The Effect of Interface Domain on the Decision Making Experience

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ABSTRACT
Our study explores the effects of four interface domains (paper based, computer monitor based, augmented reality based and virtual reality based) on the experience of making a decision with special focus on the augmented reality domain. We wanted to see if an augmented reality system can be used to trace the decision making process or if it has too great of an effect on the decision making experience to accurately be used in its current form to track the process.

Author Keywords
Decision making process tracing, augmented reality, virtual reality, decision making experience, decision matrix, interface domain.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

It is difficult to quantify the underlying processes of how people make decisions in a natural environment; often the recollection processes inaccurately reflect the actual processes that were used when making the decision. However, as technology improves certainly there should be some way to measure the decision process as it is happening in real time using human computer interaction technology. What we did was create and evaluate an augmented reality interface to determine if it can be used in tracking the decision making process. To do this, a typical consumer decision making experience of buying a car was evaluated through different interface domains paper and pencil, desktop application, augmented reality (AR) and virtual reality (VR). In the augmented reality domain, computer generated images are overlaid onto the real environment while virtual reality is a completely computer simulated environment but limits the users' mobility because it is contained (within the C6 CAVE at Iowa State University, for example). The potential advantage that we saw of AR over VR is that AR systems are less expensive to create and use and allow for greater freedom of movement which is equal to the freedom of movement in a real environment because the environment is real but the objects are virtual. Also, for comparison, we have two, more familiar domains. The first will track decision making processes in a completely real environment, the paper and pencil domain. As well we will also be observing the effects on the decision making experience of making decisions in a 2D computer screen domain. The motivation for this project lies in finding ways to track the decision making process as it is happening to avoid the hindsight bias present when interviewing people after they have made a decision. When asked to recall how they made decisions, they often do not remember the details accurately. One cannot evaluate decisions as they are being made or accurately capture what happened due to evaluation tools interfering with the decisions and the inability to replicate natural decision making scenarios after they have occured. In the future, a decision matrix in augmented reality could help people make the best decision, as well as train people to make the safest, best decision when under high stress. To summarize, we focused on answering the question below.

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RESEARCH QUESTION

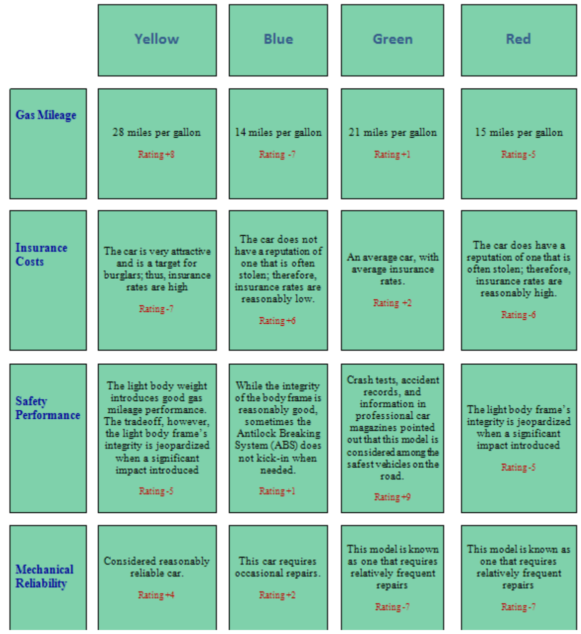
Considering evaluating the decision making process with a decision matrix, is augmented reality an effective way to make observations on the decision making experience when compared to observations in reality on paper, a two-dimensional computer display, and virtual reality?

LITERATURE REVIEW

Decision making has been a frequently studied topic. However, until now the main way that the process is evaluated is through the use of interviews or surveys after a decision has been made. This leads to an often studied phenomenon known as the hindsight bias. The hindsight bias causes people to recall having more information available before an event took place than they really did [1]. In decision making studies this can be problematic because any questions a researcher asks may have answers distorted by the hindsight bias in which the decision maker is more confident of their decision because they think they had more information all along than they really did. The way we seek to eliminate the hindsight bias is by tracking a decision making experience as it is occurring in real time through the use of augmented reality.

