Product Research

N.R. Srinivasa Raghavan • John A. Cafeo
Editors

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The Art and Science Behind
Successful Product Launches

Springer

Editors

N.R. Srinivasa Raghavan
General Motors India Pvt. Ltd
Whitefield Rd.
Bangalore-560066
Units 1-8, 3rd Floor, Creator Bldg.
India
srinivasa.raghavan@gm.com

John A. Cafeo
General Motors R & D Center
Manufacturing Systems
Research Lab.
30500 Mound Road
Warren MI 48090
USA
john.cafeo@gm.com

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Editorial

1 Motivation for this Book

New product development is a highly creative exercise, often involving interdisciplinary decision making and execution. Some of the several functions in an organization responsible for chartering the course of this process including product design, R&D, engineering, manufacturing, marketing, procurement, planning, finance, and information systems. Not to ignore the role that strategic suppliers, customers and regulators can play in this process. The more complex the nature of the product, the more strategic is the impact of this process on the financial viability of a company. Given the complicated nature of product development, it is extremely important for an organization to invest in product research. Generally, product research concerns itself with processes, tools, and methods that aid in understanding customer needs (both expressed and latent), planning for the right product features to suit an appropriate portfolio of products, translating the needs into engineering specifications, and monitoring the consumer feedback so that better products can be sold to consumers in the future.

In this book, we have a compendium of research articles on various issues concerning product research, written by research scholars both from academia and industry. Our aim in this book is to highlight through these articles, the state-of-the-art in a number of areas within product research. We hope this book will be a useful reference material for both practitioners and researchers in academia.

2 Summary of Research Articles

This book has four clusters around which we thought it will be best to organize the papers we reviewed. The first cluster is on innovation and information sharing in product design. The second cluster is on decision making in engineering design. The third cluster is on customer driven product definition. The fourth cluster is on quantitative methods for product planning. We now summarize the contributions of authors in their respective clusters.

2.1 Innovation and Information Sharing in Product Design

New product development is all about innovation. Advanced decision making needs to be enabled by information as much as by intuition. Understanding the role of intuition, creativity, and appropriate customer and process information is critical for world class product design. In this cluster, authors address the above concerns in their papers.

For products where lead times for development can run into several years, it becomes important to make decisions that are 'intuitively' good. J. Hartley's paper deliberates on what exactly is intuition, how does one go about affecting it, and finally, how does one create a shared intuition among potentially divergent minds involved in product development. The second article in this cluster, by A. Chakrabarti, proposes a framework for improving chances of a successful product launch, by good creativity management. In the process, he answers questions such as: what do we mean by a successful product; how is a successful product created; how do we improve the chances of being successful, etc.

Designing customizable products for mass markets is indeed a challenge, especially for hi-tech products. In their work, J.Y. Park and G. Mandyam present a persona-based approach to wireless service design. The product design cycle is analyzed starting with the initial ethnographic research and ending with usability testing prior to a commercial launch. In the last paper in this cluster, J.A. Rockwell, S. Krishnamurty, I.R. Grosse and J. Wileden bring out the role of the design information and knowledge necessary for decision-based design, which may come from across multiple organizations, companies, and countries. Integrating distributed engineering information that allows decision makers to easily access and understand it is essential for making well informed decisions. The authors present a knowledge management approach for documenting and seamlessly integrating distributed design knowledge during the evaluation of design alternatives.

2.2 Decision Making in Engineering Design

Many products that customers use in their day to day lives like automobiles, are quite complex from an engineering perspective. It goes without saying that several design parameters co-evolve during the product development process. Uncertainty in design influencing factors needs to be given due treatment while optimizing the design variables. In this cluster, we have articles that address this issue.

G. Hazelrigg presents a treatise on the mathematics of prediction. He establishes the basic concepts of prediction in the context of engineering decision making. J. Donndelinger, J.A. Cafeo, and R.L. Nigel, present a case study using simulation in which three engineers were independently tasked with choosing a vehicle subsystem design concept from a set of fictitious alternatives. The authors acted as analysts and responded to the decision-makers' requests for information while also

observing their information collection and decision-making processes. The authors then compare established theories of normative decision analysis, cognition, and psychological type.

S.S. Rao and K.K. Annamdas present a methodology for the analysis and design of uncertain engineering systems in the presence of multiple sources of evidence based on Dempster-Shafer Theory (DST) is presented. DST can be used when it is not possible to obtain a precise estimation of system response due to the presence of multiple uncertain input parameters. A new method, called Weighted Dempster Shafer Theory for Interval-valued data (WDSTI), is proposed for combining evidence when different credibilities are associated with different sources of evidence. The application of the methodology is illustrated by considering the safety analysis of a welded beam in the presence of multiple uncertain parameters.

Robustness can be defined as designing a product/service in such a way that its performance is similar across all customer usage conditions. R. Jugulum gives an overview of the principles of robust engineering or Taguchi Methods. The author describes the applicability of robust engineering principles in new product development with several case studies.

A. Deshmukh, T. Middelkoop, and C. Sundaram bring out the complex trade offs that are germane to distributed product development activities. They propose a negotiation protocol with an attendant optimization formulation that helps the distributed design team members to better explore globally optimal decisions. The authors conduct experimentations to verify the social optimality of the proposed protocol.

2.3 Customer Driven Product Definition

New products are seldom crafted without due diligence into understanding consumer behavior. Often frameworks like quality function deployment are adopted by product manufacturers, for a structured approach to prioritize product and technology features. Analytics is then carried out around the voice of customer that needs more focus. In this cluster, authors present their research centered on this theme.

