), and the nature of the design task (e.g., time provided, scope of design mission) could potentially influence the relationships observed.

Given the limitations identified above, a follow-up study was conducted to test the generalizability of the main study results. To explore the generalizability of the findings of the main study, the follow-up study examined two variables that might potentially influence the obtained results. Specifically, the designer-market interface and the product being designed were altered. To do this, the design context was changed in two important ways. First, to change the designer-market interface, the distance between the designer and the target customer segment was greatly reduced. It may be argued that the benefits of visualizing the customer appear only when
the target audience is significantly different from the designers themselves, as was the case in the main study. Second, a different consumer product from the one used in the main study was used for the design task. A replication of the main study results with a different product form would further establish the generalizability of the research findings.

The chapter consists of two sections. The first section deals with the study methodology. In the second section, preliminary analyses and tests of the hypotheses presented in Chapter Four are conducted.

I. Research Method

Research Design

The study used a between subjects factorial design that involved the manipulation of two experimental factors: imagery type and customer incorporation in visualization during the design process. There were two levels of imagery type (memory imagery vs. imagination imagery), and two levels of customer incorporation (no customer incorporation vs. customer incorporation).

Product Designers

Designers participating in the study were 73 male undergraduate engineering students. They had all completed coursework in design fundamentals and were recruited in design engineering classes through announcements offering $10 for participation.
Customer Segment and Product

Young women (age 20-24) were chosen as the target customer segment. This target segment was similar to the designers in terms of an important demographic characteristic, age, while differing on another, gender. In reducing the distance between the designer and the target segment, it was important to use a target segment that still had some dissimilarity to the designer population. Using a target segment identical to the designers would not allow a separation of the effects of including oneself from including the customer, in the visualization.

Informal discussions held with young women to determine products that they felt could be improved. An umbrella was a product identified by a number of discussion participants. Thus, the design task was the development of a new umbrella for female young adults (age 20-24).

Independent Variables

The manipulation of imagery type closely followed the manipulation used in the main study (see Chapter Six). In the memory imagery condition, designers were instructed to “dig deep into their memory” and visualize umbrellas that they had previously seen when developing their design solution. In the imagination imagery condition, designers were instructed to “go beyond” umbrellas that they would normally see and use other image forms to develop their design solutions.

The customer incorporation manipulation also followed the main study manipulation (see Chapter Six). In the no customer incorporation condition, designers did not receive any instructions to visualize the customer. In the customer incorporation condition, designers were
given a training exercise and then received customer incorporation instructions. The training
exercise was identical to that used in the main study (see Appendix A). This created a more
realistic training experience, as the designers imaged a focal character similar to the target
customer they would be subsequently designing for.

Procedure

The procedure of the study was identical to that used in the main study (see Chapter Six).
Designers in the customer incorporation condition first received the training exercise. Designers
in all conditions then received the instructions for the design task. They were asked to design an
umbrella for female young adults (age 20-24), and were told to produce a “thumbnail sketch” of
the central aspects of their design idea. The designers then received the imagery type treatment,
and those designers in the customer incorporation condition also received the customer
incorporation instructions. After receiving the appropriate treatment instructions, designers
completed the design task. They were given 30 minutes to develop their design. After
completing the design task, designers filled out a short questionnaire. They were then debriefed
and paid for their participation.

Dependent Measures

To investigate the success of the manipulations, an open-ended measure that asked the
designers to describe any mental pictures they had during the design exercise was used. Designers
then completed an open-ended question that asked what they thought was the purpose of the
study. They also indicated their age and study major.
A target sample of judges composed of young women (age 20-24) was used to evaluate the produced designs. Similar to the main study, a separate sample of judges was used to evaluate the originality \((n = 19)\), usefulness \((n = 19)\), and customer appeal \((n = 20)\) of the designs. The judges were asked to rate each of the umbrella designs on 3-item, 7 point semantic differential scales that represented one of the constructs of interest. The scales were identical to those used in the main study (see Chapter Six). The judges received course credit for their participation.

