Web-Enabled Customer Design and Configuration as a Method of Informing the New Product Development Process

by
Sandra M. Corbett Kramm
B.S., Mechanical Engineering (1996)
GMI Engineering and Management Institute

Submitted to the System Design and Management Program in Partial Fulfillment of Rcquirements for the Degree of Masters of Science in Engineering and Management

AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY, FEBRUARY 2001.

Signature of Author:
Sandra M. Corbett Kramm
System Design and Management Program

Certified by: ______________
Thesis Supervisor: Ely Dahan
Assistant Professor of Marketing and Management Science

Accepted by: ______________
LFM/SDM Co-Director: Stephen C. Graves
Abraham Siegel Professor of Management

Accepted by: ______________
LFM/SDM Co-Director: Paul A. Lagace
Professor of Aeronautics & Astronautics and Engineering Systems

Web-Enabled Customer Design and Configuration as a Method of Informing the New Product Development Process

by
Sandra M. Corbett Kramm

Submitted to the System Design and Management Program January 2001 in Partial Fulfillment of Requirements for the Degree of Masters of Science in Engineering and Management

1 Abstract

When embarking on the early phases of designing large and complex products, the product development team is faced with an overwhelming abundance of design options. The emphasis of this present work is on how design options can be narrowed in an effort to meet both the customer needs and the requirements of the product development process. This paper addresses how and when a product development team should fully exploit emerging web-enabled marketing techniques in resolving design uncertainty very efficiently.

The web-enabled marketing tools, "Web-based Conjoint Analysis (WCA)" and "User Design (UD)" as described by Dahan and Hauser, (2000) are demonstrated on two product examples; an emerging automotive vehicle segment, the crossover vehicle, and on a vehicle telematics system. Telematics refers to the convergence of telecommunications and internet connectivity in the automobile, and enables products and services that seamlessly transport information and data to and from a vehicle.

With a limited sample size, the data from WCA and UD are compared and show good correlation. It is possible to predict fairly consistently what a consumer will design using the drag and drop method, by comparing their utilities obtained in the conjoint.

The user design technique offers many benefits, the greatest being its interactivity with the respondent. It is this engaging interactivity of user design that defines its uniqueness as a marketing tool.

A method for translating the customer needs gathered during this type of testing is also discussed. It lends itself to the utilization of web-based customer design and configuration testing in an iterative way. The benefits of user design make this iterative approach a possible and very attractive option for design teams.

Advisor: Ely Dahan
Title: Assistant Professor of Marketing and Management Science

2 Acknowledgements

I wish to thank Ely Dahan, Asst. Professor of Marketing and Management at MIT, for his much needed guidance and support throughout the SDM thesis research process. I would also like to thank Ford Motor Company for supporting my efforts, both financially and professionally, through the completion of the MIT SDM program.

3 Table of Contents

4 List of Figures

5 Introduction

5.1 *Motivation*

As engineered products become more and more complex, the function of the system architect has become more steeped in upfront planning and decision-making. The product development team needs a prescriptive means for identifying customer attributes that are valued and that can therefore, elicit higher customer satisfaction ratings for their products.

A web-enabled customer design and configuration tool is available for soliciting these needs, which can then be utilized in prioritization of features and resources during the new product development life cycle. This research looks at this method for resolving uncertainty as an attractive alternative to those currently used in the early stages of the design process. This allows for the design team to prioritize features early that will eventually offer the highest customer satisfaction leverage.

5.2 *Thesis Goals*

The main objective of this work is to determine if the user design method is appropriate for informing the product development team. Its consistency with the conjoint technique will be analyzed. Specifically, user design and web-based conjoint methods will be tested and compared to determine if what is dragged and dropped in an ideal design is consistent with what the respondent implied in their conjoint utilities.

User design will be presented as an attractive technical method for the determination and the narrowing of product attributes at the front end of the product development process.

With this emphasis on leveraging customer preferences as the key to designing products, this paper will demonstrate the benefits of the user design method in resolving uncertainty more efficiently than with traditional approaches. The conjoint analysis utility function will be compared with the choices made in the customer's ideal configuration.

Another goal is to identify the need for, and suggest a framework that effectively translates customer wants into design decisions. This needs translation is a necessary step when systems of components provide the valued customer service or attribute.

6 Overview of Methods

The following overview of web-enabled marketing methods assumes that the researcher or product development team has already identified a selection of product needs and features through both customer input and creative ideas generation by the product development team members. Dahan and Hauser (2000) summarize many of the methods that are commonly used to elicit these very early, upfront needs and generate creative ideas among team members during what they refer to as the fuzzy front-end stage of the product development process. The summary of some of these methods used in this fuzzy front-end stage include the use of focus groups, surveys, interviews, affinity diagrams, and actual user observation, among others. McQuarrie (1996) cautions the product development team to use customer feedback in this step, "Don't try to put together the attributes for use in a choice modeling by huddling around a white board with your colleagues. Do go out into the field and use customer visits, focus groups, and other exploratory techniques to identify these attributes and ascertain the words customers use to represent them." These product needs and features are what will later be used as the design attributes of the product to be tested in the following two methods. The quality of the choices made during this step is very important as they act as the starting point for the testing.

6.1 Web-Based Conjoint Analysis (WCA)

Tradition conjoint analysis methods were developed in the early 1970's and have become widely used in the new product development process-for selecting among alternative product designs, targeting, and pricing (Dolan, 1990). Web-based conjoint (WCA) (Dahan and Hauser, 2000) has emerged to overcome some of the limitations of the traditional design; these include cost, speed, administrative burden, and a difficulty in communicating the actual product concepts with their bundles of attributes to the customers. WCA employs the capabilities of the internet and world wide web to do this and expands the capabilities of the traditional conjoint.

Dolan's (1990) stages for development of a conjoint test hold true for the WCA method and are shown in Figure 1. And although the steps remain the same for WCA, WCA is profoundly different in the approach and execution of the following steps.

The 1^{st} and 2^{nd} stages of the experiment design relate directly to what the test respondent will be asked about. Identifying attributes, stage 1, was discussed earlier as part of the fuzzy front-end stage of product development and is not unique in the design of a WCA test. These attributes are features that the design teams already know matter to the consumer, what this type of testing is trying to identify is precisely how important each attribute is to the consumer.

Figure 1- Decision Stages in Conjoint Study (Dolan, 1997)

1. Determine Relevant Attributes

↓

2. Choose: Stimulus Representations (i.e., how products will be described to respondents)

↓

3. Choose: Response Type (i.e., Judgments respondents will give: choice among alternatives, rankings, ratings)

↓

4. Choose: Criterion (i.e., the standard to be used by respondents: liking, preference, likelihood of purchasing)

↓

5. Choose: Method of Data Analysis

The 2nd stage in the WCA eliminates the need to rely on only text to explain the attributes to the respondent, a downfall of the traditional test that could lead to confusion or even in influencing the attribute values. The capabilities of the internet enable a media rich pictorial representation of product concepts which allows the respondent to view and interact with the product concepts in a virtual way. Ariely (2000) and Klein (1998) have shown that this type of media richness and respondent interaction improves both decision quality and memory. And although some research (Dahan and Srinivasan, 2000) suggests that an even more media rich approach of using animation of a product concept yields the same results as a static representation, animation may be beneficial in presenting hidden features, aesthetics, or ease of use of certain concepts. The researcher should consider this when determining how their product will be represented visually to the customer. Another benefit of the virtual representation on the web, is that the site visuals can be linked back to feature descriptions allowing the respondent to very easily, with a click of a mouse, learn about any of the features present on the current product that they are viewing. Again, this enhances the respondents learning and interactivity with the task.

The 3rd and 4th stages relate to how the respondent will be asked to respond to the attributes. This could be either a choice among alternatives, rankings, or ratings. These choices can remain the same for WCA although the task for the respondent is enhanced as they 'click' through their responses to the design.

And the final, 5th stage is the analysis of the data gathered. The collection of data while using the web is direct and instantaneously. The administrative burden is lessened and total time to complete the entire study will be shortened. Attribute worth's or utility functions can be calculated and other analysis, such as clustering; can be done at this time. An even greater benefit of the web capability for collecting the consumer choices directly would be to link the spreadsheet and have it configured to automatically run certain analysis with pre designated output graphs such as test correlations.

6.2 User Design and Configuration (UD)

Another inventive approach to utilizing the internet as a means of understanding customer preference in concept designs is a method known as User Design (UD) (Dahan and Hauser, 2000). In theory, it puts the test respondent in the engineers or designers seat and allows them to in fact design their ideal product within the given category. The respondent is limited to the features and levels that are pre-designated by the researcher. In our later examples, the same attributes are used for both the WCA test and for the UD test although price in the UD test is not considered to be independent, it is tied directly to the feature options. User design allows the respondent to make tradeoffs among the attributes and their levels by using a drag and drop method in a virtual design space. In real time, the customer sees the consequences of their decisions; both in terms of the product taking form visually as they choose their ideal level of an attribute but also in terms of the price tag changing with each feature that is dragged from the features bin to the ideal product canvas. The customer can continue to manipulate the design configuration until there is a satisfaction with the combination of features and the price point that has been achieved; hence this becomes their ideal design.

In theory, with respect to a comparison with conjoint analysis, this method indicates their highest rank of all possible design permutations given all of the attributes and their corresponding levels. It is another tool that the product development team can use to constrain the list of possible design features and can influence their designs by placing priority on certain features.

Park, Jun, and MacInnis (1999) have shown that the way in which a product is initially proposed to the respondent has a definite effect on how they will choose among the various features. These researchers prove that option-framing yields very different results when a consumer is designing their ideal product. Option-framing can present the consumer with a either a fully loaded product, where they must then delete options, or it can present them with base model (no options) where they are then asked to add options,. The later, additive option framing results in the consumer choosing fewer options with a lower total option price. Therefore, researchers that employ the User Design method need to be aware of the implications of the initial configuration shown to customers. It would be of benefit to vary this starting point among the respondents to realize the actual value delivered by the options that are traded off by the consumer and thereby associating their willingness to pay for certain features.