Augmented reality is a relatively new field in which virtual objects are overlaid onto a real environment. Many applications of this have been virtual objects used to model real object in a way that is cost effective and can find defects before spending the money to build the real object. An example of this is modeling and simulating designs for building payloads for NASA [2]. However, while this is the primary use of augmented reality right now, we are more focused on using augmented reality to track psychological processes.

We have created our AR system to render three-dimensional cars however that is really not the main focus of our AR system. The main application of our AR system is the graphical user interface which is a decision matrix. A decision matrix is a tabular user interface in which the options being considered are listed across the top and the factors considered when making that decision (referred to as evaluation dimensions) are listed down the side. Each option is then assigned a numeric value (as well as a verbal description) for each evaluation dimension. Therefore, the best decision would be the one whose sum of all evaluation dimensions has the highest total value. Our decision matrix used for our experiment listed car choices across the top by color and the evaluation dimensions were gas mileage, insurance costs, safety performance, and mechanical reliability.



	Yellow	Blue	Green	Red
Gas Mileage	28 miles per gallon Rating +8	14 miles per gallon Rating -7	21 miles per gallon Rating +1	15 miles per gallon Rating -5
Insurance Costs	The car is very attractive and is a target for burglars; thus, insurance rates are high Rating -7	The car does not have a reputation of one that is often stolen; therefore, insurance rates are reasonably low. Rating +6	An average car, with average insurance rates. Rating +2	The car does have a reputation of one that is often stolen; therefore, insurance rates are reasonably high. Rating -6
Safety Performance	The light body weight introduces good gas mileage performance. The tradeoff, however, the light body frame's integrity is jeopardized when a significant impact introduced Rating -5	While the integrity of the body frame is reasonably good, sometimes the Antilock Breaking System (ABS) does not kick-in when needed. Rating +1	Crash tests, accident records, and information in professional car magazines pointed out that this model is considered among the safest vehicles on the road. Rating +9	The light body frame's integrity is jeopardized when a significant impact introduced Rating -5
Mechanical Reliability	Considered reasonably reliable car. Rating +4	This car requires occasional repairs. Rating +2	This model is known as one that requires relatively frequent repairs Rating -7	This model is known as one that requires relatively frequent repairs Rating -7

Figure 1 – The decision matrix used for the paper and pencil domain. For reference, a larger version is on the last page.

A study on the effects of information overload on consumers in the internet shopping environment, by Yu-Chen Chen, concluded that inexperienced consumers in particular, cannot effectively handle too much information. [11] People have a limited information processing system and limited processing capacity for human memory; if consumers have too much information, overload occurs. [12] Findings suggest that a large amount of information is detrimental and leads to poorer decision making and dysfunctional performance [12]. Our decision matrix approach will therefore serve two important purposes; first, by limiting the information that people can view to one evaluation dimension of one option at a time, they are less likely to be overwhelmed by too much information. The other purpose is that we can easily keep track of what people look at when making a decision. The latter purpose will be critical when these domains are used to evaluate decision processes in the future.

Earlier this year, Doug Bowman worked with how to make 3D user interfaces more effective. [3] This is important to our research because we used a 3D matrix for the 2D and VR domains. A 3D user interface is effective if the goals are realized, tasks are done better, and the user does not get frustrated or feel uncomfortable [3]. In our research we strived to be sure that all of these criteria were met. In addition we made it a goal to make the interface match the user's perception of making the decision in a real life situation while staying within the limitations of using a decision matrix (i.e. we had information relevant to car purchases available as well as virtual models of the cars themselves).