II. Results

**Preliminary Analyses**

The open-ended responses that provided a description of the visual images that the designers used during the design exercise were examined. To assess the success of the experimental manipulations, the responses were coded in two ways. For the imagery type manipulation, coding involved identifying the number of images that differed from an umbrella. It was expected that those in the imagination condition would use many more images not involving an umbrella. For the customer incorporation manipulation, coding consisted of identifying the number of images that involved the customer. Those in the customer incorporation condition were expected to use more images involving the customer.

As expected, a two-way ANOVA with the count of the number of images different than an umbrella as the dependent variable indicated only a significant main effect for the imagery type manipulation \((F (1, 69) = 3.17, p < .05)\), with those in the imagination condition producing more
images unrelated to an umbrella (means: imagination = 5.24, memory = 3.97). For the customer incorporation manipulation, a two-way ANOVA with the count of the number of images of the customer as the dependent variable showed only a significant main effect of customer incorporation (F (1, 69) = 23.87, p < .001). As expected, the designers that received no instructions to incorporate the customer used fewer images of the customer (mean = 0.65) than those in the customer incorporation condition (mean = 2.03). Designer's responses to the question related to the perceived purpose of the study were also examined. None of the designers were aware of the experimental hypotheses.

Following Olney, Holbrook, and Batra (1991), a reliability analysis for the ratings of the customer judges was performed (see Chapter Seven). Satisfactory reliability for each of the measured constructs was achieved (all alphas > .70). To confirm the structure of the three construct measures, the mean scores across the judges for each of the nine items were subjected to a confirmatory factor analysis. Once again, a three-factor model provided a good fit for the data (Bentler-Bonett Normed Fit Index = .918, Comparative Fit Index = .934, χ² (25) = 114.23, p < .001). Consequently, as in the main study, mean scores across the three items comprising each of originality, usefulness, and customer appeal were used as the dependent measures in the analyses reported below (see Table 8-1).

Test of Hypotheses

Consistent with H1, an ANOVA for the usefulness variable revealed an interaction effect (F (1, 69) = 5.75, p < .05, ω² = .060). None of the other effects reached statistical significance
(see Table 8-2). A planned contrast indicated that the designs produced in the imagination imagery customer incorporation condition were rated as more useful (mean = 3.51) than the designs produced in the imagination imagery no customer incorporation condition (F (1, 71) = 9.28, p < .01, mean = 2.85). A contrast between the memory imagery customer incorporation condition (mean = 3.15) and the memory imagery no customer incorporation condition was not significant (F (1, 71) < 1, mean = 3.23). Thus the data again support hypothesis 1.

Supporting hypothesis 2, the ANOVA results for originality revealed a significant main effect for imagery type (F (1, 69) = 5.90, p < .05, $\omega^2 = .062$, means: memory imagery = 3.94 and imagination imagery = 4.59). None of the other effects reached statistical significance (see Table 8-3).

The ANOVA results for customer appeal revealed an interaction effect (F (1, 69) = 4.18, p < .05, $\omega^2 = .042$). None of the other effects reached statistical significance (see Table 8-4). Supporting hypothesis 3, the planned contrast between the imagination imagery customer incorporation condition (mean = 3.69) and all of the other experimental conditions combined was significant (F (1, 71) = 4.71, p < .05, mean = 3.30).7

Following the criteria proposed by Baron and Kenny (1986) and Aiken and West (1990), which have been noted earlier (see Chapter Seven), originality and usefulness were tested as mediators of the effect of imagery type and imagery content on customer appeal. As shown

---

7 When done separately, the contrasts between the imagination customer incorporation condition (mean = 3.69), the memory customer incorporation condition (mean = 3.31) and the imagination no customer incorporation condition (mean = 3.17) were significantly different at the .05 level. The contrast between the imagination customer incorporation condition and the memory no customer incorporation condition (mean = 3.42) was marginally different (p < .10). The other conditions did not differ significantly from each other.
above, the independent variables have significant effects on both the mediators (H1 and H2) and the ultimate dependent variable (H3) (see Figure 8-1). An analysis of covariance showed that the previously significant interaction effect ($F (1, 69) = 4.18, p < .05$) of imagery type and customer incorporation on customer appeal (H3) disappeared ($F (1, 66) < 1$) (see Figure 8-2).

