A

Dissertation Report

On

A Conjoint analysis of user preference for home theatre system design

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by

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CERTIFICATE

This is to certify that the dissertation entitled "A Conjoint analysis of user preference for home theatre system design" **being submitted by** Sudipto Kayal (2013PIE5043) **is a bonafide work carried out by him under my supervision and guidance, and hence approved for submission to the** Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur **in partial fulfilment of the requirements for the award of the degree of** Master of Technology (M.Tech.) **in** INDUSTRIAL ENGINEERING**. The matter embodied in this dissertation report has not been submitted anywhere else for award of any other degree or diploma.**

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CANDIDATE'S DECLARATION

I hereby certify that work which is being presented in the dissertation entitled **"A Conjoint analysis of user preference for home theatre system design"** in the fulfillment of requirement for award of the degree of Master of Technology (M. Tech.) in Industrial Engineering and submitted in Department of Mechanical Engineering of Malaviya National Institute of Technology Jaipur is an authentic record of my own work carried out during a period from July 2014 to June 2015 under the supervision of **Prof. Gopal Agarwal**, Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur. I have not submitted the matter embodied in this dissertation for the award of any other degree. As per the availability of free plagiarism checking online system by the "Plagiarism detector" software, I further certified that the plagiarism content of this report is 12% and referenced content is 3%.

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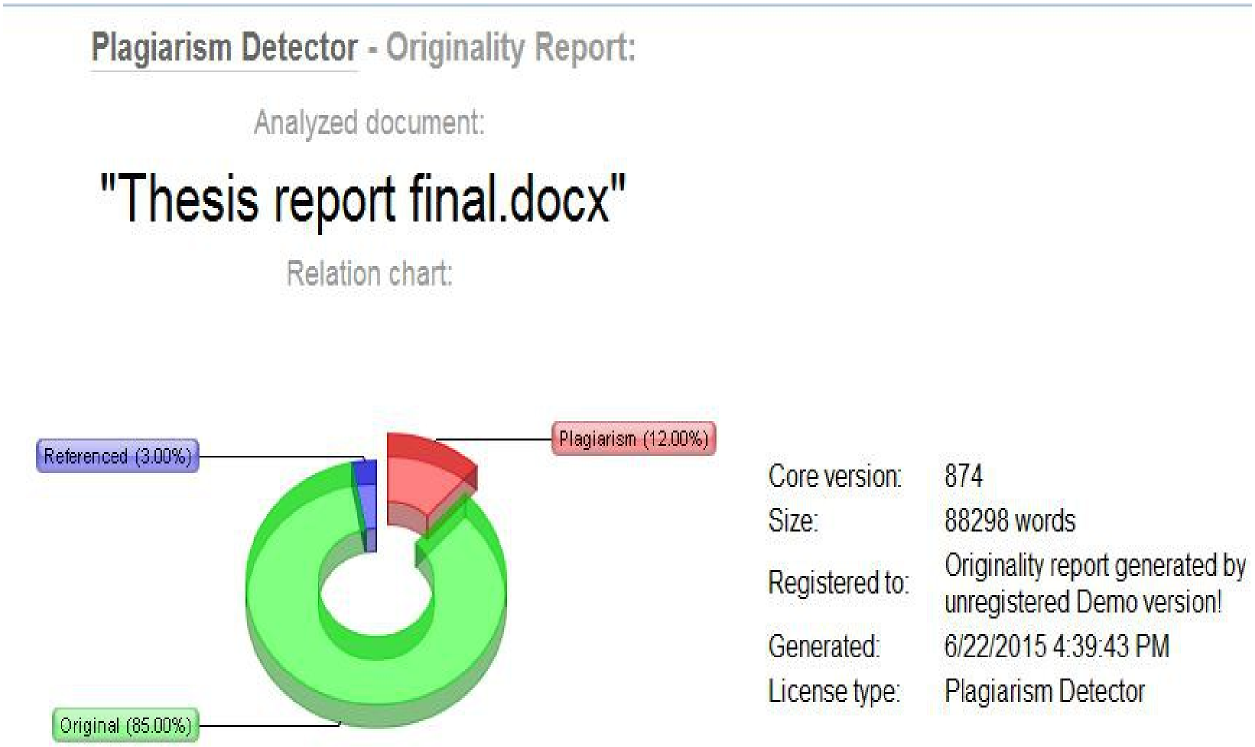

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Sudipto Kayal

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Abstract

The home audio system market is changing very fast. With the increase of buying LCD / LED TVs, using of home theatre is also increasing. Little research has been conducted about users need or favor in home theatre system selection. The main aim of this thesis is to find users or customers' reaction towards the preference for home theatre selection and to make a solution which attracts customer the most with a focus on the attributes of channel, sound output, power consumed, price range, and wire system.

This study took a quantitative approach in addressing the proposed research question while incorporating a traditional conjoint analysis methodology. The sample was derived from MNIT students and some friends who have the experience of home theatres in their home or want to buy new system. The size of the sample was 60 students and friends.

The results determined that preference existed to some degree for all presented attributes. It was observed that almost all of participants valued a single attribute, Channel was preferred the most by the participants, Sound output was the second most preferred attribute, price and wire system were preferred almost at same rate, though price was preferred slightly above the wire system.

Upon conclusion of the study, the researcher does not believe there is one specific combination of design variables that would create the "perfect" overall sound system setup for a specific kind of users. Within the scope of this experiment, most of the respondents did give the more preference to the channel attribute.

Chapter 1

Introduction

Experiencing an immersive movie and music experience can be achieved at home with a home theater system. This home theatre system allows the user to view a movie with thundering sound effects and whispered dialogues just like at the theater. This device is widely used by musicians, also used for entertainment and other purposes. Though for last few years home theatre industry was not growing in the market but after the change in human needs, change in television industry its market is now growing.

1.1 Reasons for Interest

The researcher continues to be interested in the changes occurring within the sound system industry and aimed to provide research that contributes to the process of making combination or design which is more preferable to customers. The researchers are enjoying the opportunity to examine thing that contains so many unknowns and is presently evolving. The researcher hopes that the conclusions drawn from this study will aid and inform future design of home theatre system.

Chapter 2

Traditional Conjoint Analysis Mathematical Model

This chapter provides the conjoint analysis mathematical model required for, and employed throughout, the implementation and analysis of this thesis experiment. Conjoint analysis places the participant in a hypothetical use scenario and allows for the evaluation of preference for multi-attribute alternatives (Myung, 2003). In *Getting Started With Conjoint Analysis: Strategies for Product Design and Pricing Research*, author Bryan K. Orme (2006) describes the conjoint analysis methodology as, a decompositional approach to estimating people s preferences for features, rather than an explicit, compositional approach From the whole, we are capable of more easily seeing the impact of the parts.

Variables being examined within conjoint analysis are regarded as *attributes*. Each attribute (e.g. Channel, Sound output, Power consumed, etc.) is then broken down into variations regarded as *levels* (e.g. 2.1, 4.1, 5.1, etc.). The combinations of each attribute and the respective levels are classified as *profiles*. Participants are given profiles to evaluate via rating or choosing. Utility values are calculated for each level, based on the respondent s choices. Upon calculating utility values, importance scores can also be determined. These scores help illustrate the impact the attributes have in the individual respondent s selections.

There are three main methods of conjoint analysis: traditional, adaptive, and choice-based. This study utilizes a traditional conjoint analysis approach. Traditional fullprofile conjoint analysis is a method that involves the respondents seeing full-profiles, with all attributes present. This method can measure up to six attributes (Orme, 2006). Compound attributes, combinations of levels from more than one attribute, can be used in traditional full-profile conjoint analysis to measure interactions of attributes in a limited capacity (Orme, 2006). Preference, as measured by traditional conjoint analysis, is represented by the equation:

$Y = b_1(x_1) + b_2(\mathrm{x}_2) + b_3(x_3) + b_4(x_4) + b_5(x_5)... + b_0$, where b_0, the constant, represents the base case.