7 Cross Over Vehicle Tests

The example that is used to demonstrate both the web-based conjoint method and the user design method is a new emerging class of vehicles known as the cross over vehicle segment. It combines many of the elements and advantages of the SUV, the minivan, and a luxury sedan. These shared characteristics include improved seating and cargo capability, a smooth car-like ride, an appearance incorporating styling cues from all three classes, and all wheel drive functionality. Examples of this segment that are currently available in the marketplace include, among others, the Toyota Highlander, the Lexus RX-300, and the Mercedes Benz ML320.

7.1 Design of Experiments

Ely Dahan and I conducted the following tests at MIT. There was a suite of four different web-enabled tests and one paper-based choice test relating to the cross over vehicle segment administered to 42 people. Two of the tests, WCA and UD are highlighted in this paper, and the paper based choice test is also presented for further data comparisons.

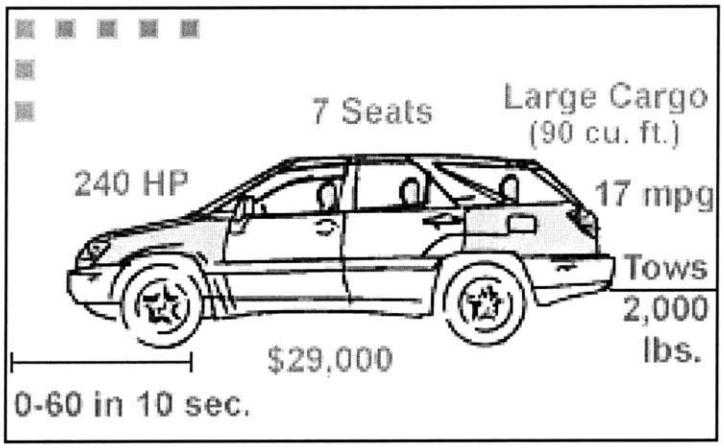
7.1.1 Web-based Conjoint (WCA) with Cross Over Vehicles

The customer needs identified as attributes for the cross over vehicle are summarized in Figure 2. Each is offered at two different option levels.

Figure 2 – Crossover Vehicles Attributes for Web-based Testing
(Note the correspondence between the attributes in the table and those shown in Figure 3)

	Product Attribute						
Alternative Levels	**Seats**	**Cargo**	**MPG**	**HP**	**0-60 time**	**Tows**	**Price**
Lo	5	50 cu.ft.	**17mpg**	185 hp	**10 sec.**	**2000 lbs.**	$37,000
Hi	**7**	**90 cu.ft.**	23 mpg	**240 hp**	7 sec.	5000 lbs	**$29,000**

Figure 3 – One of the twelve product cards used in WCA



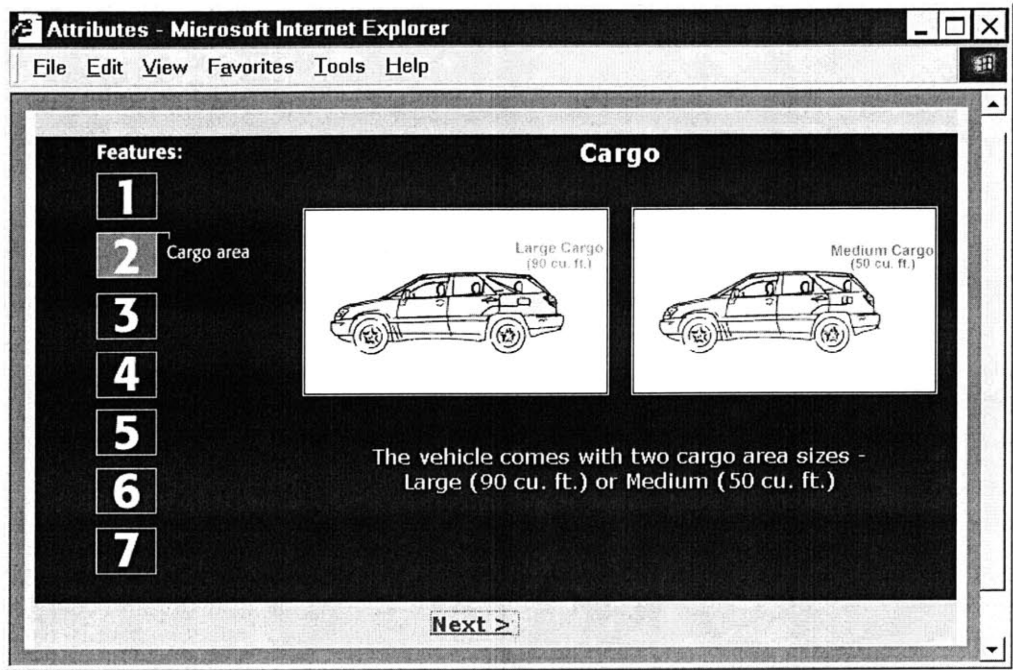
The seating option can be configured with either 5 or 7 places. The cargo area size options are 50 cubic feet or large at 90cu ft. The fuel economy option is designated by miles per gallon (mpg) and is available at 17mpg and 23mpg. The horsepower of the vehicle can be either 185 ft lbs or 240 ft lbs. The acceleration times from 0 to 60 miles per hour are at either 10 seconds or at 7 seconds. The vehicle can either tow 2000lbs or 5000lbs worth of payload. And finally, the two possible prices for vehicles are $29,000 and $37,000.

Given these features and levels, the number of viable product is 128 (2 x 2 x 2 x 2 x 2 x 2 x 2). Rather than asking customers to evaluate all of these available products, a fractional factorial orthogonal array was constructed which provided 12 product offerings "cards" with varying levels of features. Note that the term "card" is taken from the traditional conjoint test where it is common practices to place each product offering with it's different levels of attributes on one of twelve cards and ask the respondent to rank order the cards reflecting their order of preference or their likeliness to buy. Many commercially available software programs exist to aid in the design of an experiment such that the respondent is asked to evaluate a much smaller sample than the viable combinations. The 12 "card" array allows the researcher to gather tradeoff information among the features and establish utility values for each of the levels. By limiting the number of products, the consumer's task becomes much more manageable. Figure 3 is one of the twelve product cards used in testing. Note how the high-level options of HP, seats, cargo, and price, are designated in red text and areas of the vehicle are filled in to reflect these high levels. Low-level options of mpg, towing capability, and 0 to 60 time, is reflected in blue text. This is consistent across all 12 cards and both tests.

Each of the 12 web cards depicts a generic sketch of a cross over vehicle. The sketch is intended to represent the vehicle as a segment but does not intentionally depict any one brand. The changes in seat configurations are visible through the windows and are also highlighted or filled in with color to depict low level or high level of attribute respectively. The cargo differences also share the highlighting and filling in distinction and the sketch itself actually grows in the rear quarter panel area to depict the higher, 90 cubic feet option. The fuel economy option uses the gas tank door to draw attention to its differences. Highlighting or filling in the front quarter panel where the engine is housed illustrates the horsepower feature. Both towing and 0 to 60 times represent capabilities of the vehicle and visually, the sketch of the vehicle itself did not change. Towing options were shown with a trailing line from the bumper of the vehicle. And 0 to 60 times were indicated with a similar line extending from the front tires of the vehicle denoting either 7 seconds or 10 seconds. Note that all attributes on the cards were supported with text along with the visual depictions just described. The text followed a pattern, all test for low levels of attributes is in blue and all text for the high level of attributes in red. This is another way that this testing reinforces the differences between cards and attributes and should aid in the consumer's decision process.

The very important first stage of the actual web test experience is to navigate the respondent through a series of screens that aim to educate them regarding the attributes and their choice of levels. See Figure 4 as an example of one of these teaching screens. It teaches the respondent that there are two levels of cargo area, 50 cu.ft. and 90 cu.ft., and illustrates how these changes will be reflected in the card visuals. The final of the teaching screens, the price, also indicates to the respondent, that they should not infer lower or higher quality product based on price and that other than the features discussed, all vehicles are to be considered identical. Note that vehicle brand was not considered as a factor in this WCA. This independence of all of the attributes is an assumption of this conjoint testing.

Figure 4 – Web page used to teach respondent about attributes (Cargo)

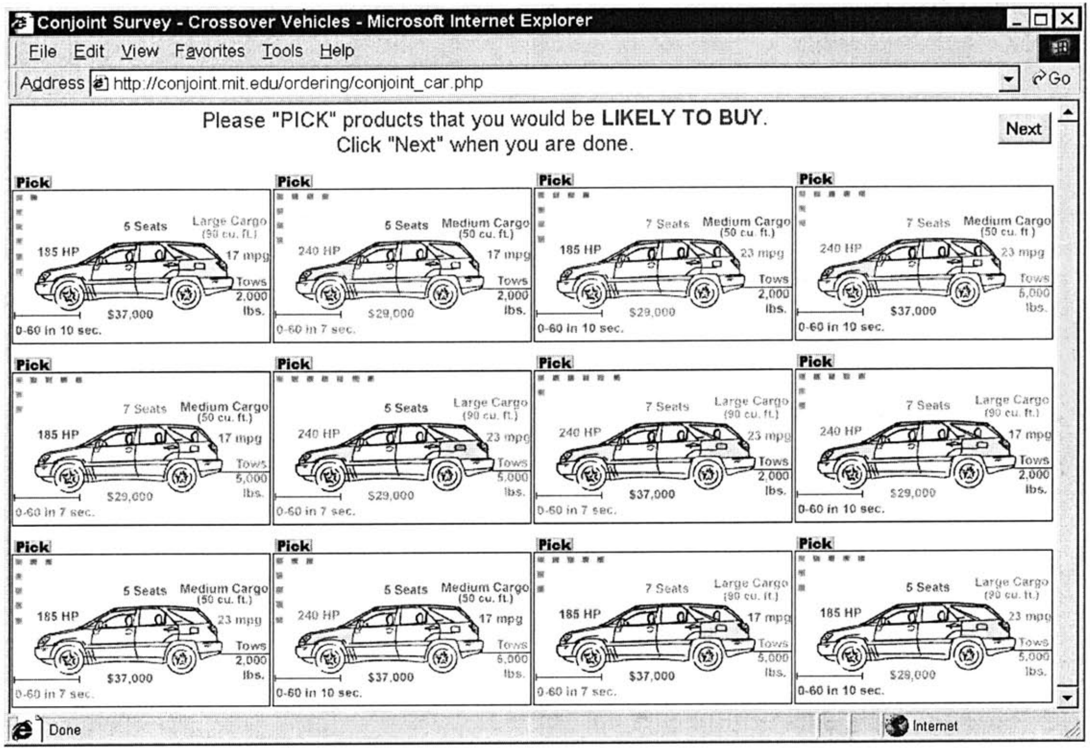


The task of sorting all 12 product cards is made less cumbersome for the respondents through the development of a procedure prescribed by Dahan and Hauser, (2000) that creates 3 different piles of cards as the respondent clicks through to identify:

- The products they would be "LIKELY TO BUY"
- The products they would be " UNLIKELY TO BUY"
- The remaining products are identified as "NOT SURE"

Figure 5 shows the first screen of the test, after the teaching phase, where the respondent is asked what products they would be "LIKELY TO BUY". Note that as the respondent makes product choices, they so by clicking on a card, then the chosen card disappears from that screen.

Figure 5 – Rank Order task for the Web-based Conjoint Analysis (Dahan, 2001)



When the 3 virtual piles are established, the respondent can then perform the function of rank ordering on these smaller piles. Two paired comparison question are then asked as error checks. The least likely vehicle of the "LIKELY TO BUY" pile is compared with the most preferred of the "NOT SURE" pile and the least liked vehicle of the "NOT SURE" pile is then compared with highest ranked vehicle in the "UNLIKELY TO BUY" pile. The three piles are then combined to give the overall ranking of the 12 product options. From this ranking the researcher can now establish utility functions (customer values) for each of the attributes.

7.1.2 User Design with Cross Over Vehicles

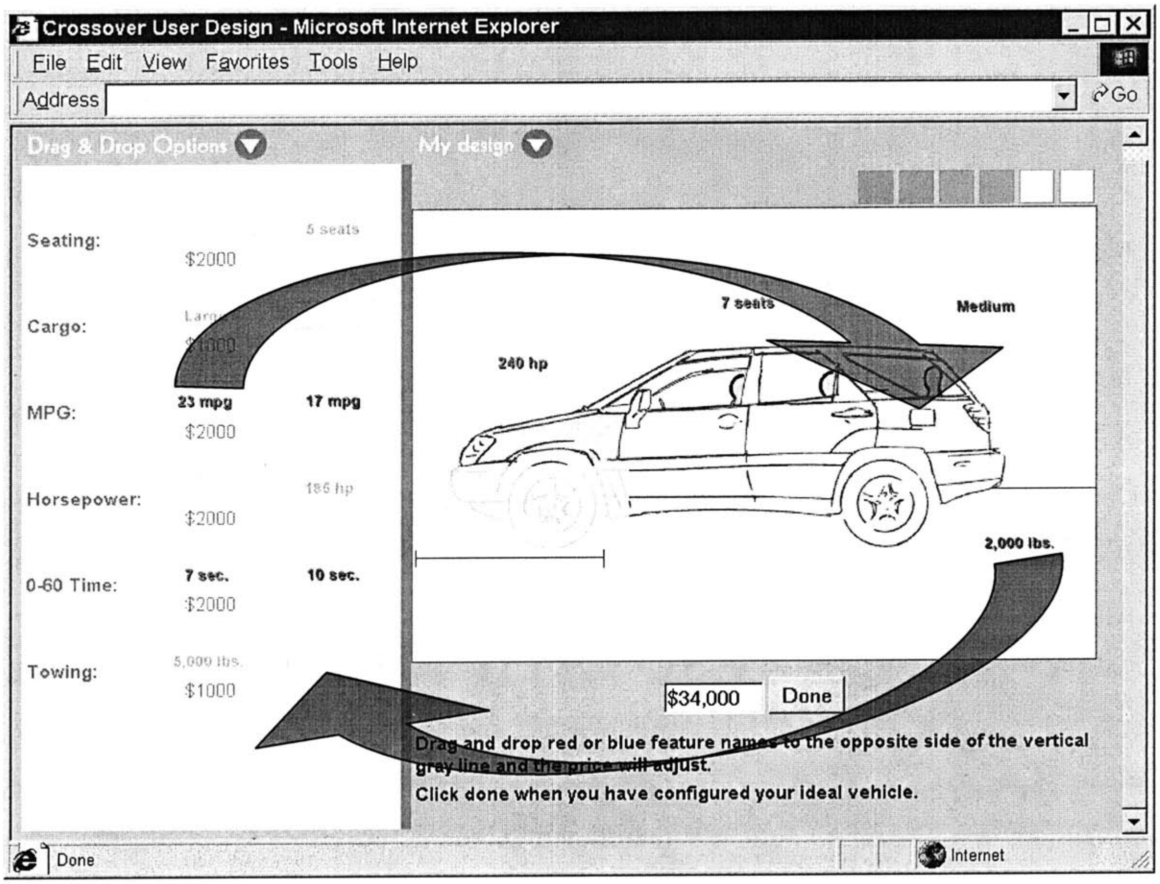
The User Design test for cross over vehicles utilizes the same attribute categories and levels as the WCA test described above, although in this test, the price is not constrained to just 2 levels. The overall vehicle price has a range from $28,000 to $38,000 and is reflected and updated as choices are made among the attributes. The consumer can use an iterative process of trading among the features until their ideal design, including price point, is reached. This is their ideal product. In theory, this would be the respondent's highest ranked card if faced with ranking all 64 viable product permutations, a much more cumbersome and time-consuming task.

Similar to the WCA, the UD test has a learning section as a precursor to the actual test. Rather than a series of screens, one for each attribute, this test uses one screen that allows the respondent to roll the cursor over a text list of attributes and immediately see how these choices are illustrated through the changes in the vehicle sketch. This gives an even more interactive approach than the WCA offered. Also, as a part of this learning section in this user design, the consumer is given an opportunity to practice the drag and drop method. They are shown a hypothetical feature, ride height, which they can drag and drop and watch the vehicle representation change accordingly.

The next screen asks for some personal data including email address, type of vehicle currently driving, and when and what type of vehicle they plan on purchasing next. the respondent moves to the next screen, which is the actual design space for their ideal vehicle. When this if complete, the respondent moves on to the actual design phase.

Figure 6 shows the actual design screen where the respondent will make their design choices. Note how a thick vertical line divides the survey page. The left side shows the available drag and drop options and the larger space to the right reflects the design area that changes as decisions and trade offs are made in the quest for the consumer's ideal vehicle configuration. Both price and visual representation of the vehicle are updated in this area.

Figure 6 – User Design of a Cross over vehicle (Dahan,2001)



Note that the base price of the vehicle shown when the respondent enters the design phase is $33,000, which is half between the highest price and the lowest price possible given the feature options. This price changes either positively or negatively by half of the feature price depending on whether the low or high level is chosen. For example, seating options is considered to be a $2000 feature. The vehicle configuration price would lower by $1000, and become $32,000, if 5 seats were chosen as opposed to the higher level of 7.

The consumer ends the test when they have made all of the trade offs of features that creates their ideal design at an ideal price based on their choices. User design provides an interactive, iterative process that is quick to complete and very engaging and fun for the consumer.

7.1.3 Paper-Based Cross Over Choice Test

Figure 7 represents a paper sheet that was given to the respondents after the WCA and UD were completed. The respondents were asked to pick their top 3 choices given the 8 real life vehicle options. Each vehicle is an actual brand and the attributes are ranked using a consumer's report rating ranging from the worst, completely filled black dot, to the best, completely filled red dot.

Figure 7 – Paper based Cross Over Vehicle Choice Test

Please rank your 1st, 2nd and 3rd choices at the given

	Pontiac Aztec	Mercedes-Benz ML320	Acura MD-X	Buick Rendezvous	Lexus RX-300	BMW X-5	Audi All-Road	Toyota Highlander
Seats	5	5 (7 opt.)	7	7	5	5	5 (7 opt.)	7
Seating Flexibility	◑	◑	●	◑	○	○	◑	◑
Cargo Volume	◑	○	●	◑	○	◐	◐	◑
Fuel Economy	●	○	◑	◑	◑	◐	◑	◑
Horsepower	◐	○	◑	◐	○	●	◑	○
0-60 acceleration	◐	◐	◑	◐	○	●	○	○
Towing Capacity	○	◑	○	○	○	●	●	○
Price	$24,000	$39,000	$37,000	$30,000	$36,000	$49,000	$42,000	$29,000

7.2 Data Analysis

This preliminary look into the availability and quality of user design as a method of informing the product development process is very positive. It appears to be very successful in capturing the preferences of customers indicated by their conjoint utilities although a much larger sample size would be needed to make these results statistically valid. There were only 42 respondents who took part in these tests.

The group was asked about their gender, the vehicle they currently own (figure 8), the vehicle they plan on purchasing next (figure 9), and the time frame in which they expect to be making their next vehicle purchase. Ideally, a product development team would like to have a sample of people who are already in their intended segment or are interested in purchasing within their segment. However, the features of a cross over, by definition, cross boundaries of the car, the minivan, and the SUV, so sample from those categories would not be excluded.