Additionally, usefulness as a covariate, was significant ($F (1, 66) = 164.40, p < .001$), as was the interactive effect between usefulness and originality, albeit at a $p < .10$ level ($F (1, 66) = 2.81$) (see Figure 8-3). Originality, as a covariate, was not significant ($F (1, 66) = 0.01, p > .10$). Thus, all three criteria required to infer mediation are met, providing additional support for both hypotheses 4a and 4b.
Table 8-1

Table of Means*  

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Imagery Type</th>
<th>Customer Incorporation Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Customer Incorporation</td>
</tr>
<tr>
<td>Usefulness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>3.23</td>
<td>3.15</td>
</tr>
<tr>
<td></td>
<td>(0.77)</td>
<td></td>
</tr>
<tr>
<td>Imagination</td>
<td>2.85</td>
<td>3.51</td>
</tr>
<tr>
<td></td>
<td>(0.42)</td>
<td></td>
</tr>
<tr>
<td>Originality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>3.96</td>
<td>3.93</td>
</tr>
<tr>
<td></td>
<td>(1.27)</td>
<td></td>
</tr>
<tr>
<td>Imagination</td>
<td>4.91</td>
<td>4.25</td>
</tr>
<tr>
<td></td>
<td>(1.41)</td>
<td></td>
</tr>
<tr>
<td>Customer Appeal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td>3.42</td>
<td>3.30</td>
</tr>
<tr>
<td></td>
<td>(0.72)</td>
<td></td>
</tr>
<tr>
<td>Imagination</td>
<td>3.17</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>(0.41)</td>
<td></td>
</tr>
</tbody>
</table>

* Cell sizes for the memory conditions and the imagination customer incorporation condition were n = 18, for imagination condition n = 19.

\(^b\) The standard deviations for each reported mean is contained in parentheses {}.
Table 8-2

Analysis of Variance for the Usefulness Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>1</td>
<td>1.57</td>
<td>3.55</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>2.54</td>
<td>5.75*</td>
</tr>
<tr>
<td>Error</td>
<td>69</td>
<td>30.46</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>72</td>
<td>34.62</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .05 level.
Table 8-3
Analysis of Variance for the Originality Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>7.50</td>
<td>5.90*</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>1</td>
<td>2.15</td>
<td>1.69</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>1.79</td>
<td>1.41</td>
</tr>
<tr>
<td>Error</td>
<td>69</td>
<td>87.63</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>72</td>
<td>99.33</td>
<td></td>
</tr>
</tbody>
</table>

\* Significant at the p < .05 level.
Table 8-4

Analysis of Variance for the Customer Appeal Variable

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>F-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery type</td>
<td>1</td>
<td>0.08</td>
<td>0.18</td>
</tr>
<tr>
<td>Customer incorporation</td>
<td>1</td>
<td>0.75</td>
<td>1.71</td>
</tr>
<tr>
<td>Imagery type x Customer incorporation</td>
<td>2</td>
<td>1.85</td>
<td>4.18*</td>
</tr>
<tr>
<td>Error</td>
<td>69</td>
<td>30.47</td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>72</td>
<td>33.17</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at the p < .05 level.
Figure 8-1

Conditions for Mediation: Independent Variables have Significant Effect on Mediators and Ultimate Dependent Variable
Figure 8-2

Conditions for Mediation: Independent Variable’s Effects are Covaried Out - Effect

on Ultimate Dependent Variable Disappears

\[ \text{Customer Incorporation} \rightarrow \text{Usefulness} \rightarrow \text{Customer Appeal} \]

\[ \text{Imagery Type} \rightarrow \text{Originality} \]

Nonsignificant \((p > .10)\)
Figure 8-3

Conditions for Mediation: Covariates are Significant

Customer Incorporation

Imagery Type

Usefulness

Significant (p<.001)

Customer Appeal

Significant (p<.10)

Originality
This chapter is presented in four sections. In the first section the findings of the two experimental studies are discussed. In the second section, implications are drawn for both theory and practice. The limitations are discussed in the third section, and directions for future research are presented in the final section.

I. Discussion of the Findings

Overall, the findings of both experimental studies are consistent and lend empirical support to the intuition that visual mental imagery can play an important role in new product design. The findings support the proposed conceptual framework that outlines how visual mental imagery can influence relevant aspects of a product design.