Traditional automotive product development can be segmented into the advanced development and execution phases. In his paper, S. Rajagopalan focuses on three specific aspects of the Advanced Vehicle Development Process. The author highlights the different issues involved in understanding and incorporating the Voice of the Customer in the product development process. A catalog of questions is provided to help the product planners make informed decisions.

R.P. Suresh and A. Maddulapalli in their work formulate the problem of prioritizing voices of customer as a multiple criteria decision analysis problem and propose a statistical framework for obtaining a key input to such an analysis. They apply a popular multiple criteria decision analysis technique called Evidential Reasoning and also investigate a statistical approach for obtaining the weights of consumer surveys relevant to key voice analysis.

Primary and secondary market research usually deal with analysis of available data on existing products and customers' preferences for features in possible new products. S. Shivashankar, B. Ravindran and N.R. Srinivasa Raghavan present their work on how manufacturers need to pay immediate attention to the internet blogs as a valuable source of consumer tastes. The authors focus on application of web content analysis, a type of web mining, in business intelligence for product review.

M. Bhattacharyya and A. Chaudhuri, in their paper, observe that the product design team often needs some flexibility in improving the Technical Characteristics (TCs) based on minimum performance improvements in Customer Requirements (CRs) and the imposed budgetary constraints. The authors present a fuzzy integer programming (FIP) model to determine the appropriate TCs and hence the right attribute levels for a conjoint study. The proposed method is applied to a commercial vehicle design problem with hypothetical data.

2.4   Quantitative Methods for Product Planning

The role of advanced decision making using quantitative approaches has gained popularity over the last two decades. Product planners often need tools for scenario analysis for better new product risk management. In this cluster, authors present their research on innovative ways of addressing this issue.

J.B. Yang, D. Tang, D.L. Xu, K.S. Chin argue that New Product Development (NPD) is a crucial process to maintain the competitiveness of a company in an ever changing market. In the process of developing new products of a high level of innovation, there are various types of risks, which should be properly identified, systematically analyzed, modeled, evaluated and effectively controlled. The authors investigate the Bayesian Network (BN) method to assess risks involved in NPD processes. Their approach is discussed in a case study on a multinational flashlight manufacturing company.

Predicting the trajectory of customers' preferences for product attributes for long range planning, is a complex exercise. S. Bukkapatnam, H. Yang, and F. Madhavi aim to provide a mathematical model for this issue, based on Markov models. One and five step ahead prediction results of the proposed model based on simulated data indicates that the predictions are 5–25% more accurate than the models commonly used in practice.

Choosing products to launch from a set of platform based variants and determining their prices are some of the critical decisions involved in any NPD process. Commercial vehicles are products, whose sales are closely tied with the economic conditions. A. Chaudhuri and K.N. Singh present a mathematical model and a case study for profit maximization. The authors develop a two period model to choose the platform based variants, their prices and launch sequences within the two periods, spanning two economic conditions, boom time and recession.

Acknowledgements

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Part I
Innovation and Information Sharing in Product Design

Chapter 1
Improving Intuition in Product Development Decisions

Jeffrey Hartley

Abstract Market research has traditionally been aimed at collecting and delivering information to decision makers. A major problem has been that decision makers filter information according to its fit with their intuition. The present article maintains that market research must therefore directly target the intuition of decision makers. To do this, two problems must be solved. The first is to bring the intuition of the company mind into alignment with the thinking of the customer mind. Equally important is the need to bring the intuitions of the various functions within the company into alignment with each other. This research philosophy has led to two specific methods at General Motors: Inspirational Research and Iterative Design. Examples of these two approaches and evidence of their effectiveness are presented.

Keywords Intuition · Decision-making · Confirmation bias · Design · Iterative design · Data

> **"The human mind is not a container to be filled but rather a fire to be kindled."**
>
> **Dorothea Brande**

The prevailing metaphor for market research has been one of carrying information from customer to decision maker. This is evident in the ways market research is commonly defined:

> "Marketing research involves the specification, gathering, analyzing, and interpreting of information to help management understand its environment."
>
> Aaker, *Marketing Research*, 1986

> "Market research is the collection and analysis of information about consumers, market niches, and the effectiveness of marketing programs."
>
> investorwords.com, 2008

J. Hartley (✉)
Global Product Research, General Motors Corporation, 30200 Mound Road Warren,
MI 48092-2025
e-mail: jeff.l.hartley@gm.com

"Market research is the systematic and objective identification, collection, analysis, and dissemination of information for the purpose of improving decision making related to the identification and solution of problems and opportunities in marketing."

<div align="right">www.nadbank.com, 2008</div>

And it is evident in the fact that most of us treat market research as a corporate function more than a way of thinking. Most of the large firms employ a staff of market researchers, ready to venture out to the provinces and collect data on or from customers, then bring it back to the imperial decision makers in our companies. Information is the unit of exchange and the unspoken assumption is that it serves as some sort of nutrient which, if fed to the decision makers in abundant supply, will lead to wise decisions.

But this "information as food" metaphor breaks down under scrutiny. It breaks down for two reasons.

The first reason is most evident in design research (i.e., research meant to help designers develop successful innovative designs which appeal to customers) but I think that it holds for a much larger portion of market research. This problem stems from the fact that not all information is easily transported.

Some information is "stickier" than other information (von Hippel 1994) in that it is difficult or costly to move from one place or mind to another place or mind. Aesthetic information is a good example of this and that is why the "information as food" metaphor breaks down for design research.

Imagine that a customer says she wants a car interior to hold four people and she wants it to be "charming". The second piece of information is stickier than the first in that the recipient of the information understands what the first one means and can act upon it with a lot more certainty than they can for the second. Much of the customer information that a designer needs is sticky.