2.1 Historical Context and Review of Conjoint Analysis

The application of Luce and Tukey s mathematical psychology and statistical analysis work was pioneered by Paul E. Green and Vithala Rao in the 1970 s in an attempt to solve complex marketing research problems (Orme, 2006). The two researchers developed one of the first iterations of a full-profile card-sort conjoint analysis model. The card-sort method, requiring participants to rank the cards from best to worst, was later eclipsed by a rating method for each card, that allowed preferences to be derived via least squares regression. By utilizing rating in lieu of ranking, researchers could examine a larger set of attributes.

The next big advancement for conjoint analysis came with the introduction of Richard Johnson s pairwise trade-off process. Instead of assessing all attributes at once, participants were asked to evaluate two-attribute trade-offs. Johnson had developed matrices that ensured all attributes would be covered in his study. The combination of the matrices with the participant ratings allowed him to estimate importance for a larger list of attributes than was possible with a full-profile methodology (Orme, 2006).

The growth in popularity of conjoint analysis led to the development of commercial and personal software for conducting conjoint analysis in the 1980 s. The continued development of software meant that conjoint analysis studies could be administered using computers, rather than paper-and-pencil. The computer simplified the process by collecting all of the respondent data while presenting the study trade-offs in the most relevant, user-friendly manner possible (Orme, 2006). Orme points out that in the 1990 s a consensus developed among researchers concluded that there was no single right method for conjoint analysis. Another change in the field saw the expansion of conjoint analysis application from marketing into other areas like design, human resources, and buying (2006). The most recent developments to conjoint analysis include increases in survey efficiency, precision of estimates, technological support for the analysis software, as well as decreases in implementation costs and required manual effort. Bryan K. Orme describes conjoint analysis as being in the robust stage of its life cycle. Orme continues to explain that while conjoint analysis has established itself as a reliable form of quantitative research, it continues to evolve (2006). Conjoint analysis has been used to evaluate consumer s preferences for multiple attributes of products and services in various fields such as psychology, decision theory, and economics ever since the early 1970 s(Green PE, Srinivasan V, 1978). There are many different types of conjoint analysis techniques. The theoretical foundation for conjoint analysis was laid by Luce in 1964 and others followed soon thereafter(Carrol JD, Green PE,1995). Over time, several different approaches to conjoint analysis have evolved(Orme BK., 2009).

The goal of consumer research is to predict behavior, and while other methods (regression, discriminant analysis) attempt to compose a behavioral rule with regard to consumer action and purchase, conjoint analysis is decompositional in orientation and more closely aligned with traditional experimentation. Conjoint studies conduct "experiments" with factors identified as determinant while controlling the levels of these factors (Hair et. al., 1992). The procedures of conjoint analysis are actually based on models of information processing and complex decision making (Hair et. al., 1992; Louviere, 1988). The conjoint approach assumes that consumers are fairly rational about comparing choice alternatives; hence the technique tends to work best with high-involvement, extended problem-solving situations rather than low-involvement, impulsive situations (Wyner, 1992).

Complex decision making follows a general pattern beginning with need awareness and culminating with consequences of behavior (Engel, Blackwell, & Miniard, 1990). Conversely, low-involvement situations are typified by limited problemsolving on the consumer's part. In these situations, it is common to simplify the process and reduce the number and variety of information sources and alternatives.. It is important to note that complex and limited problem solving are extremes on a continuum; a range of possible behavior exist between the two (Engel et. al., 1990).

Consumers' involvement with the decision will also influence the number of criteria used in alternative evaluation. A lesser number of evaluative criteria are likely to be utilized by the consumer as involvement decreases (Engel et. al., 1990). Similarly, Wyner (1992) suggests that conjoint analysis works best in situations where the product attributes are described in easily understood terms and the number of determinant attributes is small.

The underlying assumption of conjoint analysis is that a "composition rule"--a rule used in combining attributes to produce a judgment of relative value or utility for a product/service--determines respondents' preferences (Mike Bendixen, 1996). It is assumed that any object or concept is evaluated as a bundle of attributes. These attribute bundles are ultimately judged by combining the separate amounts of utility provided by each attribute (Hair et. al., 1992). An implicit supposition of this operation is that such an evaluation occurs within a competitive environment. Summarily, conjoint analysis refers to any "decompositional method that estimates the structure of a consumer's preferences given their overall evaluations of a set of alternatives that are prespecified in terms of different attribute levels" (Green et. al., 1978). Empirical research has scrutinized whether consumers actually use linear compensatory decision-making models (e.g. those assumed to be used in conjoint studies) or the evidently simpler evaluation models such as the lexicographic and conjunctive. This research has found that simpler rules are usually preferred. However, this apparent problem is subsumed by the fact that the compensatory model of conjoint analysis can typically approximate the outcomes of other kinds of decision rules quite closely (Green et. al., 1978).

2.1.1 Full Profile Conjoint Analysis

One of the earliest methods for collecting data which became popular was known as the full profile or conjoint value analysis approach. During the 1970s this approach was often used in lieu of the two-factor-at-a-time procedure approach or trade off procedure where only two factors were considered at a time (Green PE, Srinivasan V, 1978). The respondents were then asked to rank the combinations so that the most desirable combination was most preferred and the least desirable combination was least preferred (Green PE, Srinivasan V, 1978). In contrast, the full profile approach used the full set of attributes, and displayed all of them on a card simultaneously (Green PE, Srinivasan V, 1978). Experts within the field acknowledge that it may be hard for respondents to look at more than six attributes at a time (Orme BK., 2009). If more than six attributes are presented at a time, respondents may ignore attributes which they do not consider to be important, or ignore certain levels within important attributes due to information overload (Orme BK., 2009). The full profile approach has different formats for presenting the data (Green PE, Srinivasan V., 1978). For example, all of the attributes may be presented for one product or service and the respondent may be asked how likely they are to purchase the product on a continuous scale (Green PE, Srinivasan V., 1978). The scale could have different lengths such as 1-10 or 1-100.89 This approach is particularly good for new products that have not yet come onto the market (Green PE, Srinivasan V., 1978).Another option is for respondents to be presented with a full set of product profiles, and to rank the profiles from their most desirable to their least desirable. Finally, respondents can be presented with two profiles at a time, known as pairwise presentation, and asked to evaluate which one they would purchase and the strength of their preference for that product (Green PE, Srinivasan V., 1978). For example, a respondent would have the option of saying they strongly prefer product A, somewhat prefer product A, have no preference for either product A or B, somewhat prefer product B, or strongly prefer product B (Green PE, Srinivasan V., 1978).Some researchers believe that the ranking system may be more reliable, citing the premise that it may be harder for consumers to accurately express the magnitude of their preference for a product than simply stating which product they prefer (Green PE, Srinivasan V., 1978).

2.1.2 Adaptive Conjoint Analysis

As stated previously, one of the main limitations of full profile conjoint analysis is that a limited amount of attributes may be used (Orme BK., 2009). Adaptive conjoint analysis was developed by Richard Johnson of Sawtooth Software in the mid 1980s, principally as a means to bypass this limitation (Green PE, Srinivasan V, 1990). In adaptive conjoint analysis, the respondent s previous answers within a section are used by a computer in order to select the next question so as to provide the most information (Green PE, Srinivasan V, 1990). While the number of maximum attributes to be analyzed under full profile conjoint analysis was six, the number of attributes that can be used in adaptive conjoint analysis can be up to 24. In reality most studies using adaptive conjoint analysis have between 8-15 attributes. This is accomplished by taking the respondent through a set of partial profiles where only a few of the attributes are displayed at one time (Orme BK., 2009). The adaptive conjoint analysis interview potentially goes through several stages. The first stage, the adaptive conjoint analysis rating question type is designed to find out which levels of an attribute the consumer prefers. This question is not used for attributes where it is obvious that one level is preferred above another, where for example a lower price is understood to offer greater utility than a higher price. The next stage in adaptive conjoint analysis involves the adaptive conjoint analysis importance question. This set of questions is designed to find out which attributes are most important to the respondent. The next stage involves the adaptive conjoint analysis pairs question which is comprised of questions which use conjoint analysis principles. This is similar to the full profile pairwise presentation where the respondent is asked to choose between two products and services and indicate how strong their preference is for the product or service they choose. However only a part of the full number of attributes is usually presented in a scenario, and the next question is chosen by the computer to find the most information possible about the attributes. Although Adaptive Conjoint Analysis has several advantages, it also has distinct limitations. One obvious limitation is that it requires the use of a computer. It is also difficult to account for interactions with Adaptive Conjoint Analysis because it is a main effects model where the utilities for each attribute are measured in the context of other attributes being equal (Orme BK., 2009). The Adaptive Conjoint Analysis method also has a tendency to underestimate the importance of price when it is included as an attribute, and this underestimation is more pronounced as the number of attributes increases.