Consistent with the proposed hypotheses, the results indicated that, including the customer in imagination visual imagery during the design process, has a greater effect on the usefulness of the designs produced, than including the customer in memory visual imagery. Including the customer in the imagination imagery serves as a guideline that focuses imagination imagery and increases the designer’s ability to discover the design features that will effectively meet the customer’s needs. Incorporating the customer in memory imagery does not enhance the usefulness of the designs produced. It is argued that this null finding is obtained for two reasons: first, in the memory imagery
conditions, because the designer is unable to break free from previous memories, the incorporation of the customer in visualization fails to provide benefits in helping to facilitate designs that better meet the customers’ needs. Second, product designs retrieved from memory are likely to have at least some usefulness, or they would not likely be on the market. This reduces the scope, for customer incorporation in the visualization, to further enhance the usefulness of the design. This is particularly likely to be the case for mature products, such as the ones used here. Finally, it is interesting to note that the use of imagination imagery, when it is not focused by the incorporation of the customer, leads to designs that are perceived as less useful than in any of the other conditions. This is not inconsistent with the proposed framework because; as noted above, in the memory condition, products that come to mind have to be at least somewhat useful to have remained on the market. Unconstrained imagination imagery may simply provide too much freedom and lead to flights of fantasy that result in inappropriate product designs.

The experimental results also show that when imagination imagery is used, the resulting design is more original than when memory imagery is used. This would be expected since, in contrast to memory imagery, imagination imagery provides an expanded solution space and an environment more conducive for creative cognition. Interestingly, this finding extends across the customer incorporation conditions in both experimental studies. The main effect for imagery type indicates that the presence of images of the customer in the visualization does not inhibit the creative cognition stimulated by imagination imagery.
The results also support the hypothesis that the appeal of a design is positively affected by using imagination imagery that incorporates the customer. Design output produced by designers using imagination imagery that incorporates the customer were rated significantly higher than the design output produced by designers in the other visual imagery conditions. These two visual strategies provided a clear advantage in the production of appealing new product design ideas. In both studies, the mediation analysis (Baron and Kenny 1986) supported the conceptualization that the customer appeal of a design is driven by both the perceived usefulness of the design and its originality. A significant effect for the usefulness covariate in the mediation analyses indicates that when a product design is perceived to be useful it will be appealing to the customer. The covariate for the interaction term of originality and usefulness was also shown to be marginally significant in both studies. This provides some support for the hypothesis that original designs are more appealing as long as they are also perceived to be useful. The nonsignificant results for the originality covariate in the mediation analyses also suggests that originality, by itself, does not influence customer appeal. To be successful, products need to meet customers' needs in addition to being original.

In the main study, the results for the memory condition and the control condition were similar across all the dependent variables. This indicates that a) even in the absence of imagery instructions, product designers use imagery during the design process, and b) the type of imagery spontaneously used is memory imagery. This finding adds strength to the conclusions that imaginative forms of imagery, that incorporate the customer, lead to an improvement in the resulting customer appeal of the design.
Finally, the effect sizes for the ANOVAs, as reflected by the omega squared statistic, obtained across both studies, ranged between .032 and .159. According to Cohen (1977), a “large” effect produces an omega squared value of .15 or greater. A “medium” effect is .06, and a “small effect” is .01. Thus, but for the main effect of originality in the first study, which was large (.159), all the other effect sizes would be considered moderate. Thus, the variables studied are important and explain a reasonable portion of the variance in the data.

II. Implications

This research adds to the marketing and design literature in several ways. Foremost, a theoretical framework is developed which identifies two factors, type of imagery and content of imagery, which are important in the context of designing new products. The distinction between types of imagery has been made in the past (e.g., Childers and Houston 1983), but this is the first attempt to empirically look at different types of imagery and to show the value of the distinction in a marketing and design context. The findings show that a distinction between imagination images and memory images is both relevant and important to product design. The freedom gained when using imagination imagery leads to more original design output, and when this form of imagery is guided by images of the customer, more useful and appealing designs are produced. The exclusive reliance on memory forms of imagery does not provide any advantage to product designers. These findings show the importance of the imagery type, and indicate a potential for this distinction to play a role in other marketing and design contexts (e.g., consumer response to advertising, product design evaluation).
The importance of the customer has been recognized in the marketing literature (e.g., Blattberg and Deighton 1996), but as many marketing failures suggest, it is difficult to implement a customer focus. This research proposes a mechanism for incorporating the customer in the design process and for keeping the customer front and center throughout it. By using images of the customer in the content of visual imagery used during design, the findings show that the resulting designs will be more useful and appealing to the end-user. For marketers, this finding provides empirical evidence of the importance of the customer in achieving successful product design. This research also indicates that the content of the visualization of the product designer can be an important area of study. Imagery content is shown to be both a critical and a manageable factor in the realization of effective product design.