Figure 8– Vehicle type that respondent currently owns

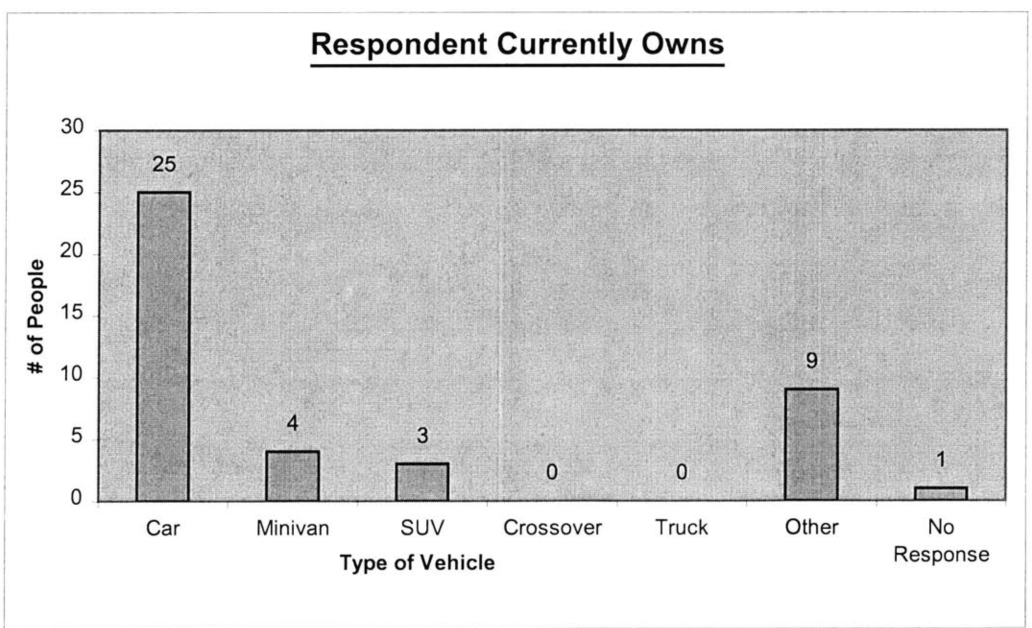
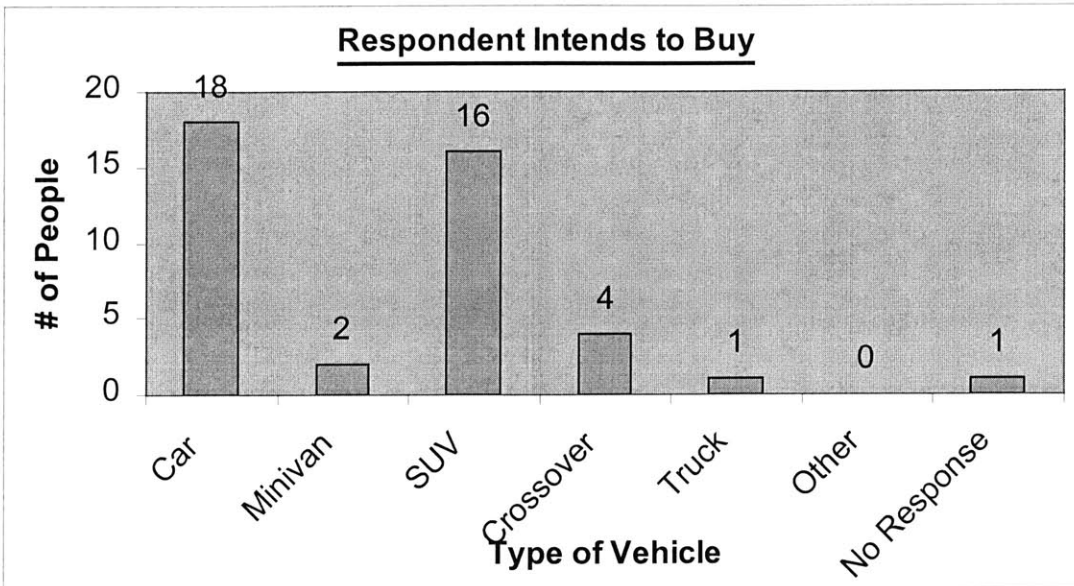


Figure 9 – Vehicle type that respondent intends to buy



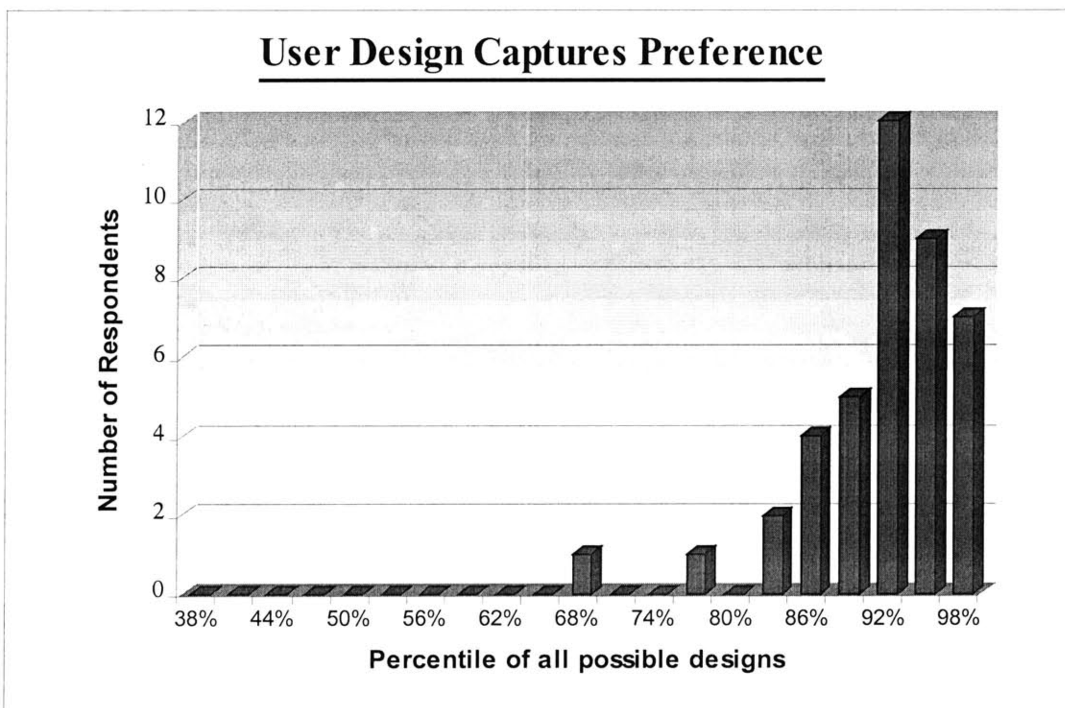
Notice that only 4 of these respondents plan on purchasing in the cross over segment. And of these 4 people, 3 are coming from a car currently and 1 comes from a minivan into this cross over vehicle purchase. If this trend continued over a larger sample size, it could indicate a cannibalization of the car market, something for a vehicle manufacturer to pay particular attention to in an overall business case. For example, with this new offering, how much is the overall vehicle market expected to grow and what percentage of the car market do we expect to decline because of this new offering?

The purchase decision timeline was also forecasted by polling respondents regarding when they will purchase their next vehicle. 22% of the correspondents planned to purchase in the next 6 months, 22% in the next 6 to 12 months, and 56% in greater than the next 13 months. In reality, for over half of the respondents, real life purchase decisions regarding these types of tradeoffs are long term. To really inform a product development team, people interested in purchasing the cross over segment, within a shorter time frame, would be more representative.

The WCA test was conducted first and the calculated utilities for each of the attributes can be found in Appendix 1. The results yielded only 2% violated pairs. As a measure of how well the utility explains behavior, this indicates a very successful test.

In a perfect world, if UD were completely consistent with WCA, we would expect the ideal design to be the consumer's top ranked card among all possible choices. This data shows that although user design was not perfect, we can see from figure 10 that what the consumer is designing virtually is capturing the vast majority of the utilities as defined by WCA. We see that close to 80% of the time, UD predicts between the top third of the available cards.

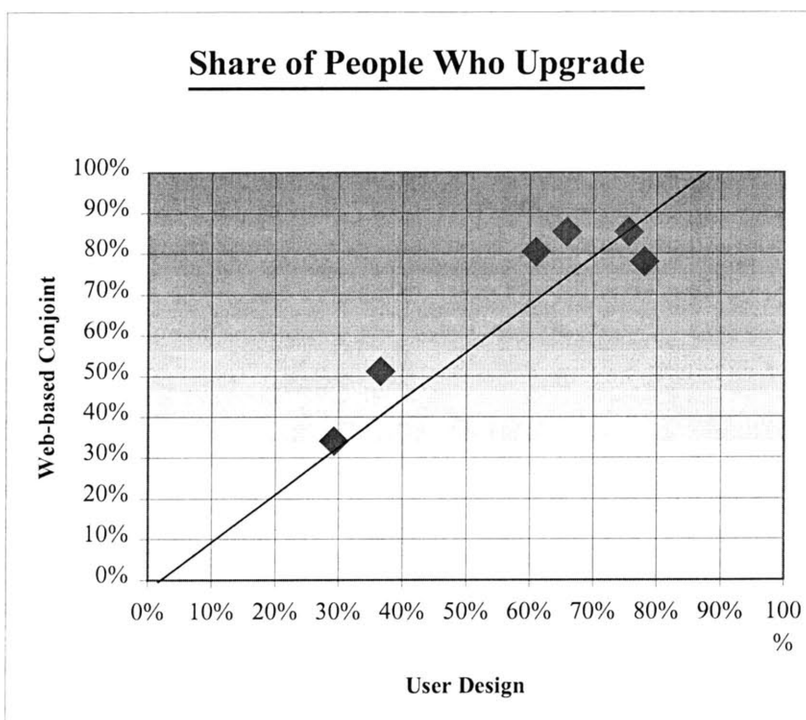
Figure 10 – User Design Captures Preference



This is analogous to placing all 64-card designs on a tabletop and asking a consumer to pick the one they would most likely buy. This would be a daunting task in itself, but to compare to our user design results, the consumer would need to complete the task 77 seconds. This is the average time the respondent takes to design their ideal product, with the quickest time being 27 seconds and the slowest at 205 seconds. The probability of a consumer being able to find their top choice among 64 in even 205 seconds is very low if not impossible at the same success rate as user design.