For this experiment, we are evaluating the decision experience of a low stress, low risk scenario: purchasing a car. It is important here to distinguish the decision making process and the decision making experience. The decision making process is the psychological functions that occur when a decision is being made, while the decision making experience is how the user feels in the environment. For this particular study we defined the decision making experience to include such things as the emotions a user experiences when making a decision, the information available to the user, and how comfortable a user is making a decision in the environment. In the case of this study we only focused on the decision making experience. This is done in order to gauge the effects of the domain on the decision making experience to know how effectively a particular domain (especially augmented reality) can be used to eventually measure the decision making process. Eric J. Johnson and John W. Payne have extensively studied purchase sessions and consumer decision making. [4][5] They have evaluated consumer decision tasks, consumer decision processes, choice heuristics, predicting online buying behavior [7] and searching patterns. Their research has produced numerous results, including information about preferences. For instance, people often do not have well defined preferences; rather they construct them on the spot when they must make a choice. In understanding how people make decisions, this information shows that processing approaches may change as consumers learn more about problem structure and choices highly depend on a variety of factors characterizing decision problems, individuals, and the social context. Choice among options is context dependant, it depends on how one is asked and how the choice set is represented or displayed. [6]

In order to plan the usability study [8] and understand the best way of evaluating the decision making experience, i.e. the most effective questions to ask the user post experience to gather the best data, we have looked to the Journal of Consumer Research[9] and the Journal of Retailing[10]. A survey, more focused on quantitative results but also including some qualitative basis, would be an effective way to measure the user experience. We would like to gauge comfort level, ease of use in the domain environment (clarity, comprehensiveness, complexity), emotions (excited, bored, frustrated, et cetera), design (look, innovation) as well as level of engagement. These are the factors that make up the decision making experience.

METHODS

There were 51 participants in our study, 33 males and 18 females. Each participant only experienced one domain. The reason for doing a between-group design (each participant goes to one session only, look at results between groups) as opposed to a within subject design is because biases occur. For example if we had a participant go through two domains in the same scenario we thought that there final choice in each domain would probably not change as they would have a bias toward what decision they had already made.

A typical consumer decision making experience, particularly a car purchasing experience, was evaluated through different interface domains of paper and pencil, desktop application, augmented reality and virtual reality. The subject was given a short survey asking for demographic information. After completing the survey, the respondent was assigned one of the four conditions listed below (augmented reality, virtual reality, two-dimensional, or paper and pencil). In each condition, the respondent was asked to make a decision by looking at information in the decision matrix. In this experiment, they looked at four cars and each car's respective insurance costs, gas mileage, safety performance and mechanical reliability, in order to make a decision about which car they would prefer to purchase. All this information was viewed in a decision matrix in which the order of the cars and evaluation dimensions were rotated for each participant (i.e. the car listed in the far left column for one participant was moved to the far right column for the next participant and the top evaluation dimension was moved to the bottom for the next participant) so as to prevent biases with selecting the top-left box from greatly interfering with results.

In addition the cars were not all equal. If they are evaluated with all four evaluation dimensions being considered equally and their overall quality obtained by adding the four evaluation dimensions, the best car is the green car (sum = +5), the second best car is the blue car (sum = +2) and the third best car is the yellow car (sum = 0). Red was the worst car by far (sum = -23). We didn't make all cars equal because we wanted to evaluate how good a decision was based on some established criteria. The appearance of the cars was also not the same as you can see in figure 2 below.