This research also identifies a set of dependent variables that are customer driven. Previous research in design (e.g., Bralla 1996; Garvin 1984) has used evaluative measures that rely on technical jargon that may be difficult for the end-user to understand. For example, Bralla (1996) indicates appropriate evaluation dimensions to include product conformance, upgradability, ergonomics, and time-to-market. This dissertation identifies and uses evaluation measures that are easily understandable by the end-user and represent product perceptions of the end-user. The perceived usefulness and originality of the product design is shown to drive the customer appeal of a new product concept. These measures are derived from previous research in marketing (e.g., Cooper and Kleinschmidt 1987; 1990; Song and Parry 1997) that identifies the importance of innovation and meeting customer needs to achieve new product success. The experimental validation of these ideas establishes originality and
usefulness as critical factors in evaluating the ability of a new product design to succeed in the marketplace.

From a practical perspective, the results of this research suggest potential ways in which the new product design process may be managed more effectively. Of most importance, they suggest that designers should be encouraged to visualize by using imagination imagery that incorporates the customer. Education and training should be modified to include these ideas. For example, an effective educational training session could involve both visualization exercises that foster imagination as well as activities that better familiarize the designer with the target customer segment. Exposure to detailed visual images of the customer (e.g., video documentaries), role-playing customer needs and concerns, and actual interaction with the end-user are potential approaches that the designer could use to help improve the richness of his or her customer knowledge and visualization ability. Like brainstorming, association techniques, and synergetics, design engineers can use imagination imagery that incorporates the customer when they are faced with new product design problems.

For marketers, these results support their perspective on the importance of the customer. Their potential role in the design process could range from ensuring that the customer is always in the forefront of the designer's mind to a more specific role of providing relevant insights about the customer and their behavior for design engineers, so as to facilitate the designer's ability to visualize the customer. Marketers should be actively involved in the development of training and educational materials that enable the designer to achieve a customer focus.
III. Limitations of the Research

The limitations of this research stem primarily from the product design contexts chosen for the experimental studies. As indicated in Chapter Eight, a number of variables that were not addressed in the main study could potentially influence the relationships identified. The follow-up research conducted in Chapter Eight addressed some of these limitations and thereby provided support for the robustness of the conceptual framework and the research findings. However, a number of limitations were not addressed and remain contingent factors that qualify the research results.

One such limitation relates to the characteristics of the product designer sample. Engineering design students, though trained in product design, have limited experience and knowledge regarding the design process. A lack of real-world design experience may have contributed to the effects realized. A designer with years of experience might well have been more adept at using visualization in the design process. Experienced designers may be able to better incorporate images from memory in developing design ideas and may have a better understanding of how to incorporate the customer in the design process.

The nature of the product being designed also has implications for the generalizability of the findings. In both studies, the design task involved development of a consumer product. It remains to be seen whether these findings extend to other product forms (e.g., services, industrial products). Additionally, the products used to operationalize the design process in this research were ones with which the customer could physically interact. Not all products are experienced so directly by the customer. For example, a component part (e.g., ball bearing, computer chip) may never be seen or
handled by the end-user. For these types of products, visualizing the customer may not only be difficult, it may also contribute very little to the overall suitability of the product’s design.

The nature of the task provided to the designer may also have influenced the relationships observed in this research. In both studies, the designer was given 30 minutes to develop a product concept that fulfilled the design requirements. Although this time constraint was deliberately chosen, based on what was identified as reasonable by pretesting and previous research (e.g. Jansson and Smith 1991; Shah, Nico, and Kraver 1993), it did not characterize actual industry norms. Designers are under extreme pressure to complete their design tasks quickly, but they are typically given anywhere from several hours to a week for concept generation.