Another aggregate result comparing user design against conjoint prediction is shown in Figure 11. Each axis represents one of the tests, with the diamonds each representing the 6 attributes.

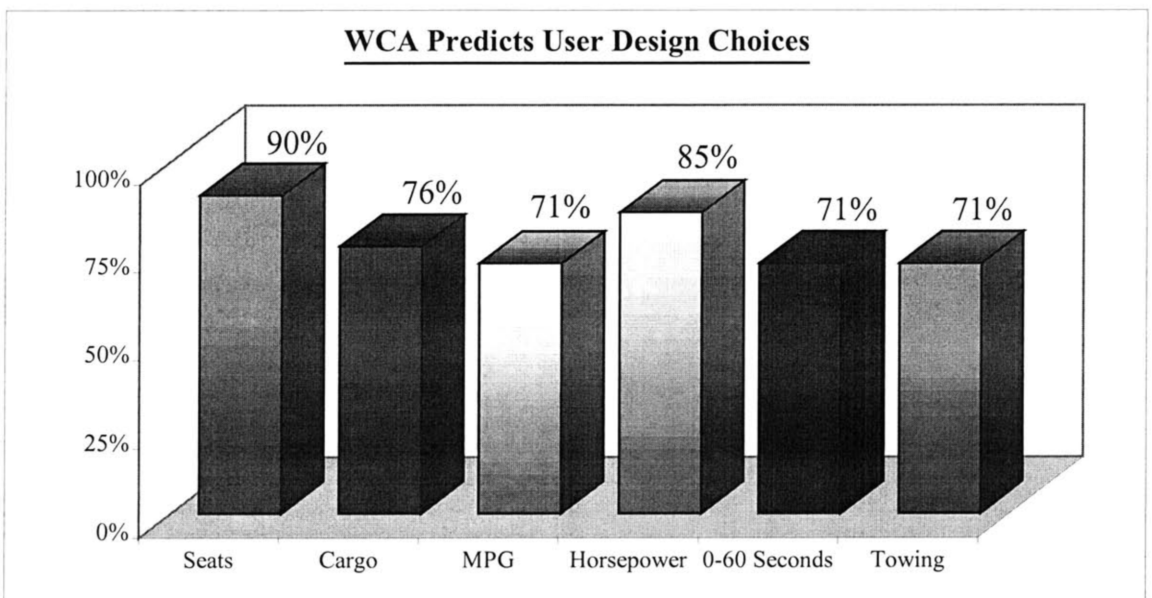
Figure 11 – Share of People who Upgrade



Price is not included here, since in user design, price is a function of the other attributes and not considered independently. This graph shows a very strong correlation between the two tests when looking specifically at the shares of people who upgrade features in either test.

Next, in Figure 12, we highlight each of the attributes independently. Here we find that there is not a great difference among the attributes with respect to the success rate of using WCA to predict the choice behavior in UD.

Figure 12 – WCA Predicts User Design Choices



In this testing, other than price, we have assumed that all of the attributes are independent. The next graph, figure 13, gives us an indication of the features that the consumers might tend to value together when designing their ideal cross over vehicle. The values indicate a correlation but none is high enough that our independence assumption no longer holds true.

Figure 13 – Correlation of Attributes in User Design

	Seats	Cargo	MPG	HP	0-60 Sec.	Towing
Seats	100%	29%	8%	-13%	-22%	18%
Cargo		100%	13%	4%	-5%	-9%
MPG			100%	-3%	-13%	16%
HP				100%	31%	20%
0-60 Sec.					100%	-9%
Towing						100%

For example, we see that those people that are interested in 7 seats are also interested in a larger cargo volume but they are actually opposed to paying for a quicker 0 to 60mph time. Not surprisingly, those consumers that like a higher horsepower are also interested in the quicker 0 to 60 time and better towing capability.

Finally, we look at the paper-based survey that asked the customer to rank their top three choices of real life vehicles. Since we assert that user design correlates well to conjoint, we now see how well conjoint reflects choice although there are some differences between the tests. The biggest difference in this test as opposed to the WCT and UD is that it indicates brand and also appearance or aesthetics of that brand. WCT and UD contained the same generic vehicle sketch across the board with the only changes being within the features themselves. The paper-based choice test also had a rating scale for the attributes that was similar to the consumers rating scale rather than the two level features. Given these differences, we determine if the feature utilities from the UD are sufficient for predicting choices made in the paper-based test. Figure 14 shows the correlation between WCA utilities and their 1st choice with an r^2 value of 49%. Figure 15 shows the correlation between WCA utilities and the respondents' top 3 choices with an r^2 value of only 27%. These differences show how brand and visual richness can effect a consumer's decisions.

Figure 14 – WCA predicts 1st Choice

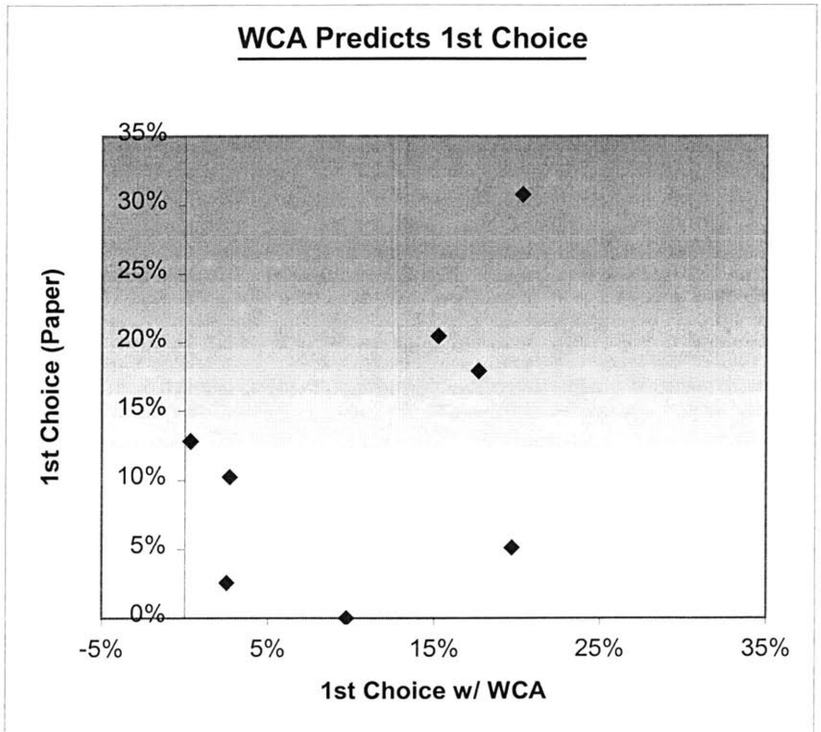
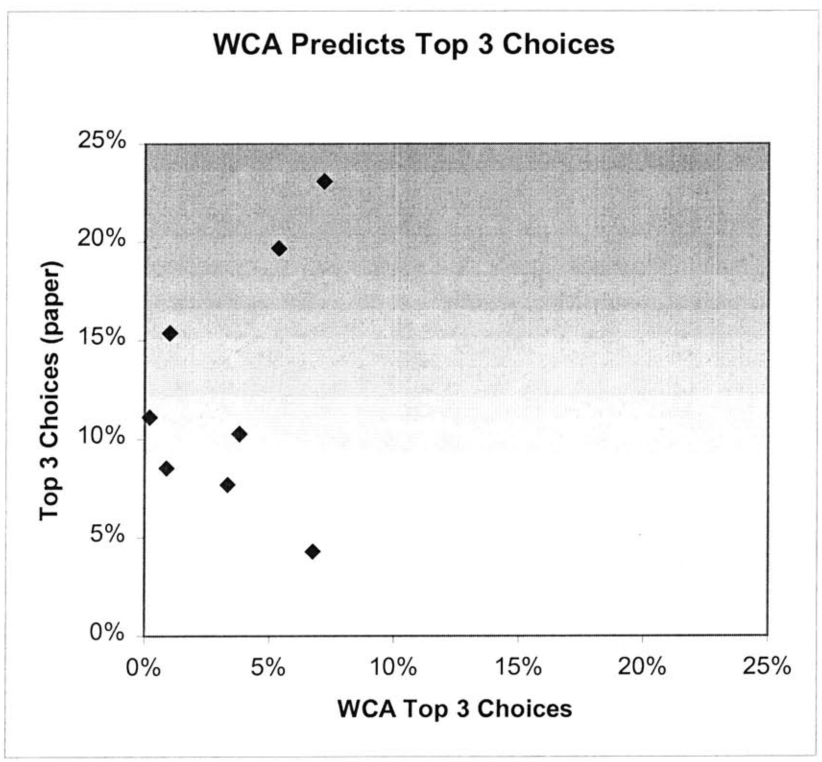
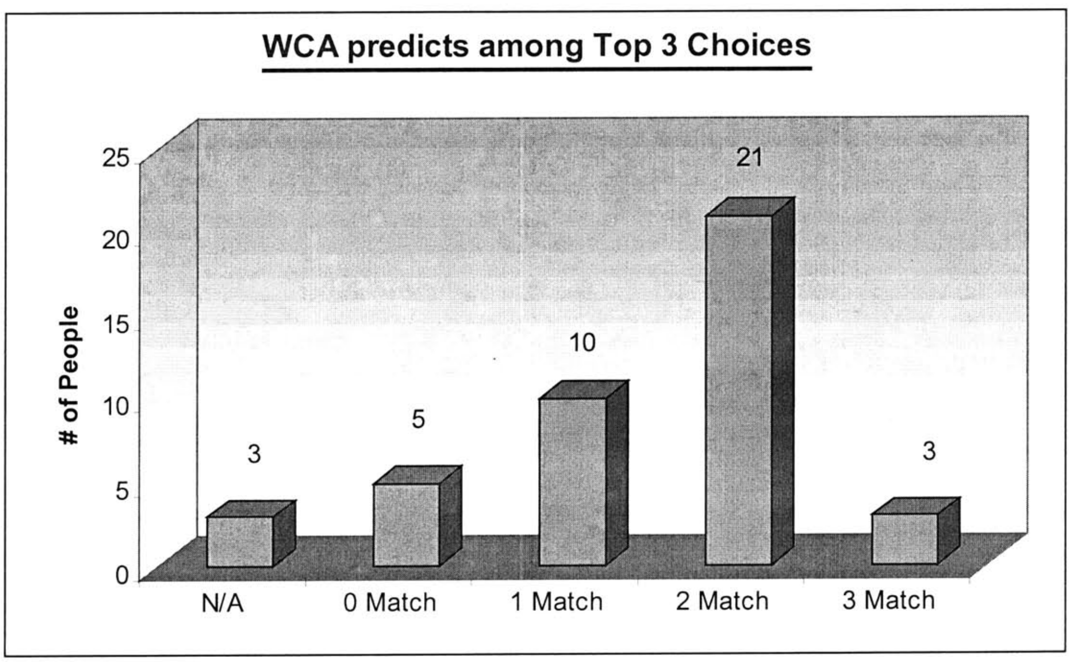