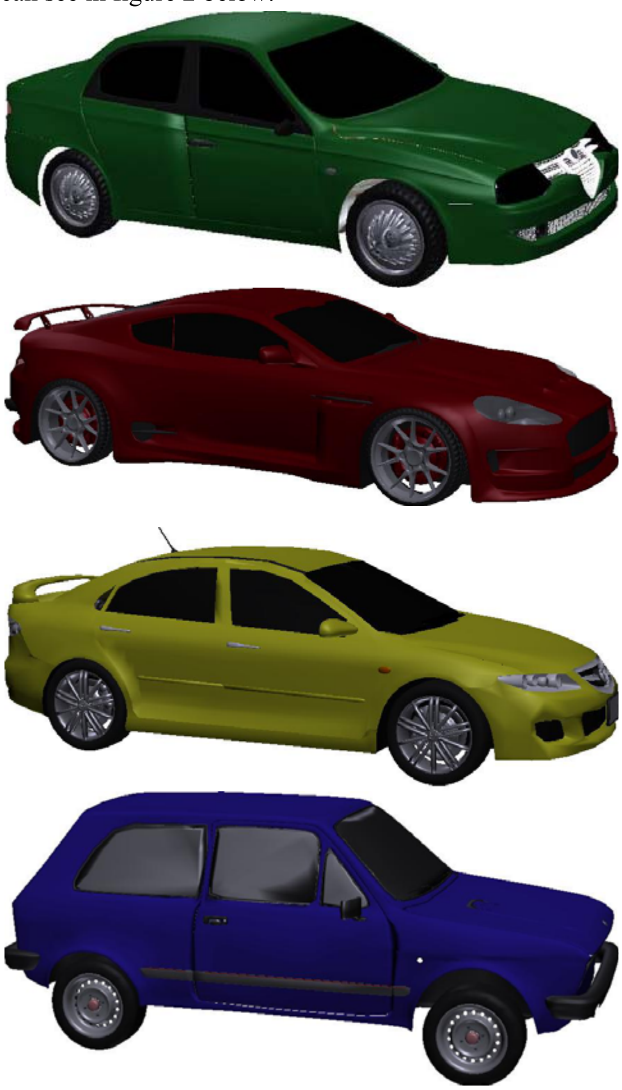


Figure 2 – The four cars used in all domains of the experiment (from top to bottom: green, red, yellow, and blue). In 2D they were displayed in an OpenGL program, in paper and pencil they were displayed as pictures and in AR and VR they were displayed as virtual objects.

The domain environments were prepared as follows:

Augmented Reality (AR) - In this condition, the user put on a head mounted device to view the cars and matrix. This device has one web camera mounted on it and the video in reality is displayed as the background on the screen (the headset has two screens, one in front of each eye). Our AR system was coded using ARToolkit and renders the four cars on markers as well as the decision matrix at a fixed location in the participant's field of vision. Participants were able to open the decision matrix whenever they wanted by using a wireless presentation remote. They were able to select boxes of the decision matrix and view the information in those boxes; everything they clicked on was recorded by the program. They were also fully mobile, and walked around 4 large pieces of cardboard. The camera would recognize 6 markers on each of the boards and display the appropriate car. We recorded the objects the user looked at within the matrix to make his or her decision on which car to purchase.

Virtual Reality (VR) - This condition was performed in the C6 Virtual Reality CAVE (a six sided environment where images are projected on to the walls, floor, and ceiling). The user entered the CAVE and put on head tracking 3D goggles. They were fully immersed in this environment (e.g. seeing cars in a lot and being able to navigate around them by moving their body). The user used a game controller to bring up the decision matrix and used the head-tracking functionality of the goggles to navigate the matrix.

Computer Screen Display (2D) - In the two dimensional condition, the user saw an application on the computer screen with a decision matrix. He or she would be able to navigate the matrix with the arrow keys to select the boxes they wanted to view. There was also a second screen where the virtual images of the four cars were displayed.

Reality (Paper and Pencil) - In the paper and pencil condition, there was a camcorder set up on a tripod to capture the decision making experience. The user would have a sheet of paper with a matrix printed on it in front of them. There were cardstock squares stabled on top of the sheet of paper and when the user wanted to see the information of an attribute on the matrix, they would lift up the tabs one at a time to see it. There were also cutout pictures of the four cars. They would finish when they made a decision about the scenario and chose a car to purchase. To show which car they were purchasing, they placed appropriate car cutout and over the "purchase car" sheet.

When the subject finished the decision making experience in the appropriate domain, they would continue taking the rest of the survey about their experience. This post-experiment survey had questions about the domain that they had just experienced. It was from the answers to these questions that we got most of our results.