The design tasks used in this research also required designers to work individually. In actual product development work, design is sometimes handled by design teams composed of several individuals with different areas of expertise. However, Ulrich and Eppinger (1995; see also McGrath 1984) note that, even in design teams, concept generation is often done individually. They note that this stage of the design process realizes better results when done on an individual basis.

Finally, as indicated in the introductory chapter, the design missions used in this research were uniformly narrow. In practice, the nature of the design task can vary from responding to a very broad “customer need” to meeting a narrowly defined product improvement requirement for a specific set of customers (Ulrich and Eppinger 1995). The specific scope of the design tasks used in this research qualifies the findings and points towards the need for more research into the use of visual imagery in design.
IV. Directions for Future Research

Visual Mental Imagery as an Evaluation Tool in Product Design

This dissertation has focused on the importance of visual mental imagery in the early stages of the product design process. Specifically, it has examined the application of visual imagery as a design tool that facilitated concept generation in product design. Visual imagery may also be a useful tool in other aspects of the new product development process. One promising area for application is during the concept selection stage of product design.

Concept selection is the process of evaluating concepts produced during the conceptual design stage, and selecting one or more concepts for further development (Ulrich and Eppinger 1995). It involves defining the relative strengths and weaknesses of a concept with respect to customer needs and other criteria. Much like concept generation, the designer utilizes a variety of techniques and tools during the concept selection phase. For example, Pugh (1990) developed a concept selection methodology that uses a decision screening matrix that rates and ranks concepts according to established selection criteria. Roozenburg and Eekels (1995) identify the "reverse brainstorming" technique that focuses on determining reasons why a concept would fail. Other concept selection methods involve prototype testing, trade-off analysis, external decision reviews, and intuitive decision making (Ulrich and Eppinger 1995). It is important to note that the customer can and should be an important part of this stage of the design process. Customer usability labs, focus groups, computer simulations, and prototype testing are examples of how the customer can be incorporated into this part of product design (Bailetti and Litva 1995; Palmiter et al. 1994).
At this stage of the design process, visual mental imagery does not have an acknowledged role as a potential design tool. Previous research (e.g., Lorenz 1990; Roozenburg and Eekels 1995) has primarily linked visual imagery to the concept generation phase of design because of its important role in enhancing creativity. A good opportunity to extend the role of visual mental imagery in design lies in recognizing its potential application in concept selection. Visual imagery has relevance to this design stage for a number of reasons. First, creativity is a necessary aspect of product concept evaluation (Thomas 1993). Visualization can assist in creating both accurate simulations of product usage and forecasts of market reactions to product concepts. Second, this dissertation has shown how visual imagery can be used to better incorporate the customer in the design process. Visualizing the customer can provide empathy and understanding of the needs and wants of the end-user. This type of knowledge can be implemented and would be beneficial to the concept selection process. Given this reasoning, future research investigation should be directed towards confirming the potential use of visual imagery in concept selection and determining the most effective approach to its application.

Computer Technology and Cognitive Approaches in Product Design

A second potential area for future research involves the investigation of the impact of computer technology and software development on the new product development process. In the past decade, advances in computer programming and software applications have increased the scope and ability of computer technology to assist the designer in all stages of the design process. Recently, Rangaswamy and Lilien (1997) identified and reviewed the software tools that are available for supporting new product development. In this research, major categories of design software were classified according
to their application in the product development process, and the goals, advantages, and disadvantages of the respective software tools were highlighted.

One of the central categories identified by the authors was software for facilitating the concept generation stage of the product design process. Software in this category (e.g., Mindlink, IdeaFisher, Inspiration, NamePro) attempts to support idea generation by enhancing creativity. A central premise that underlies this type of software application is that the interaction between the designer and the software leads to creativity enhancements (Rangaswamy and Lilien 1997). This premise leads to a number of interesting research questions - Is this premise correct, and if so, what conditions facilitate this interaction? What is the role of cognitive approaches (i.e., visual mental imagery) in idea generation when computer software is being utilized? What dangers, if any, exist from incorporating software applications into the concept generation phase of product design?