2.1.3 Choice-Based Conjoint Analysis

Choice-Based Conjoint is relatively new, as it started to become popular in the early 1990s, and is now the most popular method for conjoint analysis (Orme BK., 2009). Choice-based conjoint analysis does not ask respondents to rate or rank either one or two products; rather it asks respondents to choose one product or service from at least two (Orme BK., 2009). In fact, there have been cases where respondents have been presented with up to eight different products or services at one time and asked to choose which one they would purchase. Choice-based conjoint analysis offers several theoretical advantages over ratings or ranking based systems. The process of choosing one product is analogous to what consumers actually do in real life situations, so that people are able to understand this process quite readily. It is also possible to choose a none option. This option in particular contributes data about demand for price increases. Choice-based conjoint analysis is also capable of exploring interactions between different attributes, which has been cited as a limitation in full profile and adaptive conjoint analysis. However choice-based conjoint analysis does have limitations. Each question answered by a respondent offers less information because little information is gained about the products which were not chosen (Orme BK., 2009). There is no data gathered on how strongly the chosen product was preferred or the rank order of the products which were not chosen. Therefore, the choice-based conjoint analysis method may require more questions per respondent or a larger sample size. Another limitation associated with conjoint analysis is the fact that it analyzes responses at the aggregate or group level and inferences may not always be made about individual level utilities as is possible when using rating or ranking systems. However with newer methods such as hierarchial Bayesian estimation, individual level utilizes can be gathered from choice-based conjoint analysis. In addition, the limitation of attribute levels in choice-based conjoint analysis is even more pronounced than in full profile conjoint analysis. Because more than two products or services may be presented at once, it is improbable that respondents will be able to process information for more than six attributes. In fact, even this number of attributes may be too many when there are many complex levels within attributes. With choice-based conjoint analysis, there is a lot of information to consider as all attributes are typically presented for each service.

2.1.4 Potential Problems with Using Traditional Conjoint Analysis Methods

With this dissertation, there were several factors that dictate what would be the most appropriate method to use. One of the most important factors was the fact that this study had eight attributes. Furthermore, the respondents were senior citizens who may have cognitive limitations. As stated earlier, the maximum number of attributes recommended for a full profile study and a choice-based conjoint analysis study is six. Therefore, this seemed to preclude the full panel analysis or the choice-based method from being used in this study. As stated previously, adaptive conjoint analysis is able to handle more than seven attributes. This seemed to make adaptive conjoint analysis a viable choice as the method to use in this study. However, this method has the limitation of being inaccurate as relates to price data (Orme BK., 2009). Therefore, adaptive conjoint analysis was not without major flaws as a method to use in this study as this study had attributes which related to cost such as the premium price and the copayment amounts.

2.1.5 Adaptive Choice-Based Conjoint Analysis

Fortunately, there is a method which combines features of both choice-based and adaptive conjoint analysis which is known as adaptive choice-based conjoint analysis (ACBC). This form of conjoint analysis was developed in response to the fact that many respondents seemed to be answering choice-based conjoint analysis items too quickly in order to be able to fully evaluate all of the attributes and levels presented for each scenario. Therefore it was proposed that many respondents have a must have feature which they look for and select no matter what other options are available, or they may have features which they attempt to avoid at all costs. ACBC analysis has several stages just as adaptive conjoint analysis does. The first stage is a build your own question where the respondent chooses their preferred levels for each attribute. Where it is obvious that certain levels will be preferred for a particular attribute they are left out of this question. This would include attributes such as price where it is obvious that a lower price would be preferred. Based upon responses to this question, a pool of variations of the product or service being offered is created where all of the attributes and levels are included, but ones which are closer to the preferred levels of the respondent occur more often.93 The subsequent stage is called the screening section. In this section, approximately four variations of the product or service being evaluated are presented to respondents at a time. Respondents are asked to indicate which of these they think are possibilities for them to buy. Based upon the responses to the screening section, the respondent may be presented with the option of selecting a certain feature (level) which they believe is a must have. Also, the respondent may be presented with the option of selecting a feature which they would always like to avoid. The next stage is the choice tasks section. The respondent is presented with multiple variations of the product of the service being offered and asked to choose which one they prefer, just as in choice-based conjoint analysis. However, all of the choices presented have any feature which was identified as a must have, and they omit any feature that was identified as one the respondent must avoid. In addition, any attributes which are the same among the products are highlighted so that the respondent can concentrate only on those features which are dissimilar. Even though all attributes are presented, this helps reduce the amount of information which the respondent must process. Because of this, one can measure more than six attributes, with recommendations that no more than a dozen are measured. Furthermore, ACBC is recognized as being a good method to analyze price attributes, and is able to produce estimates for part worth values at the individual level. For the aforementioned reasons, ACBC represented the most reasonable approach for this study. There are potential limitations to ACBC. ACBC does tend to take more time to compete as respondents may take twice as long to complete an adaptive conjoint analysis survey as they do with choice-based conjoint analysis.93 In addition the administration of ACBC requires a computer. When all factors were taken into consideration, the benefits of using ACBC outweighed any problems that may be associated with it s use in this study.(Wingate,2011).

Applications

This inference of preference structure explains how important each factor is in overall preference, and how the differing levels within a factor contribute to overall preference. This information is used for: 1) definition of the object/concept with the optimum combination of attribute levels; 2) showing the relative importance of each attribute and level to overall evaluation; 3) estimating consumer judgments to predict market shares among differing attribute combinations; 4) definition of potential high and low segments by grouping consumers having similar preference structures; and 5) exploring the potential for non-existent or hypothetical attribute combinations (Hair et. al., 1992). Users of conjoint analysis have generally emphasized predictive validity as of primary importance and have regarded explanation as a desirable, yet secondary, goal (Green et. al., 1978).

Variable Selection

After the research problem has been stated, a preliminary data collection procedure is employed identifying those attributes most frequently regarded as relevant. This can be accomplished by numerous means including customer surveys, focus groups, and consulting product managers and others knowledgeable about the product/services and its uses. The task is then to reduce the number of attributes to a reasonable size while still retaining the strength to estimate consumer behavior. According to a survey by Cattin and Wittink (1982), in which the researchers reviewed conjoint procedures frequently used in practical applications, the median number of attributes used was between 6 and 7. Too many additional attributes complicates the respondent's job and can introduce unreliable data due to fatigue; too few attributes may not provide an accurate description of the product. In the case of continuous attribute spacings, the most frequent practice has been to rely upon equally spaced attribute levels to represent the appropriate range. Darmon and Rouzies (1989) have questioned the soundness of this practice and have found that this convention may not always be appropriate to the study. Specifically, their study suggests that "using smaller attribute level spacings in the steepest slope range of the utility function will yield more valid results than using equal or larger spacings." The researchers investigated these effects by varying level spacings, function range, shape, curvature, and estimation method. In general, Darmon et. al. (1989) propose that using smaller spacings helps recover the utility functions' ranges and curvature, and reduces the average error between recovered and true utilities. They caution, however, that if there is no reason to assume a specific functional form a priori, then equal attribute level spacings should be used because unequal spacings in the wrong direction could considerably misrepresent the recovered utilities. In another paper by Kumar and Gaeth (1991), the authors addressed whether attribute importance weights changed with the relative position order of the attribute in a conjoint task.