SURVEY

The survey we used was designed to gather demographic information prior to taking part in the experiment. This piece of the survey included questions to find out how familiar the participant was with virtual reality, augmented reality, decision matrices, and other components of our study. We also asked them about how frequently they played video games.

The post-experiment survey was the main component of the experiment that we used for data analysis. The questions here asked participants how well the system was designed in their opinion, how much fun they had using the system, how comfortable they were making a decision in the domain, how likely they are to purchase anything using a system like this one, and how easy it was to navigate and understand the system. These were the questions pertaining to the decision making experience.

In addition to the survey we also had an output file from the program that logged what each participant looked at when making his or her decision with output statements such as: "Viewed Gas Mileage of Blue at time: Mon Jul 13 11:15:44 2009". The log also showed what car was ultimately selected as well as a start and end time for the decision making experience.

RESULTS AND CONCLUSIONS

In this experiment we wanted to see if augmented reality can be used to measure the decision making process. It was therefore important to find out how factors such as navigation, confusion, and enjoyment of the experience (collectively referred to as the decision making experience) are affected by one domain (specifically augmented reality) compared to the other domains. It is important to note that because we want this type of AR system to eventually be used to track the decision making process in different types of situations that we did not necessarily expect major differences due to the domain as they may indicate difficulties in using the system to measure the decision process in future decision making studies.

That being said, we did find significant differences on a few of the survey questions that indicated differences in the decision making experience of different domains. For example, one question asked the participant how much fun they had using the domain and we found a difference of .99 in the quantified Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) values from 4.133 in AR to 3.142 in paper and pencil ($p = .0156$). On the other hand, people reported being significantly more confused by the augmented reality domain ($\mu = 1.46667$) than paper and pencil ($\mu = 1.928$) (where a response of 2 indicates an answer of "no" and 1 indicates "yes", $p = .0083$) and also more confused by AR when compared to VR ($\mu = 1.900$) ($p = .0160$). There were also moderately significant results in the question about how easy it was to navigate the matrix in each domain between 2D ($\mu = 4.416$) and paper and pencil ($\mu = 3.857$) ($p = .0694$) indicating that the 2D domain's matrix was easier to navigate than the paper matrix. We also had significant differences on this survey questions between VR ($\mu = 4.500$) and paper and pencil ($p = .0482$) indicating that, perhaps not surprisingly, people could more easily navigate in a virtual car lot than they could navigate a paper and pencil based scenario. Perhaps our most important result came from the question about how comfortable the participant was making the decision which was a question with possible answers of "very comfortable" (numeric value = 4), "comfortable"(3), "somewhat comfortable"(2) and "not comfortable at all"(1). There were significant differences here between AR and 2D and AR and paper and pencil and AR and VR. The means were 2.0000 for AR, 2.5833 for 2D, 2.7143 for paper and pencil, and 2.700 for VR ($p = .0078$ between paper and pencil and AR, $p = .0338$ between 2D and AR and $p = .0201$ between AR and VR). This is an important result because it suggests that the decision being made may have been affected by the comfort of the participant as they experienced the domain.

Indeed, we found that, interestingly enough, the predominant choice in the paper and pencil and 2D domains was the green car (17 out of 25 trials over both domains) while the yellow car was the one chosen a majority of the time in the AR domain (9 out of 15 trials) and in the VR domain green and yellow were tied (3 each out of 9 trials). The reasons why this occurred may have to do with how comfortable people felt in the domain. Considering all evaluation dimensions equally (which many participants likely did not do) the green car was the best car in terms of the sum of its numerical values of its column in the decision matrix (sum = +5), the yellow car was third best based on the same criteria (sum = 0). It is reasonable to think that maybe people's comfort in making a decision led them to make a poorer choice in augmented reality. This hypothesis is reinforced when looking at the data collected in the decision matrix's output file.