Software that facilitates idea generation would likely have the ability to provide positive benefits to the designer during concept design. Indeed, the software reviewed in the Rangaswamy and Lilien (1997) study was easy to use, encouraged divergent thinking through free associations, and kept a record map of ideas that could be easily revised for future use. However, as Rangaswamy and Lilien (1997) note, there is likely to be some danger in relying heavily on these software tools. Software packages take a structured approach to idea generation, thereby potentially undermining the objective of encouraging experimentation and creative thinking. Visual mental imagery succeeds as a creative tool because it provides an unconstrained freedom in the cognitive idea development of the designer.
Future research should examine the relationship and appropriate balance between idea generation software and cognitive design tools in an effort to determine what constitutes the best design approach.

*Other Research Opportunities*

Opportunities for future research are also provided through the limitations imposed by the product design contexts used in this dissertation. For example, product design research involving visual mental imagery could be conducted that varies the scope of the design mission. This dissertation focused on narrow design missions involving known product forms. Design for really new products may require different approaches in visualization. Further, the generalizability of the conceptual framework and its implications could be advanced with replication using more experienced product designers or by using different products and services. Visualization research involving design teams also offers interesting opportunities for research extensions.

An additional opportunity for future research involves exploring individual differences in the ability to visualize. Do individual differences moderate the findings of this research? Previous work in psychology and marketing (e.g., Childers, Houston, and Heckler 1985) has developed scale measures that identify those individuals that are more adapt at visual processing. Do the manipulations used in this current research have a differential impact on those that predominantly use visual mental imagery in their thinking? Can the ability to visualize be enhanced through training? These questions provide an interesting direction for future work.

A further opportunity for future research lies in a better understanding of the dependent measures that influence customer appeal. In this research the focus was on the perceived originality
and usefulness of a design concept rather than on any antecedents to these constructs. For example, an antecedent to the perceived usefulness of a car jack for senior consumers would be the "ease of use" of the product. What is the form of the relationship between "ease of use" and the overall usefulness rating? Does the importance of "ease of use" vary by product? Additionally, at later stages in product development, other variables (e.g., reliability, durability, upgradability, economic cost) may also be important in generating customer appeal. Future research should investigate the importance of other variables and also assess their relationship to the constructs used in this study.
REFERENCES


Galton, F. (1883), *Inquiries into Human Faculty*. Dent.


Watson, J. B. (1913), "Psychology as the Behaviorist Views It," *Psychological Review*, 20, 158-177.


APPENDIX A

Training Task

In solving design problems, many designers find that forming visual images (pictures in the mind) can help them produce innovative and effective designs. One visualization strategy that has been shown to aid in the design process involves visualizing the potential customer of the product. Seeing in your mind, a product-user being involved and interacting with a proposed product design can facilitate the development of design solutions.

For many individuals, visualizing the customer is a difficult task. The present training task is a guided imagery exercise that provides practice in visualizing the customer. Please read through the following paragraph and attempt to visualize the images expressed. After reading each sentence, close your eyes and visually process the expressed ideas and try to "see" the customer in the product usage situation.

Please picture in your mind a young adult. Perhaps someone that is in their early twenties. Imagine that the young adult is quite thin and petite. In your mind you can see them in their apartment. The apartment is quite small having only a bedroom, kitchen, living room, and a bathroom. Imagine the young adult coming into their living room. You see that they are dragging a large box. The box is obviously very heavy for the young adult and the size of it is almost overwhelming. You watch as they struggle to move the box into the centre of the room. After quite some time they finish positioning the box and begin to open it. The thick packaging tape makes opening a difficult task. You can see the young adult getting frustrated and in anger they attempt to rip at the cardboard. Finally the box is open. You see that in the box are the pieces to a set of new wooden tv dinner stands. Dumping the contents on the living room floor, the young adult searches for the page of instructions. The instruction sheet is on a small piece of cardboard and you can tell that the printing on the sheet is quite small. You can tell that the young adult is having trouble reading the fine print of the instructions. You watch as the young adult reaches to a nearby shelf and opens a glasses case, retrieves a pair of
glasses, and then puts them on. The young adult studies the instruction sheet for what seems like an eternity. Finally, they put down the instructions and they begin to assemble the stand. You can tell that they are confused by the instructions and the many differing types of screws, pieces of wood, and other assembly materials. You watch as the young adult picks up the largest piece of wood from the floor. You can tell that their small hands are obviously not large enough to hold the wood, and you watch as the heavy piece slips from their hand and crashes to the floor. Leaving this scene you wonder if the new stand will ever be assembled.