This experiment was specifically meant to investigate the role order effects play in conjoint task decision-making. Their empirical evidence revealed an absence of order effects for a familiar product category, but the presence of systematic order effects for an unfamiliar product category. It was further recommended by Kumar et. al. (1991) that the order of the attributes be counterbalanced or randomized between subjects to avoid biases. Obviously, this procedure is appropriate when the researcher is interested in aggregate problems. But attribute order could be randomized within subjects (Kumar et. al., 1991). While this solution would add unsystematic variation and inflate the conjoint model's error term, it also would guarantee coefficients not biased. This procedure tends to improve with a disaggregate interpretation of the utilities. Another solution suggested by Kumar et. al. (1991), maintained by Page and Rosenbaum (1989) and useful to remember when constructing the conjoint task and stimuli, is to simply present the attributes in the natural order they occur when consumers encounter the products. Again, the correct solution depends upon the nature of study and the proposed research questions. Regardless, the attributes and their levels must be realistic, distinct and represent a single concept while at the same time accounting sufficiently well for consumer preferences and avoiding multicollinearity (Green et. al., 1978, Hair et. al. 1992).

Preference Model

A preference or composition model is then specified and an assumption made about customer information processing. The issue is whether the predictive validity of the model with interactions would be better because of increased realism or worse because of the estimation of several additional parameters, a common trade-off problem in social science. There is some evidence that the model with interaction items often leads to lower predictive validity and that this is due to the inclusion of additional parameters in the model (Green and Srinivasan, 1990). The additive model already discussed assumes that consumers simply add up the part-worths, or utility associated with each level of each attribute, to get the total worth of the product/service. An interactive model assumes the total worth is more, or less, than the sum of its part-worths. The interactive model may be a more accurate representation of the customer decision-making process, but the additive model allows better estimates of part-worths. Once the general model is chosen, the part-worth relationship must be specified. While the composition model decides how the attributes are related, defining the part-worth relationship indicates how the levels of a attribute are related. The part-worth relationship can be estimated three ways; vector (linear), quadratic (ideal point) or separate part-worth(Stephanie Fallon, 2014).

The separate part-worth model provides the greatest flexibility in allowing different shapes for the preference function along each of the attributes in that both the vector and ideal-point models can be derived from it. However, this flexibility is delivered at the cost of estimating additional parameters and approximating intermediate levels by linear interpolation (Green et. al., 1978). To determine a part-worth value outside the range of estimation, extrapolation of the linear function would be needed. The validity of this procedure is disputable, hence it is important to initially incorporate an inclusive range of the attributes when possible.

In choosing the appropriate model, the flexibility of the shape of the preference model becomes greater as we go from the vector to the ideal point to the part-worth function models. Derivation of degrees of freedom, in which part-worth models have the fewest degrees of freedom, also follows this pattern. In fact, the typical conjoint study using a part-worth model often has no degrees of freedom (Green et. al., 1990). The reliability of the estimated parameters, however, is likely to improve in the reverse order.

From the standpoint of predictive validity, the relative effectiveness of each model is generally unclear and most often depends upon a priori conclusions about the variables. It is possible to incorporate a mixed model where some attributes are best represented using a vector model while other attributes--categorical variables for instance--may require a part-worth model. Lastly, in the Cattin et. al. (1982) survey, the part-worth was the most common model used, an indication of its flexibility and robustness.

Estimated Parameters

Conjoint analysis can not only assess each attribute level's part-worth value, but can also assess the importance of each attribute relative to the other attributes. Since part-worth estimates are on a common scale, the attribute with the greatest contribution to overall utility or the highest range of part-worths will be the most important attribute. This is accomplished by dividing each attribute's range value by the sum of all range values. This results in a relative importance value for each attribute. Within each attribute, conjoint analysis derives relative importance scores for each attribute level from the ranking or rating data. These utility scores are analogous to regression coefficients and their range is used to find the relative importance of each factor. This information is useful when deciding which combination of attribute levels is best for a product/service or predicting sales given specific combinations of attribute levels (Hair et. al., 1992).

The conjoint function can then be applied at the aggregate (group) or disaggregate (individual) level. In the disaggregate approach, each respondent is modeled separately and the researcher appraises the behavior of each respondent relative to the model's assumptions. This approach also allows for the exclusion of respondents who demonstrate such poor preference structure that it is assumed they did not perform the preference task correctly (Hair et. al., 1992).

When using the aggregate approach, the analysis fits one model to the entire set of respondents. This approach is not useful for predicting individual behavior or interpreting attribute values for any single person. Unless the researcher is definitely dealing with a population relatively homogeneous in behavior with regard to the attributes, is interested in aggregate behavior (i.e. market share), or is constrained to use an aggregate approach for nonstatistical considerations, aggregate analysis is not an appropriate line of action. Thus application to the individual or group level depends on the primary purpose of the study.

Chapter 3

Literature Review

The literature review starts with an examination of current situation in market and users habit of home theatre system using. The literature review concludes with research regarding design decisions that impact the variables selected for this thesis study.

India s audio visual market is the fastest growing market and is expected to reach US$5 bn in the coming year. Changing consumers preferences, lifestyle and media consumption habits are driving the acceptance of a range of new, innovative and non-traditional solutions for media playback. The rapid rise in technology has resulted in a portable device in everyone s hand be it a smartphone, tablet or a phablet which leads to a growing demand for music on the go, said, Ernest Sim, Regional Sales Manager for India and the India Subcontinent, Creative (National Computrade News, 2014)

Currently, there are no authentic estimates on the market size and growth of multimedia speakers. We estimate it to be around $400 m in India today and the CAGR growth rates have been hovering around 20% for the past 2 years in India, opine, Sharath Santhakumaran, Director Lifestyle, HARMAN International (India) Pvt Ltd. (National Computrade News, 2014).

It s difficult to estimate the exact size due to gray market. However, the industry has witnessed good growth over the last decade especially post-2009 and is growing at an estimated 25% YoY for the last 5 years. With introduction of multiple technologies like Remote / FM / USB / Bluetooth becoming more standard and accessible, we expect this trend to continue in the years to come, said, Yashwant Dugar, Director Sales at Mitashi Edutainment Pvt Ltd. (National Computrade News, 2014).

Saurabh Grover, Country Head India, SAARC & MEA, RAPOO, said, In India, consumer electronics brands are moving very fast. If we speak about speakers, they are creating emerging trends in the current market; every brand is coming up with new innovations and we are foreseeing consistency in the growth of this market in 2015 as well. We are focusing more on speakers sections as this will bring us opportunities with our unique and modernized approach. (National Computrade News, 2014).

Since the multimedia speaker market is widely expanding, there is much scope for vendors. Although unbranded grey market products are dominating at present, with quality, competitive pricing and availability. Creative Technology believes that the speaker market is huge and can be a profitable business. They are currently working diligently to ensure their product availability with maximum market reach. They are now driving digital entertainment segment with cutting-edge audio solutions in their range of premium wireless speakers, high performance earphones, gaming headsets and audio enhancement devices. The company s innovative hardware, proprietary technology, applications and services enable consumers to experience high-quality digital entertainment anytime, anywhere (National Computrade News, 2014).