But there is a more fundamental problem which affects all market research. It is exemplified by an interesting finding that Rohit Deshpande, Sebastian S. Kresge Professor of Marketing at Harvard Business School, described at a Marketing Science Institute conference several years ago.

Dr. Deshpande interviewed senior managers at Fortune 500 companies. One question he asked was "Why do you do customer research?". Seventy percent said they did it to confirm their views. Interestingly, the more senior the person, the higher the percentage who said they did it to confirm their views.

When it was pointed out that their answer was not exactly the way a scientist formally uses data to test hypotheses, a representative answer was "that's why they pay me the big bucks. I can make the correct call, I just need data to support it afterward."

The executive's first reaction to countervailing data is typically to keep the hunch intact but explain away the dissonance by undervaluing the research. So when the results run counter to an executive hunch, then the research methods are often scrutinized.

"Did we have the correct sample? Were the stimuli well done? Was the location representative? Were the procedures sound? Did we have the right competitors? Did the moderator lead the witness?"

Oftentimes these are stated not as questions but as declarations ("You must not have had the right sample!"). The perceived research quality pivots around the fit between the real and the desired results.

The inertia against changing a hunch is even stronger if that hunch has been publicly stated or has built up its own momentum. In our business, that momentum takes the form of a very expensive full size model of a future vehicle which has been fashioned and refashioned and adored in a design studio for several months. Meeting after meeting, various high ranking people venture in to see the artifact, and before long a reification of the hunch spreads to many people. It takes great personal strength to back down from one's hunch after proclaiming it publicly over a long period.

But the "information as food" metaphor is undermined even when the data *supports* an executive hunch. In such a situation, the market researcher gets either or both of two messages. First, the method is not questioned of course – there is no reason to question data in support of your view. But there may be a reason to then question why we "tested something this obvious."

Unfortunately, these executives are not unusual. In fact all humans behave this way. A large body of psychological literature documents this aspect of human thought, under the heading of "confirmation bias": the tendency to seek out things which confirm your preconceptions (i.e., intuitions) and to ignore things which contradict them. Humans are not passive in the intake of information. We are very active. We do not see, we look for. We do not hear, we listen for. We do not touch, we feel for. We form an expectation fairly quickly and then look for confirming evidence. This occurs at all levels of cognition from immediate perception to the more drawn out thought processes of conceptual thought and even scientific postulation.

> "It is the peculiar and perpetual error of the human understanding to be more moved and excited by affirmatives than by negatives."
>
> Francis Bacon

So all of us display the type of predisposed thought that characterizes our executives. We take in information differentially, allowing in things that support our intuitions and averting things that don't. We read things we agree with and avoid things we don't agree with. We watch or listen to media that agrees with our views. When "data" interferes with our world view, we tend to discount it.

Over time, we entrench in our views. But most of us do not even know this because the only data we accept supports us. In the political world, everyone is a moderate in their own minds, while others are radical. In the sports world, the referees are always tilted against our team.

So, given human behavior, the prevailing metaphor for market research leaves us with a quandary. When data runs counter to a hunch, the hunch usually wins. When it supports a hunch, it doesn't change thinking anyway. So one is inclined to argue, with some seriousness, why we do market research at all, since it is either superfluous or discounted. In either case, it adds little value.

One can see, then, that intuition acts as a filter to information. Information which "fits" the intuition passes through into the decision-maker's mind. Information which doesn't fit intuition is deflected. If there were a way to make the decision-maker's intuition somehow more likely to lead to successful product decisions, and if one could do this early on, before the intuition went off track and built up momentum, then wouldn't that pay dividends? For one, later research which would be more likely to lead to product success might be more likely to be accepted.

For this reason, I suggest that market research attack intuition itself and not see its role as simply the delivery of information to an ostensibly passive and even-handed mind. In fact the earlier-stated goals for market research might be replaced or augmented with this one:

1.1 The Goal of Market Research Is to Create Early and Accurate Intuition That Is Shared Across Functions

While my points are most directly aimed at design research, they also apply to market research in general to the extent that the information under consideration is sticky. I call this approach "nurtured intuition" as opposed to "information as food". And it begs 3 very important questions.

- First, what exactly is intuition? For market research to set as its goal the nurturing of intuition, a clear definition of intuition is critical. And what exactly is "accurate intuition"?
- Second, how does one go about affecting it? Researchers whom I have asked have acted as if data-delivery is the best way to affect intuition. I disagree, for the reasons already stated. But if data won't change one's intuition, what will?
- And finally, how does one create a *shared* intuition among potentially divergent minds? In the world of data delivery, the data is there for all to see and one at least has an objective foundation on which to build a shared conclusion. (My experience has been that data doesn't succeed as often as one might hope, probably due to the differing preconceptions.) But if we are serious about nurtured intuition leading to wise product decisions, we'll have to ensure that the cross-functional team shares the same intuition.

The remainder of this paper addresses these questions and presents two examples of how our research has shifted to align with this "nurtured intuition" approach.

1.1.1 What Is Intuition?

Historically, intuition has been defined as the faculty of knowing or sensing without the use of rational processes – an impression. It has been seen as immediate, somehow given to us rather than taken from facts. Oftentimes intuition has been treated

as having a divine origin. Frequently it has been treated as a special skill that only psychics, mediums, and spiritual sages can have. It almost always has been treated as unlearnable. Pet psychics are born, not made.

The definition I am proposing is quite different.