After completing the visualization exercise please raise your hand and the experimenter will give you the design task. In the design task you will be asked to image a customer using a proposed product design. We suggest that you adopt a visualization process similar to that learned in this training session. Imaging a scenario that identifies the specific characteristics of the customer as he or she interacts with the proposed design will facilitate your ability to produce an effective and innovative design.
APPENDIX B

Questionnaire for Product Designer

We are going to ask you some questions about the visual mental imagery you used in producing your design.

We would first like you to describe any mental pictures that you might have had during the design exercise. In point form in the space provided, describe the pictures you had in your mind. For example, as you were designing, if you saw a long metal pipe in your mind you would write down "long metal pipe" in the space below. This is just an example, we want you to list all the images YOU had when you were doing the design exercise. Please be sure to write down all the mental pictures that you experienced.
How hard were you trying to use mental pictures in producing your design?

Not very hard 1 2 3 4 5 6 7 Very hard

To what degree did you experience mental pictures of a previously seen car jack?

Not very much 1 2 3 4 5 6 7 Very much

To what degree did you experience mental pictures that went beyond a “normal” car jack?

Not very much 1 2 3 4 5 6 7 Very much
Please write down what you think was the purpose of the study. Please limit your response to the space provided below.

Program of study: __________________

Gender: ____________

Age: ____________

Thank you for participating in this study.

Please do not mention anything at all about this study to anyone as our results would be useless if people participate after they know what this study is about.
APPENDIX C

Instructions for Target Customer Judges

THANK YOU FOR YOUR PARTICIPATION!!!

CONTAINED IN THE BINDER IS 140 DESIGN IDEAS FOR A CAR JACK (EACH DESIGN IS ON ONE PAGE). WE WOULD LIKE YOU TO GIVE US YOUR OPINION ON HOW APPEALING THESE DESIGN IDEAS WOULD BE TO A SENIOR CONSUMER. THIS SHOULD TAKE YOU BETWEEN ONE AND TWO HOURS. FEEL FREE TO TAKE SHORT BREAKS DURING THE EXERCISE.

TO COMPLETE THE EXERCISE IDENTIFY THE DESIGN NUMBER (FOUND IN THE CORNER OF THE DESIGN PICTURE), NOTE IT IN THE SPACE PROVIDED, AND THEN RATE THE DESIGN ON THE THREE SCALES. YOU SHOULD BE ABLE TO EVALUATE THREE DESIGNS ON EACH PAGE OF THE EVALUATION BOOKLET. PLEASE NOTE THAT I HAVE USED BOTH SIDES OF THE PAPER. BEFORE BEGINNING I WOULD SUGGEST BRIEFLY FLIPPING THROUGH THE DESIGNS TO SEE WHAT TYPE OF DESIGNS ARE INCLUDED IN THE EXERCISE.

WHEN YOU EVALUATE THE DESIGN WE WOULD LIKE YOUR FEELINGS ON HOW APPEALING THE DESIGN IDEA IS ONLY. PLEASE TRY TO OMIT THINGS LIKE COST, PRESENT AVAILABILITY, OR THE ARTISTIC MERITS OF THE DESIGN FROM YOUR EVALUATION. THERE IS NO RIGHT OR WRONG ANSWERS. WE SIMPLY WANT YOUR FEELINGS ABOUT HOW APPEALING THE DESIGN IDEA WOULD BE TO A SENIOR CONSUMER.

PLEASE INDICATE YOUR AGE AND GENDER IN THE SPACE BELOW. YOUR RATINGS ARE COMPLETELY CONFIDENTIAL. PLEASE SUBMIT THIS PAPER, THE EVALUATION BOOKLET, AND THE DESIGN BINDER BACK TO THE EXPERIMENTER/ADMINISTRATOR.

AGE: ___________________  GENDER: ___________________