Figure 15 – WCA predicts top 3 Choices



By using the conjoint utilities, we can calculate the score an individual would have for each of the 8 real vehicles. And from there we can determine how many times conjoint utilities were able to predict among the top three choices. The number of matches for each individual is shown in figure 16. Note that three responses were not collected for the paper survey, leaving the sample size at 39 people. The majority of the time, WCA is effective at determining at least 2 of the respondent's real vehicle choices. When looking at these numbers, one can explain the differences based on price. It appears that when we look only at conjoint, not at brand or aesthetics, consumers over emphasize their price sensitivity. It appears that when given the brands to choose from, the desire for a brand overshadows what is indicated in WCA as price sensitivity.

Figure 16 – WCA Predicts among the top 3 for each individual



We have shown a strong correlation to customer preference between user design and conjoint utility and now we show that utility is a good predictor of customer choice The user design tool is an enhanced method for resolving uncertainty more efficiently than some traditional approaches. It holds opportunity for handling a much greater number of attributes and can be performed very quickly at relatively low cost to the product development team. The following section gives an example of how this method may be used in a system design with 10 attributes.

8 Telematics Test Approach

8.1 Telematics: An Overview

Telematics refers to the convergence of telecommunications and internet connectivity in the automobile, and enables products and services that seamlessly transport information and/or data to and from the vehicle. In contrast with the earlier cross over example, the telematics example showcases some features that are less visual in nature and more service based in the eyes of the consumer. Providing the appropriate stimulus representation for depicting these items, and conveying their service features to the customer was essential to this test design.

It is important to note that this testing would need to be targeted at owners or intended purchasers of certain segments. For example, the telematics needs of an Escort owner may be different than the needs of a Lincoln owner and the willingness to pay for such features may also be different. The features list may also change depending on the target market intended for the vehicle. Note also that there are safety considerations with the utilization of some of these features while the vehicle is traveling. This study did not intend to address all of these safety issues, only to ask the consumer about their specific preference to a feature. To address any safety concerns, the product development team could, for example, disable a feature while the vehicle is in motion or only allow access in the rear seats (video games).

8.2 Design of Experiment

Several avenues were explored in the development of the attribute features that were designed into this test. For example, telematics systems engineers were interviewed, telematics marketing analysts were interviewed, industry competitive offerings were studied, and data from earlier, more traditional, paper surveys and focus groups was reviewed. Also, several functional telematics prototype concepts were studied and photographed in vehicles.

From this work, there are 10 customer needs identified as attributes for the Telematics study and for each of the attributes, there are 2 levels. Excluding price, the levels are simply whether the option is offered or whether it is not. Each of the options is discussed below, as they would be in the teaching section of the survey for either web-based conjoint analysis or user design testing. The visual representations of these options are described within parentheses and are pictured in the following ten figures.

Telematics Test Attributes

1. **Roadside Assistance (SOS Button):** This feature allows occupants to initiate a call to the Customer Service Center, to request emergency services in the event of an accident or medical emergency situation. In the event of the airbags deploying, a customer service representative automatically contacts the occupants in the vehicle to determine the nature of the emergency. If needed, through the use of a GPS, emergency vehicles (fire, ambulance, or police) are dispatched to the vehicle location as required.

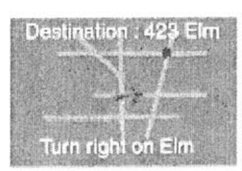
Figure 17 – SOS Button Icon

2. **Remote Vehicle Functions (Padlock on door):** This feature allows a customer to call the customer service center in the event of locking their keys in the vehicle. Via satellite technology, the customer service agent is able to unlock the vehicle remotely.

Figure 18 - Remote Unlock Vehicle Function Icon

3. **Navigation (Map):** This feature allows the consumer to get directions to any destination based on their current location.

Figure 19 – Navigation/Mapping Icon



4. **Traffic Information (Construction Pylon):** This feature allows the consumer to request up-to-date traffic and construction warnings while traveling or via the Web prior to the trip.

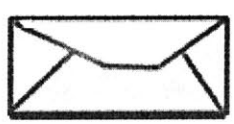
Figure 20 – Traffic Information Icon

5. **Voice Activated Communication (Microphone centered on steering wheel):** This feature allows hands-free operation of the communication device through voice commands such as automatic dialing by speaking a number or dialing pre-programmed numbers by speaking the name of the person you would like to contact.

Figure 21 – Voice Activated Communication Icon

6. **Inbound Email (Envelope symbol):** This feature allows access to an e-mail account and can convert the text of the e-mail to an automated speech format for listening while driving.

Figure 22 – Inbound Email Function Icon



7. **Personal Digital Assistant Synchronization (PDA in vehicle):** This feature allows the consumer to synchronize their PDA calendar and contact information with the vehicle system.

Figure 23 – PDA Synchronization Icon

8. **Internet Web-page Access (Netscape Logo):** This feature allows the consumer to access pre-designated web pages while in the vehicle.

Figure 24 – Internet Web-page Access Icon

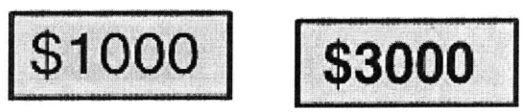
9. **Entertainment (Monitor shown for rear seat passengers):** This feature allows the occupants the ability to watch movies or play video games while traveling.

Figure 25 – Entertainment / Games Icon

10. **Price ($-$$$):** This attribute can and should be tested in two different manners given the nature of telematics systems and how they are currently being offered to customers. First, in designing these systems, the product development team needs to understand what the consumer is willing to pay at the time of purchase and then what they are willing to pay monthly as a service charge for some of these functions. Both of these factors would play a role in the business decision of what options to design for. For the WCA, the two levels for the price might be $1,000 and $3,000 representing the initial purchase price. And the UD test would allow a range from

$1,000 to $3,000 while considering initial purchase price and could range from $19.95/month to $59.95/month if trying to determine the customers willingness to pay for certain functions. Note that the service fee does not apply to all of the functions; the SOS button and other services that give the consumer access to a call center would have service fees associated with them. A feature such as voice activated dialing would not carry a service fee.

Figure 26 – Price Icons



Given these 10 attributes with two levels each, there are 1024 permutations, each of which could be a possible, viable product configuration. As discussed earlier, to make the task easier, we can capture the information that customers would provide about tradeoffs among features by asking customers to evaluate a much smaller number of products. Using software called JMP, an orthogonal array was created that gave 12 possible product combinations of our given features. The contents of the 12 card combinations are shown in Figure 27.