1.2 Intuition Is the Abstract Knowledge That Comes Automatically from Guided Experiences – A Trainable Skill, Often "Beyond Words"

It is not mystical nor divine but rather a very common and prosaic activity. In fact I would say that one's intuition is constantly fed through experience and this happens thousands of times a day. A person's active participation is an absolute requirement for the development of their intuition – it is not achievable through book learning, charts, analyses or any of the sorts of things that make up most of the "information as food" approach.

Some examples will serve to make my point. Imagine that your child wants to learn how to ride her bike. You wouldn't ever think of reading her books or showing her charts about the physics of bike riding. Rather you encourage her to develop an intuition for what her body needs to do (you don't say it this way, but essentially that is what you are nurturing in her). She learns it through trial and error. Her vestibular, kinesthetic, and visual feedback helps her to learn what she needs her muscles to do to stay upright. And however this learning happens, it does not seem to be accessible through the verbal systems of the brain.

As another example, suppose you want to learn how to recognize the art of a new artist. If I used the "information as food" approach, I would give you statistics about the percentage of times the artist used various colors, subject matters, formats, media, sizes, and so on.

But if I wanted to improve your intuition, I would show you examples of this artist's works (and to be thorough, examples of other artists' works) and have you try to classify them. If told when you were right or wrong, you would gradually learn to recognize the style. The style might not be easily described, but your accuracy would get higher with more and more experience. When you saw a previously unseen painting, you would feel some sort of inkling, or hunch, or gut feel – an intuition – about who painted it.

The third example comes from a study by neuroscientists (Bechara et al. 1997). In this study, people played a gambling game with four decks, two of which were designed to create slight losses on average and two of which were designed to create slight wins on average, although it was not obvious on any hand if the deck were loaded for or against the player. At first, people would choose equally from the four decks, but over time they began shifting away from the decks which were stacked against them. They did this *before* they knew they were doing it or why they were doing it. The authors concluded that something in the brain was generating "intuitions" which guided behavior prior to conscious awareness or the ability to verbally articulate the basis for one's behavior.

So one way to define intuition is "the mental activity, based on experience, which may not be available to verbal articulation but nonetheless which influences decisions." This is the flavor of my definition.

What then is "accurate intuition"? In the business context, it is the ability to decide as your customer would. Of the thousands of decisions a company must make as it develops a new product, some will act to enhance the product's later appeal in the market and some will act to harm it. Most of these decisions are based on the decision maker's hunch and not on data, either because no data is available, the needed information is sticky, or as we have seen, the data is ignored if it disturbs the hunch. Those intuitive decisions which enhance the product's later appeal are, by definition, based on an accurate intuition of the market.

1.2.1   How Does One Nurture Intuition?

There are two paths by which knowledge can enter the mind. One is evolutionarily much older. Humans can take in knowledge through direct experiences, and the mind has natural mechanisms for representing the central tendencies and breadth of the experiences. This knowledge is connotative, contextual, and abstract, drenched with associations, and often difficult to reduce down to words. You might call this the *experiential* path to knowledge.

The other is evolutionarily more recent and follows from the development of language and symbols, primarily letters and numbers. Humans can take in knowledge through *symbols* – what others write or speak. This knowledge is denotative, usually lacks context, is non-experiential, and is very concrete (we call it "black and white" for a reason). It also suffers from the recipient wondering about the sender's motives, a problem which is not found with direct experience. You might call this the *symbolic* path to knowledge.

The former is similar to what psychologists call "episodic memory" (i.e., memory for episodes of experience) while the latter resembles "semantic memory" (i.e., memory for facts). Episodic memory is more compelling and memorable than semantic memory.

Intuition seems to accompany experiential knowledge much more than symbolic knowledge. An intuitive grasp for something comes with experience, not by reading or hearing about it from a secondary source.

This conceptualization of intuition parallels two topics in psychology. *Implicit learning* is the process through which we become aware of regular patterns in the environment without intending to do so, without being aware we are doing so, and in a way that is difficult to express (Cleermans 1993). It accompanies experience. *Category abstraction* is the process of learning to recognize members of an ill-defined category, such as an artist's style, by seeing examples of it (Hartley and Homa 1991).

My point in referencing these topic areas in psychology is to emphasize that intuition has been studied scientifically – it is not mystical. And all the research

says that intuition improves with experience. But experience of what? That answer depends on what you want your decision maker to be intuitive about. It helps to state this as the *skill* you are trying to engender in the decision maker and then set up the experiences to grow this skill.

We want our designers to have an intuitive understanding of design tastes in our customers (which is very sticky information). But we also want them to understand what role design plays in customer decisions. We want our designers, while they are designing, to be able to envision what our customers would want if they were sitting next to the designer. In short we want our designers to develop the skills of thinking like a customer and of making design decisions that will ultimately delight the customer.

As one example, most designers think about design quite differently than our customers do. That shouldn't surprise anyone – designers have spent their lives immersed in design and so it is at the forefront of their product evaluations. For customers, it often is subjugated to function. When designers think of a car's interior, they typically ask themselves "Is it beautiful?". When customers think of a car's interior, they typically ask themselves "Is it functional?" and "Is it comfortable?" more than the designer would. This chasm between the thought worlds of designers and customers could lead to designs which sacrificed function for form and therefore displeased customers.

One way to reduce this chasm is to have designers go on a ride and drive with customers, who judge the interiors of our cars and those of our competitors. Somehow this direct experience – compelling, emotion-laden, and episodic – does more in one afternoon than all the data we may have provided about customer priorities.

1.2.2   How Does One Nurture Shared Intuition?

It is not just the chasm between the thought worlds of designers and customers that presents a problem. The chasms between the thought worlds of designers and engineers and marketers *within* the company also present problems.