In addition to our survey results, we also collected data on what evaluation dimensions and cars people looked at to find differences between the domains. In the 2D domain, the most commonly view dimensions were gas mileage and mechanical reliability (tied with 106 views each) and the car most frequently evaluated was the green car. In the AR domain the most frequently view domain was gas mileage (109) and the second most common was mechanical reliability (107) and the most commonly viewed car was the green car, but in this domain yellow was the car most frequently chosen. The similarities in the evaluation dimensions and cars viewed does seem to indicate that the discrepancy in car choice between AR and 2D was not the result of participants concerning themselves with different evaluation dimensions or being interested in different cars as the numbers are very close but rather seems to reinforce the idea that the car choice was in a large part due to the domain and not the individual. This fact further supports what we previously suggested, that the domain led people to make a poorer choice than they might otherwise have made.

For the most part there does not appear to be obvious differences in what cars people viewed in each domain with the exception of the focus on the red and blue cars (which were rarely chosen, red was chosen four times and blue was chosen three times total in all four domains). The blue car's information was observed by participants in 2D a total of 98 times while in AR it was observed only 67 times. Conversely, the red car's information was reviewed by participants in 2D 57 times compared to 83 times in AR. This suggests that people in the 2D domain were able to go through the matrix and rule out the red car (sum of evaluation dimensions = -23) quickly without multiple viewings. In the paper and pencil domain the most frequently chosen car was the green car and the second most was the yellow car. Gas mileage was the most often viewed dimension as it was in other domains likewise the green car was the most viewed car. However mechanical reliability was not a close second as it was in the other domains

Domain	Green	Blue	Yellow	Red
PP	10	1	2	1
2D	7	1	3	0
AR	5	0	9	1
VR	3	1	3	2

Table 1 – This table show the distribution of the decision made in each domain. Notice how much more frequently Yellow is selected in AR

Domain	Green	Blue	Yellow	Red
PP	102	70	89	63
2D	117	98	107	57
AR	115	67	109	83
VR	74	43	70	50

Table 2 – This table shows the how many times a car's data was viewed in the decision matrix total for all participants. Notice that in all domains Green and Yellow are the most commonly viewed in that order in every domain.

Domain	Gas	Safety	Insurance	Reliability
PP	92	79	78	78
2D	106	80	87	106
AR	109	78	80	107
VR	67	46	57	64

Table 3 – This table shows how many times an evaluation dimension was viewed within the matrix for any car across each domain. Notice that gas mileage is the most frequently viewed evaluation dimension in each domain. Mechanical Reliability always ranks second. For more information on exactly what was being viewed, see the decision matrix in figure 1.

Although we did have significant differences in previously mentioned areas such as fun, navigation, confusion, and comfort, there were some places where there was little difference. Because we were trying to find out if AR can be used to measure the decision making process, too many significantly different responses would have indicated that augmented reality is too different from domains already in use to be considered a viable option to use in other experiments. It is therefore good that many of the survey questions indicated very little difference between the experience of making a decision in AR and making a decision in other domains.

However, the results about how comfortable people were making a decision in AR indicated that currently people are not as comfortable with AR as they are with other domains which may have an impact on the decisions that they make. Therefore, before this technology can be used to accurately track the decision making process we must find a way to make people more comfortable making decisions in AR. This could come about by developing better AR systems to track the decision making experience or perhaps by exposing people to augmented reality more so that they are more familiar with it.

FUTURE WORK

In the near future we would like for this technology to be used to measure and to study the decision making process, the factors that people weigh and consider when making a decision as well as the decision making experience. This would be particularly useful for tracking how people make decisions in high-risk scenarios. It would be possible to replicate a high-risk scenario and a decision matrix in AR to better learn how people in those situations make decisions.

It might also eventually be possible to use this type of AR technology to train people to make better decisions, but that type of work is still a long way from happening. First we must use the technology to trace and to learn about the decision making process.

ETHICAL CONSIDERATIONS

This project has been reviewed and approved by the Institutional Review Board (IRB).