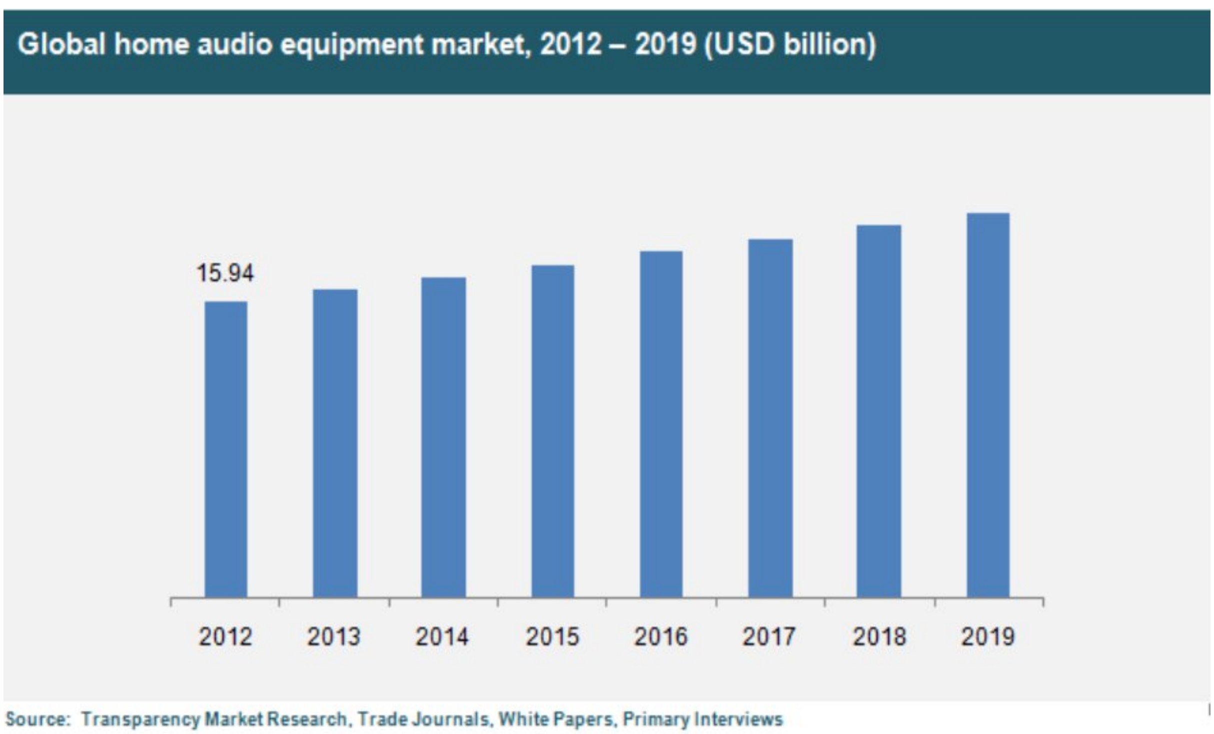
The sensational popularity of smartphones and the recent war between the Android, iOS and Microsoft Windows has created opportunities for consumer electronics products that allow phones to do more, from playing music with speakers which also increases the market of home theatre system. Philips, a major player in the home audio segment, has started innovations in the form factor of music system and plans to target them in rural markets. It has also rolled out standalone home theatre speakers. In India, while the home theatre sales may not be large, the growth is significant as increasing number of consumers want products that suit their home decor. Consumers are willing to pay more for quality sound, innovation, and compact trendy units. And, growth of the hi-end audio systems category is being fuelled by the youth as a technology differentiator for self expression and entertainment, pretty much in sync with global trends (National Computrade News, 2014).

Growing consumer preference for better quality products and rise in disposable incomes of families are mainly encouraging customers to buy such home entertainment products, thus, driving the market for home audio equipment. Additionally, availability of home theatre system that can perform audio/video switching and play and stream audio stored on PC and internet radio stations is expected to boost the home audio equipment market. However, fear of hearing loss is the major restrain for this market. Introduction of wireless streaming is expected to boost the demand for home audio equipment.

Home audio systems including music players, Blu-ray players, along with LCD and LED TVs and HTiBs are the most popular products in the market. In case of product types, other home audio accessories segment which includes speakers, subwoofers, and microphones among others held the largest share in 2012. This is mainly due to growing popularity of music applications and streaming capabilities. However, home theater in-a-box segment is expected to grow at faster rate due to the rising usage of digital entertainment and rapid transition to online platform.

In 2012, Europe held the largest market share and accounted for 29.6% of the global home audio equipment market. This is because consumers in Europe are early adopter of technologically advanced entertainment products such as smartphones, Blu-ray players, and televisions among others. The Asia Pacific region is expected to be to the fastest growing owing to the rise in living standards of the population and presence of most home audio equipment manufacturers in the region (Transparency market research, 2014).

Figure 1: Global home audio equipment market, 2012-2019



The global market for home audio equipment is fragmented in nature and contains leading players namely Akai, Dolby Laboratories Inc., DTS Inc., JVC KENWOOD Holdings Inc., Koninklijke Philips Electronics NV, LG Electronics, Panasonic Corporation, Sanyo Electric Co. Ltd., Nakamichi Corporation, Onkyo Corporation, Pioneer Corporation, Sharp Corp., and Sony Corporation.

According to a new technical market research **Digital Entertainment in the Home:Technologies and Global Markets,** from **BCC Research** (www.bccresearch.com), the global digital home entertainment systems market was valued at nearly $147.4 billion in 2012 and increased to $150.9 billion in 2013. BCC Research projects the market to grow to $176.3 billion by 2018, and register a five-year compound annual growth rate of 3.2% from 2012 to 2018.

3.1 About few factors for home theatre system design

3.1.1 Wired or Wireless

Wired home theatre systems use special wires or cables in order to connect all the different components together. They are still a very popular choice for homes, but they are especially popular amongst people that are looking for the clearest, most accurately reproduced sound as there is no chance that the transmission can be interfered with. Wired home theatre systems are incredibly flexible as you have the freedom to replace speakers as you wish in the future. This means that you can start with lower end speakers and upgrade them over time as your budget allows.

The major disadvantage of a wired home theatre system is the fact that wires or cables are required for the system to operate. This means that you will either need to hide the cables by running it through the walls, or deal with the cables being visible. You can buy special clips to hold the cables securely to the wall so that they don t pose a trip risk and to also improve their appearance. Wireless home theatre systems can also be more complicated to set up, as you have to make sure that cables are connected correctly.

A wireless home theatre system is often preferred due to the convenience in setting it up. You can place the speakers wherever you like as you don t have to worry about the cords and cables getting in the way. The lack of cables also makes things look much neater as there are no cables running along the wall or floors. Wireless home theatre systems are also incredibly easy to use. In most cases, you can unpack it, place everything in the right position, and turn it on and it will start working.

However, one thing you need to consider with wireless home theatre systems is that they may not have as good sound quality as wired home theatre does. This can be a problem if you are after the clearest, purest sound. Wireless home theatre systems can also suffer from interference if you are using other wireless technologies in the home such as cordless phone, wireless internet and so forth. Wireless speakers are also proprietary, which means that they ll also work with other equipment of the same brand, that is, compatible equipment. This can be a problem if your speakers break one day, as you may need to replace the whole home theatre instead of just the affected speakers.

3.1.2 Sound output

Sound output is one of the most important features in home theatre system. Too loud and too low sounds are not desirable to experience good quality music and movie. Generally two types of units are used for sound output: PMPO (Peak Music Power Output), and RMS (Root Mean Square). But recently customers are preferring speakers featuring RMS unit as sound output rather than PMPO unit.

The real power is RMS, while PMPO means music power. How to compare those you need to split PMPO by 3 and then you will get RMS (almost! not exacltly).

RMS is a voltage that is putting to the speaker in Constance way, without worry of sound quality or speakers damage. PMPO is the highest power at the highest voltage, at the speaker that least less than second.

PMPO is a marketing symbol, because it s much nicer for producers to put some big numbers. So to be honest, PMPO was created for cheating people at the shops.

When we speak about amplifiers, it is power that amplifier can produce at all time, without any damage.