Perhaps the best example of how to create shared intuitions among the functions is contained in the work of Dr. Edward McQuarrie, who won an MSI Best Paper Award for work he called *customer visits* (McQuarrie 1993). Although McQuarrie's work has been in business-to-business products, we have modified it for work with our products.

According to McQuarrie, customer visits are not "ad hoc visits to a few haphazardly selected customers". Rather they are characterized by three rules. The visits should be (1) made personally by the key decision makers (2) in cross-functional teams (3) according to a well articulated plan, with stated objectives, careful sampling, a focused discussion guide, and a plan for disseminating the results.

He highlights the benefits of cross-functional customer visits. The information derived from these visits is, in his words, credible, compelling, detailed,

complex, novel, contextual, and nonverbal. This leads to higher motivation to respond, higher potential for change, deeper understanding, and more opportunity to generate innovations.

Because these visits are cross-functional, they decrease disputes and misunderstandings, and they increase consensus and integration between functions. In effect, each function improves not just their skill at thinking like a customer but also the skill of thinking like their colleague. They cross-pollinate their intuitions and optimize their actions at the group level and not the individual level.

We can now turn to the specific examples of how our work has changed to adopt the "nurtured intuition" approach.

Example 1: Inspirational Research

Our interpretation of customer visits is what we call Inspirational Research, which is defined more by its two goals than by specific methods. The first goal is to enkindle in the company's minds a deep empathy and understanding for the customer which should lead to products which connect with those customers.

We want to be able to go beyond our descriptive data and understand our customer in a *deep* manner. We want to understand their *dynamic* lives (as opposed to a static set of data). We want to know the customers *as individuals* (not as a collection of population averages). We seek to understand the customer using the product *in context* (not decoupled from that experience and placed in our contrived research setting). We want to know how their lifestyle leads to their product choices. In short, we want to know the personal side of our customers.

While sitting at their desks, the company minds may not recognize how today's customers think and make decisions. But they are certainly aware of state-of-the-art designs and engineering solutions and they probably are the in-house experts on design or engineering trends. Therefore a merging of these company and customer minds, especially when the dialogue is two way and lively, provides a fertile ground for ideas to spring forth in the creative minds of the company.

Second, we want to help the company minds converge. We want them to leave the research event with a focused vision of the product they want to develop and the work they will need to do to realize this vision.

We seek to have the team come away from the event with an agreed upon understanding of the customer and how the company's product and brand will fit into their customers' lives. But we also want them to come away with a better understanding of their colleagues and how their joint decisions can make the product better. By the end of the inspirational event, each functional specialty should clearly state its goals going forward and the other functions should understand them and agree with them. The package of goals should fit together nicely.

Activities Aimed at Seeing Through the Customers' Eyes. How do we nurture intuition? Despite my earlier assault on the "information as food" metaphor, we begin with a lay of the land: what we know about current customers, about our brand's strengths and weaknesses as well as those of our competitors. And we consider how

the world will be changing over the course of the program. All of this is based on large sample, quantitative data. The team discusses what it thinks this data means and what questions it surfaces.

But this doesn't help us see through the customers' eyes. In fact this sort of analysis sanitizes all the personal aspects out of the data. And sometimes the most valuable, insightful information is impossible to capture and communicate.

So we make sure that we include activities where the company minds see what the lives of their customers are like. We see what their tastes are and how those tastes fit into their lifestyles. And we also see how our product fits into their lives.

Small cross-functional teams visit people's homes and examine or inquire about various aspects of the person's daily life, their key belongings, their tastes, and their favorite products. By studying what already connects with our customers, we are better able to develop products which connect (Homma and Ueltzhöffer 1990).

While at their homes, we also go on typical drives with them and observe how they use their vehicle, what emotions it conjures up and how it conjures them. We may also have them drive a set of vehicles to surface strengths and weaknesses of the competitors, while we watch. All of these activities help us see through their eyes.

We also have a more controlled setting to study their tastes through a line of work we call Value Cues Research. Every brand is meant to stand for some customer benefit or value, such as safety, elegance, or optimism. Designers and engineers want to know how to communicate these values to customers. We ask customers to take photographs of products they like which communicate each value and they discuss the results with our team. The results come, not in numbers but in images of real objects, the language that designers especially think in.

We encourage our team members to sketch solutions to problems while at the research event. Instead of market research data coming back in the form of numbers, we bring back an identification of a customer issue and the initial solution that a team member identified. In a sense, we are s*tocking the shelves* with partially developed, customer-inspired ideas that we can later refine.

Perhaps the most common example of inspirational research has been to "take the studio to the customer". In this approach, we use the sketches and scale models in the studio as tools to generate discussion with customers who may other wise have difficulty articulating their "sticky information" but have no problem telling us which of several hundred sketches is appealing, or is most innovative, or conveys what we want our brand to convey.

As can be seen, the activities which attack this first goal are varied and growing, but everything is aimed at seeing through the customers' eyes.

Activities Aimed at Integrating the Company Minds. These activities are of two kinds. The first involves only the company minds. We meet in teams and surface our deeply held feelings and views about our brand and product as well as those of our competitors. For this we bring in all the information we have available from both quantitative and qualitative work. We have a "war room" and we place all the research questions we brought on the walls. After each meeting with customers we brainstorm what we are learning and in so doing, we evolve our group intuition.

We also rely at times on the use of metaphors (Clark and Fujimoto 1990; Zaltman and Zaltman 2008) for surfacing deeper thoughts and feelings held by team members. (This is a method we make heavy use of with customers too.) For example, we ask "If Cadillac were an animal which one would it be and why?" "If Mercedes were a party, who would attend? What would they wear? What would they do?, etc." "If our product concept were an animal, which one would it be and why?"