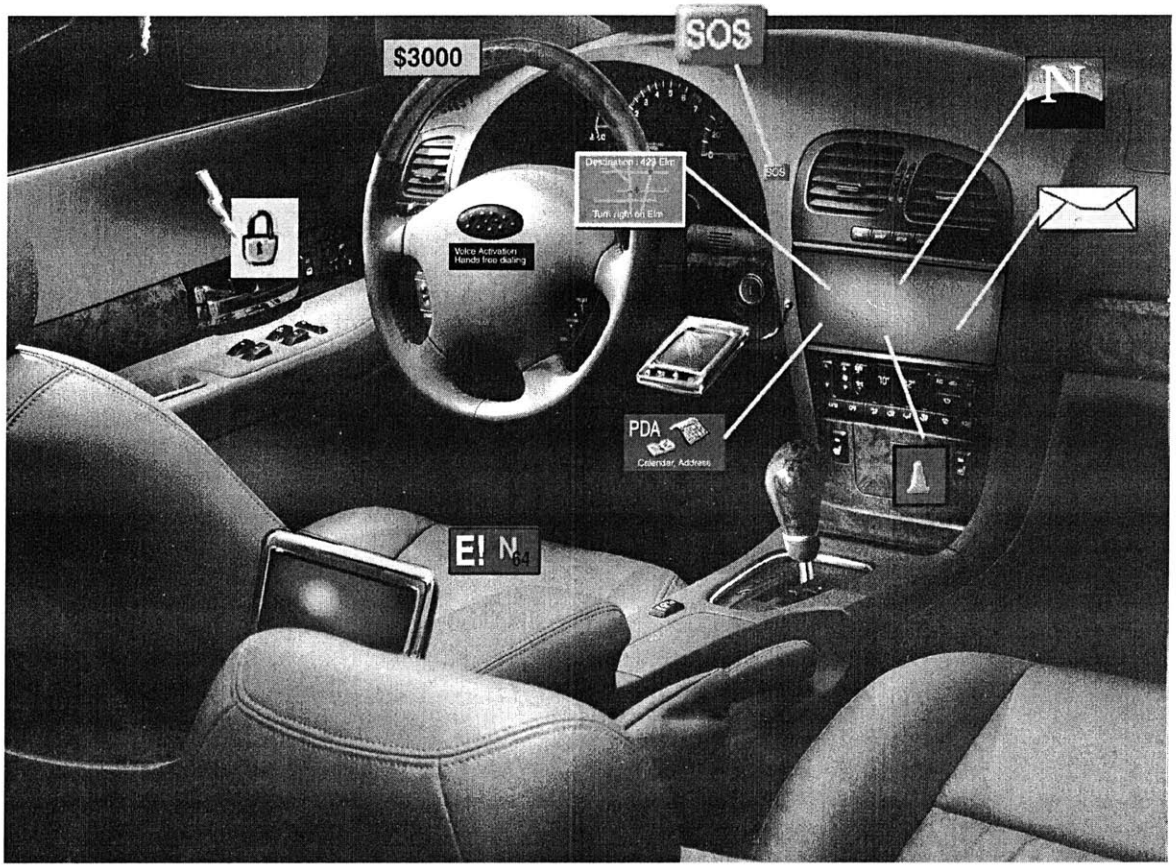
Figure 27 – Telematics 12 Card Design

	Product Attributes									
Card #	SOS Button	Remote Unlock	Navigation/ Mapping	Traffic Warning	Voice-activated Dialing	Inbound Email	PDA Sync.	Web-page Access	Entertainment/ Games	Price
1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	$3,000
2	No	Yes	No	Yes	Yes	Yes	No	No	No	$3,000
3	No	No	Yes	No	Yes	Yes	Yes	No	No	$1,000
4	Yes	No	No	Yes	No	Yes	Yes	Yes	No	$1,000
5	No	Yes	No	No	Yes	No	Yes	Yes	Yes	$1,000
6	No	No	Yes	No	No	Yes	No	Yes	Yes	$3,000
7	No	No	No	Yes	No	No	Yes	No	Yes	$3,000
8	Yes	No	No	No	Yes	No	No	Yes	No	$3,000
9	Yes	Yes	No	No	No	Yes	No	No	Yes	$1,000
10	Yes	Yes	Yes	No	No	No	Yes	No	No	$3,000
11	No	Yes	Yes	Yes	No	No	No	Yes	No	$1,000
12	Yes	No	Yes	Yes	Yes	No	No	No	Yes	$1,000

For example, card 1 would represent a telematics system that would have all of the features that we are looking to perform tradeoffs on. Card 10 would only have emergency assistance (SOS), remote unlock, navigation, and PDA synchronization. All of the 12 card designs are illustrated on a backdrop of a vehicle cockpit, the interior of a vehicle. Figure 28 shows card number 1 with all of the telematics features present.

Wherever possible, the cockpit was updated to represent how it would truly look in the event of having a certain feature. For example, a screen is added in the center console between the two front seats to represent the 'entertainment/ games' attribute. Note that not all of these features represent a change to the vehicle interior. The interface to the customer is in most cases through the instrument panel center mounted telematics screen/monitor. In these cases, for example, inbound email and internet web page access is illustrated via an icon with a tie line to the telematics screen.

Figure 28 – Card #1 for Telematics WCA (shows all attributes)

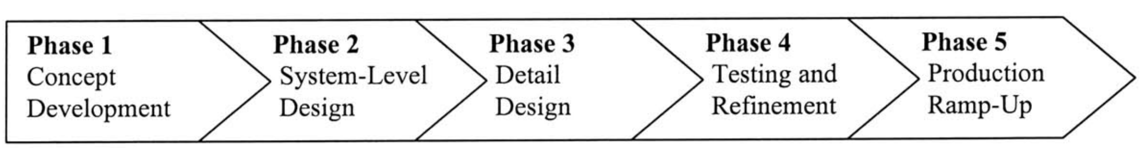


These features and graphics were designed to be utilized in both the web-based conjoint environment and in the user design environment. In user design, the respondent would drag and drop the feature icons into a cockpit design space as price would be updated.

9 Informing the New Product Development Process

The objective of all of this testing is to gather information for the product development team that will shape and mold their decision process regarding a product. All members of the product development team, including marketing, engineering, and manufacturing, need to work together during this decision process including the design of the market tests to be administered to consumers. This will ensure that products are not conceived of that customers don't want or that manufacturers cannot produce. The front grill opening in a vehicle offers a poignant example of how all members of the product development team need to part of the decision process. For engines to perform correctly they need a sufficient amount of air funneled under the hood, essentially they need to breathe and to be cooled. And although a large grill opening is a requirement for this engine cooling and performance, the body styling team has responsibility for the grill opening design. Without sufficient teamwork, a vehicle that meets the needs of the styling team could be designed but that vehicle would fail to meet it's performance targets. Always understanding the assumptions and limitations of all the stakeholders in the product will lead to the most successful launches.

Figure 29 – The Product Development Process (Ulrich and Eppinger, 1995)



Ulrich and Eppinger (1995) describe a generic product development process containing 5 phases; concept development, system-level design, detail design, testing and refinement, and production ramp-up. Prior to entering phase 1, the team will be given or will charter an overall program direction that includes a product description (a high level, needs based description to avoid defining the product concept), the key business objectives, and the target market.

Given this pre-defined market direction, phase 1 can begin. This is where the needs of the target market are established, alternative product concepts are generated and evaluated, and at the conclusion, a single concept is chosen for further development. It is in concept development where the product development team can effectively use the web-enabled marketing tools discussed in identifying needs and making decisions regarding the product. WCA and UD offer quick, fun approaches to gathering customer needs information for this phase. However, given the complexity of some products, a vehicle or a telematics system, we are not always presented with engineering direction directly from the needs identified by the web-based tools, or any other marketing tools for that matter.

For example, in the case of the cross over vehicle, we are told through user design, that fuel economy is an important feature to this respondent group. However, for an engineering team to attack fuel economy, they must first understand its components and all of the contributors. Since weight of the vehicle is among the highest of contributors to poor fuel economy, the design team could start targeting components of the vehicle to design in lighter weight materials such as aluminum or magnesium. This weight reduction would also enhance another one of the features, the 0 to 60 mph time performance. However, this solution does not come without its downfalls. The cost of aluminum and magnesium is high and fasteners for magnesium must be specially coated adding again to the cost. For structural reasons, when parts are re-engineered in these lighter metals, they grow in size and physical real estate within a vehicle is not always available. And so, the product development team begins the trade off process. When attempting to meet one of the needs fully, very often, another need is threatened. This is one of the greatest challenges of the product development process. If trade-off are recognized, understood and managed well, the project has a greater chance at being successful.

In the telematics example, as with the cross over vehicles, the customer needs or services that were studied in the tests, do not translate directly to design components or engineering direction. In this example, we find that one need requires several components to be met successfully. Figure 29 shows how one product development team might decide to meet the customer needs for a telematics system.

Note that this process would be specific to each vehicle program planning to incorporate some type of telematics system since different interfaces can often meet the needs identified. It begins the framework for concept development. The process of filling in this chart, forces decisions regarding how the needs will be met.

Notice that, for example, to meet the requirement of voice activated dialing, it is not necessary to have speech generation, although this could provide the customer with feedback that their call to the correct person is in progress. Also, it is important to understand the interactions between the needs, although the testing itself assumed independence. As an example, if a speech generator is designed into the system, the product development team should exploit its capabilities and use it in enhancing the other needs.

Figure 30 – Needs Translation Map Example

	Customer Attributes									
Engineering Attributes	**SOS**	**Remote Unlock**	**Navigation /Mapping**	**Traffic Warning**	**Voice-activated Dialing**	**Inbound Email**	**PDA Sync.**	**Web-page Access**	**Entertainment/ Games**	**Price**
Display			x	x			x	x	x	x
Location Sensor (GPS)	x		x	x						x
Cellular Communication Device	x	x		x	x	x		x	x	x
Interior Interface (locks/buttons)	x	x	x		x	x		x	x	x
Navigation Computer			x	x						x
Voice Recognition					x					x
Speech Generator			x			x				x
I/O Port							x		x	x
Radio Frequency ID				x						x

It is easy to see how this matrix might stimulate further web testing. The best approach would be an iterative process that narrows the scope of questioning with each round of testing with the final goal of defining specifications and completing phase 1 with a concept selection. The overall objective of the design team is to optimize customer utilities while balancing engineering and product development constraints of timing, development costs, and functional capabilities. The web marketing tools, WCA and UD are tools that support this effort with a more media rich, less costly, and more timely approach.

10 Conclusion

10.1 Thesis Summary

In drawing conclusions from the data presented in the paper, one must note that 42 data points is insufficient for statistical analysis. Therefore, further data points are required to support these early conclusions of this small sample size.

With that caution regarding sample size, it can be concluded that the web-based marketing method, user design, is a very promising tool for supporting the link between the customer and engineering in the early phases of the product development process. Its high correlation to feature utilities obtained through conjoint testing proves its viability as tool for resolving uncertainty upfront in a design process and predicting market share. And its other benefits make it an even more attractive tool.

User design does not require any real functioning prototypes prior to testing, making it lower cost and very well suited for the concept development phase of the product design process when attribute choices and uncertainly in the design are at their greatest.

User design is extremely fast and can effectively handle a very large attribute space both for the respondent and for the researcher. Ideal designs were being created in less than a minute while data tables were automatically being generated lowering the administrative burden of the test.