3.1.3 Channel

2.1 Surround Sound**:**

It uses two speakers and a subwoofer to play movie audio, television sounds and music. The 2.1 surround sound speakers are an ideal way to enjoy your favourite music and movies without the hassle of too many wires and additional mess. It is perfect for those with space constraint and who does not wish to cram their room with multiple speaker units. With the 2.1 home theatre system, you are sure to enjoy music and movies with absolute clarity. You can connect them to your laptop or personal computer and enjoy enhanced sound output as compared to normal computer speakers. Brands like JVC, Logitech and Philips are few of the most preferred names in this category. Advantages for this system are

- Two speakers with one subwoofer do not take much space
- Perfect for compact locations or rooms with limited space
- Detailed stereo sound response reproduced by dual speakers

5.1SurroundSound**:**

It is the most popular surround sound speaker format which features five speakers and one subwoofer. The two left and right front speakers deliver a wide sound stage and reproduce on-screen action in a movie. They reproduce sounds like car driving or sounds of people talking, with the stereo effect. The centre channel speaker reproduces dialogues which forms the crucial part of your entertainment. The two left and right rear speakers help reproduce 3D sound field so that the special effects sounds are heard from all directions. The subwoofer produces bass notes and adds impact and realism to your entertainment. It is perfect for medium to large rooms where five speakers and a subwoofer can be accommodated. The 5.1 surround sound format is suitable for pure movie buffs who wish to enjoy the perfect cinema theatre experience at home. Brands like Denon, LG, Philips and Sony are some of the most preferred names in this category. Advantages of this system are

- Adds realism and gives detailed effect of each sound produced
- Exclusively dedicated speakers for every sound effect

The dedicated speakers reproduce every sound to add realism and clarity to every sound note for an in-the-scene experience.

The biggest benefit of setting up a home theater is that you have complete control over the audio. Don't underestimate the receiver's role in this, but getting a decent pair of speakers that's right for your space will make everything you watch sound leaps and bounds better. Great speakers come at all price points and sizes, so you don't have to worry that just because you have a small space or tight budget you won't be able to enjoy great sound.

Loudspeakers have the toughest job in the home entertainment system. While source, processing and amplification components like players, receivers and amps simply have electrical signals with which to contend, speakers are transducers devices which convert electrical energy (the audio signal supplied by the amp) into mechanical energy (the music and sounds we hear). A good speaker will do this job accurately, reproducing sounds precisely as they were recorded and efficiently, squeezing the most volume from the least power. What s more, there s no single way to build a fine loudspeaker. Unlike amps, preamps and processors, which all employ the same basic circuits but differ in terms of features and construction quality, the diversity of speaker designs is nearly as limitless as the speaker designer s imagination.

All loudspeakers make sound by moving air. Your amplifier powers the speaker s drivers woofers for bass, tweeters for treble, and midrange for everything in between that vibrate at frequencies and volumes to match the original recording. Since they all work the same, why don t all speakers look the same? Because everyone s needs are different. Do you want to make your home theater the focal point of your living room, or do you believe that speakers should be heard and not seen? Are thunderous bass and lifelike volumes important, or is softer better? No matter: there s a perfect speaker for your room, budget and listening taste, once you know how to find it (Chiarella,Polk,2006).

Floorstanding Speakers

Floorstanding or tower loudspeakers are audio s equivalent of a big-block V-8 engine. Thanks to their large enclosures and increased size or number of drivers, floorstanders move enormous quantities of air, enabling them to have greater dynamic range (to play louder and cleaner) and produce deeper bass than other designs.

Advantages

Extremely wide frequency response and dynamic range make floorstanders the choice where performance is the primary purchasing criteria. And while they tendto be large, many current models feature slender cabinets with small footprints, minimizing visual impact. Also, since most of the world s best loudspeakers are towers, their manufacturers often lavish better parts or build quality on these flagship products.

Disadvantages

When space is at a premium, such as in a small apartment or smartly decorated room, towers simply might not fit. What s more, the prodigious output capabilities of such speakers means that placement can be more critical floorstanders should be located 2-3 feet from nearby walls for best performance. Finally, beware of bargains: large cabinets are expensive to build. Unusually low pricing is often the result of construction shortcuts.

Floorstanders With Built-In Subwoofers

(Powered Towers) Powered towers are floorstanding speakers with the powered subwoofers built right in.

Advantages

For 5.1 channel digital systems, the chore of selecting the subwoofer disappears. Powered towers also conserve floor-space. Since the subwoofer and main speaker drivers are designed together, they can be optimized with each other for better performance and better blending. There is no sense of discontinuity between midrange and bass as there can be with separate main/subwoofer speaker systems. While not cheap, powered towers are often less expensive than purchasing separate speakers and subwoofers of comparable quality.

Disadvantages

The best room placement for the midrange and imaging of the main speakers (usually away from walls) may not be the best placement for the subwoofer s bass output (usually close to walls). So a powered tower may force a compromise in placement and performance. Very large rooms and bass-craving listeners may require a separate subwoofer.

Bookshelf Speakers

With their compact cabinets, bookshelf speakers work where towers won t. Actually, the name bookshelf is unfortunate, since most such designs perform best when placed on sturdy stands, rather than tucked inside pieces of furniture. These speakers are not only more placement-friendly but, since small enclosures are more rigid, they produce less sonically degrading box resonance than all but the best towers.

Advantages

Usually modest in price as well as size, bookshelf speakers fit rooms and budgets that cannot accommodate a pair of expensive towers. The small, solid cabinets are both versatile-able to excel in bookcases, atop shelves or hung on walls-and feature excellent midrange clarity.

Caution:

Many bookshelf type speakers use air tunnels or ports to improve efficiency and bass output. If you plan on placing your speakers against a wall or inside a cabinet, choose a model whose port is located on the front panel, with the drivers. The exceptions to this caution are the Polk RT*i* and LS*i* Series bookshelf models that feature a rear mounted PowerPort. The PowerPort s unique design permits proper operation even under these conditions. (Couldn t resist the plug here!
Matt)

Disadvantages

Reduced cabinet volume and driver area limit the dynamic and bass frequency range of bookshelf speakers, and can also compromise power handling and efficiency. Fortunately, the addition of a separate subwoofer can overcome these problems.

Subwoofer/Satellite Systems

When even the smallest bookshelf speakers are too visible to fit your lifestyle, a satellite/ subwoofer (sub/sat) system is the answer. By combining small satellites with a subwoofer designed specifically to work with them, sub/sat systems have become one of the most popular categories in home audio.

Advantages

The big advantages here are size, placement flexibility and cosmetics. The satellites can be placed just about anywhere: on a shelf, on the wall, in a cabinet or on a table. Most are small enough to fit in the palm of your hand and are hard to spot when placed alongside books and bric-a-brac. Some satellite speakers are very handsomely styled so that even when they are seen, they complement rather than detract from the look of the room. The subwoofer section can be placed out of sight-in a corner, behind furniture or under a table. Sub/sats also have certain performance advantages over more traditional designs. The slender front baffles don t interfere with the drivers dispersion, so imaging is absolutely first rate. The best of the genre produce a wide, deep soundstage that is in some ways superior to larger speakers. The subwoofer cabinet can be placed where bass performance is best, so bass response is often awesome. Most folks are agog when they hear such loud bass apparently coming from such tiny speakers.

Disadvantages

Those little satellites can t reproduce bass on their own, making it tough to achieve a completely seamless blend between satellite and sub. There is often a hole or weak response in the area where the satellite s response leaves off and the subwoofer takes over- lower midrange or the bottom octave of a male voice. When evaluating sub/sat systems listen closely to male voices, if they sound thin the system suffers from this midrange suck-out problem. Small drivers and enclosures also compromise dynamic range and power handling. If you have a very large room to fill with sound, a sub/sat system may not be right for you.

Subwoofers

A speaker that reproduces only the lowest frequencies, a subwoofer makes it possible to achieve true full-range performance with bookshelf or satellite speakers by taking over the responsibility for the lower frequencies which small speakers have trouble delivering. Subwoofers can augment the bass of all speakers in the system as well as serve as the .1, or LFE (low frequency effects) channel, in 5.1- channel digital systems. Listeners who seek the ultimate home theater experience will want to add a subwoofer even to full-range floorstanding towers!

Advantages

Subwoofers supply the low frequencies that small speakers lack, but that s only half the story. By relieving the other speakers of their bass burden, a subwoofer actually enhances midrange and treble quality. Most subs include their own amplifier, so adding a powered subwoofer also increases your total system power. And since bass frequencies are non-directional, your sub can be tucked out of sight and still shake the floor.

Disadvantages

A subwoofer is yet another box to find a place for in your room. If this is a problem for you, consider main tower speakers with built-in powered subwoofers custom installed in the floor. In the context of a 5.1-channel system, there are few downsides to a subwoofer you need one to get the full impact potential of the home theater experience.