ACKNOWLEDGMENTS

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	Yellow	Blue	Green	Red
Gas Mileage	28 miles per gallon Rating +8	14 miles per gallon Rating -7	21 miles per gallon Rating +1	15 miles per gallon Rating -5
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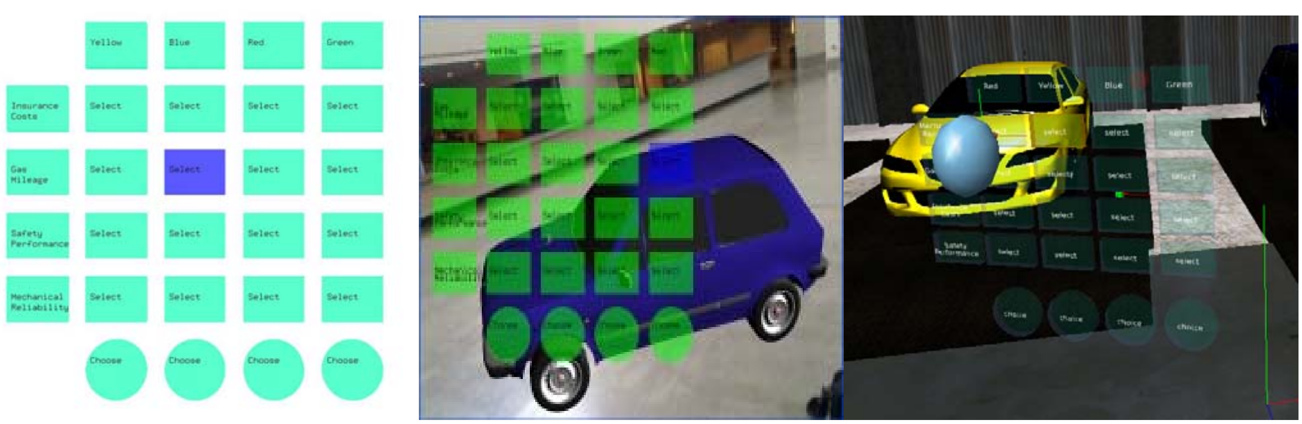
Safety Performance	The light body weight introduces good gas mileage performance. The tradeoff, however, the light body frame's integrity is jeopardized when a significant impact introduced Rating -5	While the integrity of the body frame is reasonably good, sometimes the Antilock Breaking System (ABS) does not kick-in when needed. Rating +1	Crash tests, accident records, and information in professional car magazines pointed out that this model is considered among the safest vehicles on the road. Rating +9	The light body frame's integrity is jeopardized when a significant impact introduced Rating -5
Mechanical Reliability	Considered reasonably reliable car. Rating +4	This car requires occasional repairs. Rating +2	This model is known as one that requires relatively frequent repairs Rating -7	This model is known as one that requires relatively frequent repairs Rating -7

Figure 3 – This is a larger version of the decision matrix that we used in the paper and pencil domains. Below we have the decision matrix as it appeared in our other domains; from left to right, 2D, Augmented Reality, Virtual Reality.



Survey questions used to collect data on the decision making experience. A question with a 5 point scale indicates a Likert scale from strongly agree (5) to strongly disagree (1). A question with a 4 point scale indicates the responses were something like: very appealing (4), appealing (3), somewhat appealing (2), or not appealing at all (1). A question with a 2 point scale has responses of yes or agree (1) and no or disagree (2).