The reasons given reveal deeply held views and we seek to resolve differences among team members after we surface them. We also seek to clarify how our product or brand differs from its competitors. Out of repeated engagements with this sort of exercise, coupled with the customer-related activities, the team can agree on a core metaphor.

The second kind of activity involves in depth face-to-face meetings with customers as described in the last section. But because these are cross-functional, the *sticky information* is collected jointly which helps to integrate the conclusions drawn. And the engineer and designer, for example, reveal their own "questions of importance" and in so doing help each other understand how they think.

The culmination of all Inspirational Research is a set of "Key Insights" written jointly by the cross-functional team. The process of writing this is in and of itself a purifying act – it surfaces disagreements and forces resolutions. The final document is valuable too, but perhaps not as valuable as what endures in the minds of the team.

While it is difficult to quantify the success of this approach, one tell tale indication is pervasive. Everyone who takes part in Inspirational Research, from members of our team to the customers who we engage, has come away with a very positive appraisal of its benefits. Our teams always express a deeper understanding of who their customers "really are". Our teams are unified in the actions they take afterward. And customers are thrilled at the chance to engage directly with product teams.

There are of course concerns that this general approach raises. An obvious first concern is that the team can only meet with small samples of customers and the conclusions drawn may not be representative of the larger market.

Small Samples. We first seek to minimize this problem by coupling the deep understanding we get in face to face meetings with data drawn from larger samples. This occurs in the initial briefing and it also shows itself in the video results we bring back. On edited video records of our Lifestyle Research, we overlay large sample results to bring the individual's responses into perspective.

The concern about small samples begs the question of what "small" is for learning of this sort (i.e., direct experience with members of the category). The human mind is quite capable of abstracting out central tendencies from experience. For example, after seeing several paintings by Renoir, you are pretty good at recognizing others by him. How many examples of his paintings would you have to see to learn his style?

There is evidence in academic psychology that by encountering as few as 12 examples of a category, you can recognize later members very accurately (Hartley and Homa 1981). This finding is quite similar to results found by market researchers (Griffin and Hauser 1992; Zaltman and Higie 1993). Therefore, we make sure that every team member interacts with at least 12 customers.

Divergent Conclusions. Another problem with this type of work is that individuals within the company might come away with different conclusions. So we intersperse periodic cross checks to compare notes and summarize points of agreement among the company minds. For example, we might break into teams with each one visiting the homes of two different customers in the morning. We would convene for lunch and go over what we had been learning. Differences would be noted and hypotheses would be suggested.

Later interactions would be followed by other cross check meetings where we would continue to update our shared learnings. And of course we document our final conclusions in the Key Insights and distribute them to the team in the form of specific functional goals that everyone agrees to.

Selling the Results Back Home. It is one thing to be personally inspired in this activity. It is quite another to sell that inspiration to your colleagues who remained at work while you were away. We address this problem in three ways.

First, we ideally return with video records that can be used to bring our conclusions to life.

Second, because the team was made up of representatives from each function, the results are brought back by *disciples* who are distributed among the staffs. This personal envoy can also make the results come to life and assure the team that their viewpoint was represented in the discussions.

And finally, the "proof is in the pudding". Many of the results are in the form of sketches or ideas linked to customer needs and tastes. These ideas are thereafter subject to further testing with larger samples. So we let them speak for themselves.

Example 2: Iterative Design

A clear idea of the difference between the nurtured intuition philosophy and the "information as food" philosophy is seen in the evolution of theme research at General Motors. The traditional way of doing theme research (i.e., research aimed at understanding how customers react to designs) was for the market research department to show designs – or sometimes just one design – to customers, get quantitative ratings and qualitative discussions, and then write a report of "the official" interpretation of the results.

Because the market researchers saw their job as delivering information, and because they wanted this information to be as accurate, thorough, and unbiased as possible, they spent 2 weeks writing the report. Then the results were presented in a large meeting to interested parties from Design, Engineering, Marketing, and upper management.

Of course, in the intervening 2 weeks, many usually divergent conclusions had infiltrated the different functions. These conclusions were based only on what people had seen in the focus group discussions and so they were influenced greatly by confirmation bias. Typically, the design team drew their own conclusions, which "fit" their desired outcome, and took actions to evolve their design according to what they heard.

So when the meeting finally occurred and the official results were delivered, momentum at Design Staff had already mobilized behind their conclusions, which often went against the desires of other functions. This meeting then became the battleground for airing differences between the functional areas. The customer voice often was drowned out.

Traditionally, we would do two theme studies, separated by perhaps 6 months. Between theme studies, the design would undergo hundreds of modifications, with influences from dozens of sources, such as reactions from various layers of design management, marketing, engineering, upper management, and even from competitive activity. What we would not know however was how customers would react to these changes.

So when we returned to the next theme study, the differences between the theme tested at the first study and at the second would be numerous. Hence differences in the customer reactions could not be linked to any particular design change.

There were huge problems with this approach. Theme research had become a place for entrenchment and opposition between design and other functions. Customer feedback was wielded as a weapon between functions and not as a way to improve the design. Design decisions were made before the results of the study were unveiled and, once made, were resistant to change. Designers got essentially only two swings of the bat (and sat on the bench most of the time!). The linkage between a design action and the customer reaction was not learned.

So we set out to improve theme research. We felt that if designers could get the feedback instantly and directly, insulated from the battleground atmosphere that had sometimes characterized traditional theme research, they might use it more earnestly.

We set up a design studio at the study site itself and conducted what appeared to be a traditional theme study. But it differed in critical ways.