Built-In Speakers

For environments where box-type (tower or bookshelf) loudspeakers are unacceptable, built-in speakers mount in holes cut into the wall or ceiling. Most models feature paintable grilles so you can disguise them, enabling them to virtually disappear into your decor! A new category of built-in speakers is that of built-in subwoofers that mount in walls, floors and ceilings. These subs usually come with outboard purpose-designed amplifier/crossover units.

Advantages

Since they consume no floor or bookshelf space and can be easily concealed, in-walls work when and where other speakers won t. If you plan on expanding your system throughout your home, built-in speakers are a wonderful way to bring sound to additional rooms. They are also useful as rear surround speakers when the room configuration makes it impossible to properly place box speakers. The very best examples of built-in speakers and subwoofers can rival or exceed the sound quality of free-standing speakers.

Disadvantages

Unless you are using a purpose-designed in-wall enclosure or have the ability to change the volume of space behind the speaker (by installing fire breaks), bass performance can be uneven and unpredictable. Built-ins that can deliver the dynamic range and bass response of boxtype loudspeakers are more costly than freestanding models. Unless you are a do-ityourselfer, professional installation will add to the cost of the system.

Art imitates life. In the real world, we don tjust hear sounds in front of us, but from the back and sides as well. In their attempts to make movies as lifelike as possible, directors duplicate this experience by sending certain sounds to the sides and rear of the theater. For these reasons, modern soundtracks include additional channels that surround their audiences with sound. When movies are auditioned through a multi-speaker theater array, viewers are placed in the center of the action. That s why you need all those speakers! (Chiarella,Polk,2006)

The Speaker Wire Advantage

Many people are worried that if they don t use the subwoofer output jack, they ll miss the Low Frequency Effects (LFE) channel on 5.1-channel DVDs. Not true. If you have full size speakers, and if your electronics allow an unfiltered signal to go to the subwoofer output jack, and if the subwoofer plays in all modes(stereo as well as surround), go ahead and use the subwoofer output jack. Otherwise, there are better ways to hook up your subwoofer. Almost all powered subwoofers allow you to connect them with speaker wire.

Chapter 4

Research Objectives

Technological advancements in audio technologies have changed the way music is streamed and enjoyed. Audio industry has woken up to the demands of new technology based audio devices. The end user demand for such devices arises not only from the home and consumer ends but also from commercial and other niche applications. The different driving factors, constraints and opportunities with respect to the global audio market help in identifying trends and key success factors for the speaker industry. This thesis aimed to investigate customer reaction towards the preference for home theatre selection and to make a solution which attracts customer the most with a focus on the attributes of channel, sound output, power consumed, price range, and wire system.

4.1 Research Questions

1. Do attributes i.e., channel, sound output, power consumed, price range, wire system impact preference for customers of home theatre sound system?
2. If so, what attributes have salient impact on the users preferences?
3. If a most-salient attribute can be identified, are there differences in preference among the respective levels?

Chapter 5

Methodology

5.1 Variable Selection

The attributes and levels used in this study were determined based on literature review, interviews with users, and from information through the online marketing websites (amazon, flipkart, snapdeal, ebay etc). The researcher asked users and the people who are involved in marketing of home theatre system about factors and features of home theatre system. Ultimately, five attributes were identified for the study: channel, sound output, power consumed, price, and wire system.

The next step was to define experimental levels for each attribute. Levels for attribute channel were selected by questioning users and from marketing websites. Usually 2.1, 4.1, and 5.1 are mostly featured in Indian market. So, these three levels were selected.

For the sound output attribute 600w and 1000w are mostly featured in recent home theatre market that s why these two levels were chosen for the experiment.

For power consumed attribute two levels were chosen: 38w and 55w. These two levels were chosen because at present many brands of home theatre system have either one of these two levels for power consumed with respect to certain price range.

Current market prices for home theatre system available in the market were used to determine the levels. Brands like Sony, Samsung, LG, Creative etc. are providing very good and efficient sound system within 15000 INR which attracts customer to have sound system within this price range. So, two price range were chosen: 10000 to 15000 INR and less than 10000 .

For wire-system attribute two levels were chosen: wired and wireless because some people like wireless speaker system and some people don t, they like wired system more.

5.2 Traditional Conjoint Analysis using xl-stat

Conjoint analysis is practical for imitating real-life scenarios and gives the researcher an understanding about consumer preferences (Hair et al. 1998) and also is the most widely used tool for examining consumer trade-offs (Green et al. 2001), it was chosen as the method of research to be used in this study for determining consumers preferences for home theatre system.

Conjoint analysis is defined as Any decompositional method that estimates the structure of a consumer s preferences (e.g. part-worths, importance weights, ideal points) given his/her overall evaluations of a set of alternatives that are prespecified in terms of levels of different attributes (Green and Srinivasan,1978).

The first step in a conjoint study is to determine the attributes and levels.

The experiment employed traditional conjoint analysis to assess the relative importance of the five experimental attributes, four at 2 levels and one at 3 levels.

The XLSTAT statistical analysis add-in offers a wide variety of functions to enhance the analytical capabilities of Microsoft Excel, making it the ideal tool for your everyday data analysis and statistics requirements (XLSTAT, Addinsoft, 2015).

5.3 Experimental Offerings

In this experiment there are five attributes (channel, sound output, power consumed, price, and wire system). Channel has three levels and rest of the attributes has two levels each(Table 1).

Table 1: Groupings of five level attributes

	A	B	C	D	E	F
1	Levels\Attributes	Channel	Sound output	power consumed	price range	wire system
2	Level 1	2.1	600w	38w	<10000	wired
3	Level 2	4.1	1000w	55w	10000-15000	wireless
4	Level 3	5.1				
5						
6						

Here, one has three levels others have 2 levels each. So, total number of profiles or combinations of attribute-levels should be 48 (3*2*2*2*2=48). But the 48 number of profile/combinations was too large; it had risk of fatigue for participants to rate all these 48 combinations. So, it was necessary to reduce the number of profiles to an optimum level. Xl-stat software was used to optimize the number of profiles to an optimum level. At first there was 48 profiles/combinations and after optimization it had only 18 profiles or combinations. This table was designed in XL-stat software (XLSTAT addin, 2015).

Table 2: Optimized table for combinations of attribute levels

	A	B	C	D	E	F
1	Observation	Channel	sound output	power consumed	price range	wire system
2	Profile1	2.1	600w	55w	10000-15000	wireless
3	Profile2	2.1	1000w	38w	10000-15000	wired
4	Profile3	5.1	600w	55w	10000-15000	wireless
5	Profile4	5.1	600w	55w	<10000	wireless
6	Profile5	2.1	600w	55w	10000-15000	wired
7	Profile6	2.1	600w	38w	<10000	wired
8	Profile7	4.1	1000w	55w	<10000	wired
9	Profile8	2.1	1000w	38w	<10000	wireless
10	Profile9	4.1	1000w	55w	<10000	wired
11	Profile10	2.1	1000w	55w	<10000	wireless
12	Profile11	5.1	600w	38w	<10000	wired
13	Profile12	5.1	1000w	55w	10000-15000	wired
14	Profile13	5.1	1000w	38w	<10000	wireless
15	Profile14	5.1	1000w	38w	10000-15000	wireless
16	Profile15	4.1	600w	38w	10000-15000	wired
17	Profile16	4.1	1000w	38w	10000-15000	wireless
18	Profile17	4.1	600w	38w	<10000	wireless
19	Profile18	4.1	600w	55w	10000-15000	wireless
20						

It was the final table to represent each offering in the experiment. This chart was prepared for the rating for each combinations given by the users.

5.4 Collection of data

5.4.1 Participant criteria

The population being examined consisted of students who have used or using home theatre system at MNIT Jaipur and persons who are involved in this business. The sample was, for the sake of meeting schedule deadlines, a convenience sample derived from students (users) of MNIT Jaipur. The sample was solicited for participation via e-mail blasts and word-of-mouth. It was specified that the desired participants must be aware of these attributes and levels selected for experiment and have little bit knowledge or experience of home theatre system.