1. Was the presentation visually appealing to you? (4 point scale)
2. Did you like/dislike your viewing experience? (2 point scale)
3. Did you feel overwhelmed at any point? (2 point scale)
4. Where you confused at any point? (2 point scale)
5. This tool is easy to understand and work with.(5 point scale)
6. I could easily navigate for information in the decision making tool. (5 point scale)
7. This tool was well designed. (5 point scale)
8. I had fun using this tool. (5 point scale)
9. I had positive experience. (5 point scale)
10. Would you like to see other products for purchase in this environment? (2 point scale)
11. Should I have the opportunity to use the tool, I am likely to use it, when purchasing a car in the future. (5 point scale)
12. I am likely to make a car purchase using this tool right now. (5 point scale)
13. I am likely to use this tool to purchase another item in the future. (5 point scale)
14. I am likely to use this tool to purchase another item right now. (5 point scale)
15. How useful was the information provided to you in making your decision? (4 point scale)
16. Did the tool provide you with sufficient information to make a decision? (2 point scale)
17. How comfortable did you feel making a decision in this environment? (4 point scale)
18. Do you think the tool is practical for making decisions? (2 point scale)
19. This device is useful for making decisions. (5 point scale)
20. Did the limited number of choices make it easier or hard to make a decision? (4 point scale)

	Question 1			**Question 2**			**Question 3**		
	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value
2D	2.41667	0.900337	0.3426	1.25	0.452267	0.3852	2	0	0.3943
VR	2.9	0.87856		1	0		1.8	0.421637	
AR	2.66667	0.9759		1.26667	0.457738		1.93333	0.258199	
PP	2.28571	0.726273		1.21429	0.425815		1.92857	0.267261	

	Question 4			**Question 5**			**Question 6**		
	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value
2D	1.58333	0.514929	0.0144	3.91667	0.996205	0.2563	4.41667	0.668558	0.1673
VR	1.9	0.316228		4.5	0.743223		4.5	0.676123	
AR	1.46667	0.516398		3.86667	0.743223		4.2	0.676123	
PP	1.92857	0.267261		4	0.784465		3.85714	0.949262	

	Question 7			**Question 8**			**Question 9**		
	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value
2D	3.58333	0.996205	0.3773	3.66667	0.98473	0.0092	4.08333	0.900337	0.2748
VR	4.1	0.875595		4.5	0.70711		4.4	0.699206	
AR	3.53333	0.743223		4.13333	0.99043		4.2	0.941124	
PP	3.57143	0.851631		3.14286	1.167732		3.71429	0.913874	

	Question 10			**Question 11**			**Question 12**		
	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value

	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value
2D	1.41667	0.514929	0.4501	2.91667	1.1645	0.9667	1.75	1.21543	0.453
VR	1.1	0.316228		3.1	1.19722		2.4	1.07497	
AR	1.26667	0.457738		2.93333	1.2228		2.13333	0.83381	
PP	1.28571	0.468807		2.85714	1.09945		2.28571	0.99449	

	Question 13			Question 14			Question 15		
	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value
2D	3	1.20605	0.4324	2.33333	1.07309	0.2001	2.75	0.753778	0.8439
VR	3.6	1.17379		3.3	1.1595		2.8	0.632456	
AR	3.13333	0.99043		2.6	1.12122		3	0.654654	
PP	3.5	0.75955		2.92857	1.07161		2.85714	0.770329	

	Question 16			Question 17			Question 18		
	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value
2D	1.5	0.522233	0.7896	2.58333	0.668558	0.0328	1.33333	0.492366	0.711
VR	1.6	0.516398		2.7	0.823273		1.2	0.4211637	
AR	1.6	0.507093		2	0.755929		1.2	0.414039	
PP	1.42857	0.513553		2.71429	0.61125		1.14286	0.363137	

	Question 19			Question 20		
	Mean	Std Dev	p-Value	Mean	Std Dev	p-Value
2D	3.41667	1.37895	0.2331	2.5	0.79772	0.7227
VR	4.2	0.92164		2.6	1.07447	
AR	3.8	0.7746		2.53333	1.18723	
PP	3.92857	0.73005		2.28571	1.06904	

Significantly different results

Question 4: PP and AR have a *p*-value of .0053; PP and 2D are significant with a *p*-value of .0443 and AR and VR have a *p* - value of .0160.

Question 8: AR and PP have a *p*-value of .0102 and VR and PP have a *p* - value of .0019.

Question 17: AR and 2D have a *p*-value of.0399; AR and PP have a *p*-value of .0097 and AR and VR have a *p* - value of .0201.