The research and design teams acted in unison, with design questions quickly fed into the research process and research results quickly fed into the design room. Negative customer reactions were probed to find out their exact source, leading to design hypotheses about what to change. Often we allowed the designer to ask questions directly to customers, which facilitated a more direct, intuitive form of learning.

The designers would react with new designs, based on these hypotheses, which would then be shown to customers during interviews. In short, designers took many "swings of the bat" with immediate feedback. This culminated in what was essentially a second theme study a few days later with both old and new designs shown so we could measure if the design hypotheses were right.

Because customers are much better at reacting to designs than telling us what to change and how to change it (because this information is sticky), the interjection of the designers' minds and hands into the research process itself was crucial. The result of all this activity was that designer intuition and their skills at connecting with customers through design were encouraged to ascend the learning curve.

The true output of this type of study is not a report, although we do issue one within 2 days. The real value is in the trajectories between the old and new designs

and the customer influence that led to them. It is the gain in intuition that a designer gets by trying different design solutions to customer rejections. No designer in these iterative studies has ever done anything that runs counter to their own instincts. Rather they seem to find those designs which fit their own intuition and also fit the customers' desires.

To date, this approach has been extremely successful. The percentage of programs which are green at the final test (i.e., their appeal score is significantly higher than all designs tested) has gone from under 50%, when not using iterative design, to 92% when using iterative design. Similarly, the average percent of respondents who rated the design as "Very Appealing" has gone from 16% to 30%.

Perhaps most noteworthy though is that designers speak often about the knowledge gained from the experience of iterative design. We expect the intellectual capital of our designers to blossom, in terms of a growing empathy for customers, as we make this a standard practice.

1.2.3 How Will the Nurtured Intuition Philosophy Change Company Behavior?

Because the nurturing of intuition in decision-makers requires their active participation, they must change their own conceptualizations of what constitutes their "work". So market researchers will have to convince them that it is in their interest to take part in face-to-face dialogue with customers.

This is not an easy task, since few executives question their own intuition, as Deshpande showed, and their days are already full of other activities. Nonetheless, executives will have to rebalance their calendars to accommodate the added time needed to improve their intuition. The best market researchers in this "nurtured intuition" world must be good scientists, yes, but must also be capable of convincing executives to question their own intuition.

Market researchers must also come to judge their activities by how well they improve the decision-making *skills* of their colleagues, not by how much information they transmit nor even by how impeccable it is. Like any skill, the best way to learn it is through experience with direct feedback, and so researchers would need to arrange these.

A "nurtured intuition" researcher would first identify the skill they wanted to nurture (e.g., designing cars for women) and then set up guided experiences in which the colleague made a decision, got feedback, modified their decision, got additional feedback, and so on. In short, the researcher would help the decision maker take as many swings of the bat as he could, helping the swings get more productive and accurate over time.

The training of most researchers and executives matches the "information as food" model much better than the nurtured intuition model. The latter requires a much different set of "researcher" activities; in fact the term "researcher" is probably not broad enough. We now must facilitate exchanges between minds in ways that lead to better decisions.

All of which is to say that we have a lot of work ahead of us. In fact, there is evidence that husbands and wives are mediocre at intuiting the product choices of their mates (Davis, Hoch, and Ragsdale 1986). "How can we do better?", you may ask.

I truly believe that we must take on this apparently unassailable summit – intuition – directly. The first step is to replace the "information as food" metaphor with the nurtured intuition metaphor. Under this new conceptualization, information is still vital – note how we used it as feedback in iterative design – but it's value is closely tied to how well it can improve another's intuition and targeted skills.

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Chapter 2
Design Creativity Research

Amaresh Chakrabarti

Abstract We take *design as a plan* by which some undesired reality is envisaged to be changed into some desired reality. It is the plan for creation of an intervention, e.g., a product or a service, with which to bring about this change. *Designing*, or design process whereby the *plan is conceived and embodied*, starts with the perception of the need for a design. Products and the processes of their creation have undergone considerable changes over the last decades. Products have become more complex, and stronger customer awareness and stricter legislation resulted in shorter product life cycles and tighter requirements. Products have to be technically as well as commercially successful. In order to be able to cope with these changes and remain competitive, new approaches to improve effectiveness and efficiency of the product development processes are needed. The overall aim of design research is to support practice by developing knowledge, methods and tools that can improve the chances of producing a successful product. In this chapter, we provide an overview of the broad issues that are investigated in design research, introduce DRM - a design research methodology developed for systematic exploration of these issues, and provide an overview of research at IdeasLab, Indian Institute of Science (IISc) in the areas of design creativity. The following questions are addressed: What is creativity? How can it be measured? What are the major influences on creativity? How does exploration of design spaces relate to creativity? How well do designers currently explore design spaces? How can creativity be supported?

2.1 Design, Design Research and Its Methodology

We take *design as a plan* by which some undesired reality is envisaged to be changed into some desired reality. It is the plan for creation of an intervention, e.g., a product or a service, with which to bring about this change. *Designing*, or design process

A. Chakrabarti (✉)

Innovation, Design Study and Sustainability Laboratory (IdeasLab), Indian Institute of Science, Bangalore 560012, India

e-mail: ac123@cpdm.iisc.ernet.in

whereby the *plan is conceived and embodied*, starts with the perception of the need for a design. Products and the processes of their creation have undergone considerable changes over the last decades. Products have become more complex using new technological developments and integrating knowledge of various disciplines. Increasing competition, stronger customer awareness and stricter legislation resulted in shorter product life cycles and tighter requirements. Products have to be technically as well as commercially successful. As a consequence of product changes, the product development process has changed. Complexity, quality pressure and time pressure have increased. New approaches to improve effectiveness and efficiency of the product development processes are needed to be able to cope with these changes and remain competitive.