The breakthrough for this technology is not however, in the fact that we are able to just gather this data efficiently from customers. It is their interaction with the product that defines this new method. The consumer is engaged and interacting throughout the test. They are learning and provided data at the same time. The process puts the consumer in control of the design. They have an overwhelming sense of control and ownership of the outcome, their ideal design. This process is fun and feels more like a video game to the customer than a marketing survey. Winning this game occurs when the customer has arrived at the best price point possible given their best-valued features. And everybody gets to win this game.

There is a needs translation step required when informing the new product development team about the features studied. A map from function to form is developed to aid in the link between the customer and the component. The map is program specific and will often spark further testing of the features to find the best ways to meet customer needs.

10.2 Recommendations for Further Research

The first recommendation is to further the cross over vehicle research by collecting a larger sample size (greater than 100 drawn from a population of interest) using the already configured tests, web-based conjoint and user design. A larger sample size will support the conclusions that have been drawn thus far and create a more statistically sound analysis. With a larger sample size, the order in which the respondent takes each of the tests could be switched or different groups could take just one of the tests.

With respect to the user design testing, it would be interesting to understand the limit of the number of attributes that could be tested successfully at one time. For example, at what point do we begin to see a poor correlation and at what point does the test become too large and cumbersome to the respondent?

Another recommendation for future work would be to employ the user design technique in determining ideal price points for product attributes. This would involve iterations of the UD test to understand at what point certain features are excluded based on higher and higher option pricing.

We also know from Park, Jun, and MacInnis (2000) that we can influence the ideal design choice based on whether we load the initial design and ask the respondent to delete options or whether we offer a stripped down version and ask the respondent to add their desired options in designing their ideal product. These consequences of option framing could be studied with the cross over example by presenting the initial vehicle in either the fully loaded state or a stripped down state.

The telematics tests as configured should be run and the same type of analysis used for the cross over vehicle testing should be completed. Both WCA and UD could be performed with the given visuals. Another approach using the telematics example would be to use a more media rich technique when presenting the features at the learning phase. Video clips are available that would present situations where each of the features would be utilized by a consumer. This should enhance the respondent's connection to the features and their advantages.

11 References

Ariely, Dan. (2000), "Controlling Information Flow: Effects on Consumers' Decision Making and Preference". Journal of Consumer Research, 27(2) 233-248.

Arnholt, Mike, (2000), " Paving a Telematics Future, In-vehicle electronics systems to grow tenfold," Ward's Auto World, (October), 87-90.

Dahan, Ely, (2001), "CEB Virtual Customer" Presented to members of the Center for E-Business, (MIT) presentation, January, 17, 2001.

Dahan, Ely and Hauser, John R., (2000), "Managing a Dispersed Product Development Process," Forthcoming in the *Handbook of Marketing,* (2001), Barton Weitz and Robin Wensley, Editors.

Dahan, Ely and Hauser, John R., (2000), "The Virtual Customer: Communication, Conceptualization, and Computation," Under review at *The Journal of Product Innovation Management.*

Dahan, Ely and V. Srinivasan (2000), "The Predictive Power of Internet-Based Product Concept Testing Using Visual Depiction and Animation," *Journal of Product Innovation Management*, 17, (March), 99-109.

Dolan, Robert J. (1990), "Conjoint Analysis: A Manager's Guide," Harvard Business School Case Services, No. 9-590-059.

Huber, Joel, (1997), "What We Have Learned from 20 Years of Conjoint Research: When to use Self-Explicated, Graded Pairs, Full Profiles or Choice Experiments," Sawtooth Conference, presented 1997.

Klein, Lisa. "Creating Virtual Experiences in the New Media," Unpublished doctoral thesis, Harvard Graduate School of Business Administration, 1998.

McQuarrie, Edward F., (1996), The Market Research Toolbox, A Concise Guide for Beginners, (Thousand Oaks, California: SAGE Publications, Inc.).

Park, C. Whan, Sung Youl Jun, and Deborah J. MacInnis, (1999), "Choosing What I Want versus Rejecting What I Don't Want: An Application of Decision Framing to Product Option Choice Decisions", (Cambridge, MA: MIT Sloan School).

Ulrich, Karl T., and Steven D. Eppinger, (1995), Product Design and Development, (New York, NY: McGraw-Hill, Inc.

Urban, Glen L., Bruce Weinberg, and John R. Hauser (1996), "Premarket Forecasting of Really-New Products," Journal of Marketing, 60, 1, (January), 47-60. Abstracted in the Journal of Financial Abstracts, 2, 23A, (June) 1995.

12 Appendix 1: WCA Utility Values

ID#	Seats	Cargo	MPG	Horsepower	0-60 Seconds	Towing	Price
1	-28.3	2.9	6.5	40.6	2.9	-2.9	-2.0
2	3.4	-10.9	6.8	40.3	25.2	8.1	-0.7
3	-7.3	6.9	17.7	-5.4	10.1	38.8	-0.3
4	-2.5	7.8	21.6	24.5	24.5	-8.2	-1.4
5	-20.9	-29.9	9.3	22.9	5.7	-1.8	-1.2
6	-8.2	1.8	13.4	11.7	18.1	-9.9	-4.6
7	-36.5	33.2	-4.6	8.3	6.7	-7.4	-0.4
8	-19.4	7.5	-7.5	22.4	13.4	20.9	-0.3
9	-4.7	22.7	-2.2	16.0	45.2	6.9	-0.3
10	0.0	15.8	-5.2	31.5	15.8	21.2	-1.3
11	0.0	23.0	7.9	15.4	0.0	53.8	-0.3
12	-33.3	6.8	23.2	0.0	15.6	-3.4	-2.2
13	4.0	16.0	31.9	10.1	-4.0	-6.1	-3.5
14	-30.6	7.3	-3.2	11.3	10.5	2.0	-4.4
15	-0.2	28.3	50.0	0.2	-7.0	-14.3	-0.3
16	46.5	0.0	9.3	2.3	4.7	-9.3	-3.5
17	-43.9	2.2	1.6	6.0	11.9	25.4	-0.3
18	47.4	23.0	-1.5	16.8	-0.7	1.5	-0.3
19	46.3	13.0	10.2	16.7	-3.7	-3.7	-0.8
20	8.9	-4.4	4.4	48.9	17.8	0.0	-1.9
21	-29.0	-23.4	1.9	-13.1	1.9	-5.6	-3.2
22	-5.2	15.5	5.2	5.2	2.6	2.6	-8.0
23	11.2	15.6	2.3	46.6	13.3	2.2	-1.1
24	-44.7	4.8	-9.2	0.4	20.6	-2.2	-2.2
25	10.3	13.8	25.8	-3.4	3.4	-24.2	-2.4
26	-45.4	7.1	0.7	14.9	-0.7	-0.7	-3.8
27	-12.9	-21.2	16.5	-15.3	18.8	4.7	-0.3
28	14.9	37.9	16.8	17.5	8.2	-4.3	-0.3
29	-14.0	7.9	6.1	29.8	-3.5	17.5	-2.6
30	-18.1	3.5	0.9	31.9	39.8	2.2	-0.4
31	-5.4	9.0	5.4	20.8	30.7	-6.3	-2.8
32	-46.6	-6.8	26.2	9.1	-2.3	-2.3	-0.3
33	13.9	-12.8	2.1	43.5	1.1	17.0	-1.2
34	31.4	-21.9	-7.9	-9.6	9.6	16.4	-0.3
35	30.3	19.2	11.4	15.7	13.1	-7.1	-0.4
36	-12.3	-6.5	-11.0	9.0	-18.8	12.6	-0.3
37	-36.0	29.7	-5.5	6.3	0.0	-5.5	-2.1
38	-74.0	11.5	0.0	-2.9	2.9	-2.9	-0.3
39	-27.9	11.1	14.1	12.8	10.8	3.3	-2.5
40	16.5	10.2	-5.7	21.0	-14.8	-26.1	-0.7
41	18.0	11.7	10.1	10.1	13.3	13.3	-2.9
42	31.3	12.5	6.3	6.3	0.0	6.3	-4.7

13 Appendix 2: UD Ideal Vehicle Configurations

ID#	UD seating	UD cargo	UD mpg	UD horsepower	UD time 0-60	UD towing	UD price	UD time (sec)
1	0	0	1	1	1	0	34	72
2	0	1	1	1	1	1	36	44
3	0	1	1	1	1	1	36	70
4	0	1	1	1	1	0	35	54
5	0	0	1	1	1	1	35	36
6	0	0	1	1	1	0	34	32
7	0	1	1	0	1	0	33	63
8	0	1	1	1	1	1	36	36
9	0	1	0	1	1	0	33	52
10	1	1	1	1	1	1	38	74
11	0	1	1	1	1	1	36	34
12	0	0	1	1	1	0	34	99
13	0	0	1	1	0	0	32	60
14	0	0	0	1	1	0	32	145
15	0	1	1	1	1	0	35	48
16	1	1	1	0	1	0	35	99
17	0	0	0	1	1	1	33	84
18	1	1	1	1	0	1	36	48
19	1	1	0	1	0	1	34	63
20	0	0	1	1	1	0	34	80
21	0	0	0	0	0	0	28	95
22	0	1	1	0	0	0	31	82
23	1	1	1	1	1	1	38	36
24	0	1	0	1	1	0	33	88
25	1	1	1	0	0	0	33	78
26	0	0	1	1	1	0	34	27
27	0	0	0	0	1	0	30	143
28	1	1	1	1	0	0	35	46
29	0	1	1	1	0	1	34	39
30	0	0	0	1	1	0	32	205
31	0	0	1	1	1	0	34	115
32	0	0	1	1	0	0	32	61
33	1	0	1	1	0	1	35	67
34	1	0	1	0	1	0	34	88
35	1	1	0	1	1	0	35	102
36								
37	0	1	1	0	0	1	32	66
38	0	1	1	0	0	0	31	114
39	0	1	1	1	0	0	33	60
40	1	1	1	1	1	0	37	95
41	0	1	1	1	1	1	36	43
42	1	1	1	0	0	1	34	198