The overall aim of design research is to support practice by developing knowledge, methods and tools that can improve the chances of producing a successful product (Blessing et al. 1992, 1995, 1998; Blessing and Chakrabarti 2002, 2008). This aim raises questions such as
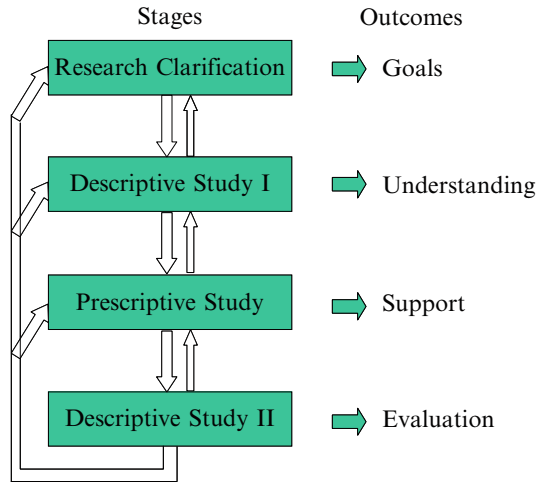
- What do we mean by a successful product?
- How is a successful product created?
- How do we improve the chances of being successful?

The first question leads to issues such as what criteria to be used to judge success, that is, what measures will determine whether our research has been successful. The second question leads to issues such as what the influences on success are, how these influences interact and how to assess them. Investigating these issues would increase our understanding of design which is needed to improve the design process. The third question gives rise to issues related to the translation of this understanding into design methods and tools and to the validation of these methods. Validation is needed to determine whether the application of these methods indeed leads to more successful products as determined by the criteria.

A pure product-focused research effort cannot resolve these issues. That this has been recognised is shown by the increasing number of studies of the way in which a design process actually takes place – to increase understanding on this process – both as a cognitive and a social process and in the organisation. Traditionally this is not the type of research conducted within engineering and it is not possible to transfer research methods directly from other disciplines – a new approach is required. To address these issues in an integrated and systematic way, a research methodology specific to studying and improving design as a phenomenon is needed.

Two characteristics of design research require the development of a specific research methodology. First, the selection of research areas is not straightforward due to the numerous influences and interconnectivity between them. Design involves, among others, people, products, tools and organisations. Each of these is the focus of a particular discipline with its own research methodology and methods, such as social science, engineering science, computer science and management science. Design research is therefore bound to be multidisciplinary. An additional complication is the uniqueness of every design project. This particularly affects repeatability in scientific research. The second characteristic of design research is that it not only

Fig. 2.1 DRM stages, links
and outcomes

Stages   Outcomes

Research Clarification   ➡ Goals

Descriptive Study I   ➡ Understanding

Prescriptive Study   ➡ Support

Descriptive Study II   ➡ Evaluation

aims at understanding the phenomenon of design, but also at using this understanding in order to change the way design is carried out. The latter requires more than a theory of *what is*; it also requires a theory of *what would be desirable* and how the existing situation could be changed into the desired. Because this cannot be predicted, design research involves design and creation of methods and tools and their validation. Methods from a variety of disciplines are needed.

Figure 2.1 introduces DRM (Design Research Methodology) – arguably the most widely used methodology for design research. A simple example is used to clarify its main stages.

2.1.1   Research Clarification: Identifying Goals

The first stage is to clarify the aims and objectives of the research, with the resulting identification of the criteria for success of the research. For instance, in an example research a reduction in time-to-market may be identified as a criterion for success. This provides the focus for the next step and is the measure against which a design method or tool developed in the research would be judged.

2.1.2   Descriptive Study I: Understanding Current Situation

In this stage, observational studies are undertaken to understand what factors currently influence the criteria for success, and how. In the example case, a descriptive study involving observation and analysis may show that insufficient problem definition relates to high percentages of time spent on modifications, which is assumed

to increase time-to-market. This description provides the understanding of the various factors that influence, directly or indirectly, the main criterion, in this case time-to-market.

2.1.3 Prescriptive Study: Developing Support

In this stage, understanding of the current situation from the last step is used to develop a support (methods, guidelines, tools, etc.) that would influence some of the factors to improve their influence on the success criteria. For instance, in the example case, based on the outcome of the descriptive study and introducing assumptions and experience about an improved situation, a tool is developed to encourage and support problem definition. Developing methods and tools is a design process in itself.

2.1.4 Descriptive Study II: Evaluating Support

In this stage the support developed is applied and a descriptive study is executed to validate the support. In the example case, this included two tests. The first test is whether problem definition is supported. The second test is whether less time was spent on modifications, and whether this, in turn reduced the time-to-market. There might be reasons as to why the second test fails, such as side-effects of the method.

Note that design research embraces both traditional, analytical research, and interventional, synthetic research. While its Descriptive Study stages involve understanding a given situation (with or without the support) as the primary motive, and therefore are primarily analytical in nature as in research in the natural sciences, its Prescriptive Study stage involves a synthesis activity, developing interventions to change the current situation. Unlike in the natural sciences, understanding a situation in design research is not per se the goal, but only a means to change the situation for better.

2.2 Objectives of This Paper

The rest of this chapter provides an overview of research at IdeasLab, Indian Institute of Science in the areas of design creativity. The following questions are explored:

- What is creativity? How can it be measured (Section 2.3)?
- What are the major influences on creativity (Section 2.4)?
- How does exploration of design spaces relate to creativity (Section 2.5)?
- How well do designers currently explore design spaces (Section 2.6)?
- How can creativity be supported (Section 2.7)?