5.4.2 Conducting the experiment

A pilot test of the experiment was conducted to identify complications with the survey and the experiment s instructions. At the conclusion of the pilot testing, one complication with the backend question structure of the survey was identified and remedied. The clarity of the survey questions and procedural instructions were confirm ed, as all pilot participants provided useable data and followed the study s guidelines.

The full-scale implementation of the experiment was conducted from February 10th to March 15th, 2015. Part one of the study required the participant to review the experimental consent form provided by the researcher. Upon signature of the consent form, the participant was asked to take a survey in which she answered demographic questions, as well as questions regarding important features.

Once the participant had completed the Part One questionnaire, they were given the print copy of the chart which is given in Table 2 to give preference ratings for each profile/combination. Each participant was instructed to view each profile of the chart carefully before assigning a preference rating. See example below:

Preference Rating: *1-Lowest, 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest*

The participants were also told that the profiles must be rated in order and were not being directly compared to one another. Upon completing all eighteen ratings, each participant was offered the opportunity to review the layouts and make any necessary adjustments to her preference ratings.

A minimum sample size of 30 was required for this experiment, according to the sampling guidelines outlined by Bryan Orme in *Getting Started With Conjoint Analysis* (Orme, 2006). While a sample of 60 participants was obtained, the responses of one participant had to be discarded due to improper execution of the experiment. The total final sample size for the experiment was 59 participants.

Table 3: Profile chart with rating for each profile by participant 19

A	B	C	D	E	F	G
Observation	Channel	sound output	power consumed	price range	wire system	Individual 19
Profile1	2.1	600w	55w	10000-15000	wireless	3
Profile2	2.1	1000w	38w	10000-15000	wired	4
Profile3	5.1	600w	55w	10000-15000	wireless	5
Profile4	5.1	600w	55w	<10000	wireless	7
Profile5	2.1	600w	55w	10000-15000	wired	4
Profile6	2.1	600w	38w	<10000	wired	6
Profile7	4.1	1000w	55w	<10000	wired	7
Profile8	2.1	1000w	38w	<10000	wireless	5
Profile9	4.1	1000w	55w	<10000	wired	6
Profile10	2.1	1000w	55w	<10000	wireless	4
Profile11	5.1	600w	38w	<10000	wired	10
Profile12	5.1	1000w	55w	10000-15000	wired	8
Profile13	5.1	1000w	38w	<10000	wireless	7
Profile14	5.1	1000w	38w	10000-15000	wireless	5
Profile15	4.1	600w	38w	10000-15000	wired	7
Profile16	4.1	1000w	38w	10000-15000	wireless	6
Profile17	4.1	600w	38w	<10000	wireless	8
Profile18	4.1	600w	55w	10000-15000	wireless	4

Here, in this table, G column represents ratings for each profile/combination. Total 60 samples of table like this were collected through survey. After the collection of data another model of profile chart was made using dummy variables.

A Dummy variable or Indicator Variable is an artificial variable created to represent an attribute with two or more distinct categories/levels.

5.5 Why dummy variable is used

Using categorical data in Multiple Regression Models is a powerful method to include non-numeric data types into a regression model. Categorical data refers to data values which represent categories - data values with a fixed and unordered number of values, for instance gender (male/female) or season (summer/winder/spring/fall). In a regression model, these values can be represented by dummy variables - variables containing values such as 1 or 0 representing the presence or absence of the categorical value.

Regression analysis treats all independent (X) variables in the analysis as numerical. Numerical variables are interval or ratio scale variables whose values are directly comparable, e.g. 10 is twice as much as 5 , or 3 minus 1 equals 2 . Often, however, you might want to include an attribute or nominal scale variable such as Channel or Wire-system in your study. Say you have three types of channel, numbered 2.1 channel, 4.1 channel and 5.1 channel. In this case, 5.1 channel minus 2.1channel doesn t mean anything you can t subtracting channel 2.1 from channel 5.1. Dummy variables are created in this situation to trick the regression algorithm into correctly analyzing attribute variables.

In table 3 which attributes were present for each observation those were indicated as 1 in table 4, and which were not present for each observation those were denoted as 0 in table 4. Dummy variables assign the numbers 0 and 1 to indicate membership in any mutually exclusive and exhaustive category**.**

The number of dummy variables necessary to represent a single attribute variable is equal to the number of levels (categories) in that variable minus one. For a given attribute variable, none of the dummy variables constructed can be redundant. That is, one dummy variable cannot be a constant multiple or a simple linear relation of another (Smita Skrivanek, 2009).

Table 4: Profile chart of table 3 for participant 19 using dummy variables

Observation	Channel-2.1	Channel-5.1	Channel-4.1	sound output-600w	sound output-1000w	power consumed-55w	power consumed-38w	price range-10000-15000	price range-<10000	wire system-wireless	wire system-wired	Rating
1	1	0	0	1	0	1	0	1	0	1	0	3
2	1	0	0	0	1	0	1	1	0	0	1	4
3	0	1	0	1	0	1	0	1	0	1	0	5
4	0	1	0	1	0	1	0	0	1	1	0	7
5	1	0	0	1	0	1	0	1	0	0	1	4
6	1	0	0	1	0	0	1	0	1	0	1	6
7	0	0	1	0	1	1	0	0	1	0	1	7
8	1	0	0	0	1	0	1	0	1	1	0	5
9	0	0	1	0	1	1	0	0	1	0	1	6
10	1	0	0	0	1	1	0	0	1	1	0	4
11	0	1	0	1	0	0	1	0	1	0	1	10
12	0	1	0	0	1	1	0	1	0	0	1	8
13	0	1	0	0	1	0	1	0	1	1	0	7
14	0	1	0	0	1	0	1	1	0	1	0	5
15	0	0	1	1	0	0	1	1	0	0	1	7
16	0	0	1	0	1	0	1	1	0	1	0	6
17	0	0	1	1	0	0	1	0	1	1	0	8
18	0	0	1	1	0	1	0	1	0	1	0	4

5.6 Analysis of Data

5.6.1 Multiple Regression

The first analysis conducted on the data was done using the XL-STAT function, which calculates the statistics for a line by using the least squares method to calculate a straight line that best fits the provided data, and then returns an array that describes the line (Microsoft, 2003). The equation used for this model is:

$Y = b_1(x_1) + b_2(x_2) + b_3(x_3) + b_4(x_4) + b_5(x_5) + b_6(x_6) + b_0$

where b_1 is the utility value of x_1 (channel 5.1), b_2 is the utility value of x_2 (channel 4.1), b_3 is the utility value of x_3 (sound output 1000w), b_4 is the utility value of x_4 (power consumed 38w), b_5 is the utility value of x_5 (price range < 1000), b_6 is the utility value of x_6 (wire system- wired), and b_0 is a constant corresponding to the utility of the base case (channel 2.1, sound output 600w, power consumed 55w, price range 10000-15000, wireless).

The known y values used in the calculation were the respondent s preference ratings. The known x values were the experiment s input variables.

Table 5: Final prepared profile chart of participant 19

A	B	C	D	E	F	G	H
	Channel-5.1	Channel-4.1	sound output-1000w	power consumed-38w	price range-<10000	wire system-wired	Individual 19
Profile1	0	0	0	0	0	0	3
Profile2	0	0	1	1	0	1	4
Profile3	1	0	0	0	0	0	5
Profile4	1	0	0	0	1	0	7
Profile5	0	0	0	0	0	1	4
Profile6	0	0	0	1	1	1	6
Profile7	0	1	1	0	1	1	7
Profile8	0	0	1	1	1	0	5
Profile9	0	1	1	0	1	1	6
Profile10	0	0	1	0	1	0	4
Profile11	1	0	0	1	1	1	10
Profile12	1	0	1	0	0	1	8
Profile13	1	0	1	1	1	0	7
Profile14	1	0	1	1	0	0	5
Profile15	0	1	0	1	0	1	7
Profile16	0	1	1	1	0	0	6
Profile17	0	1	0	1	1	0	8
Profile18	0	1	0	0	0	0	4

In table 5, for regression analysis, the columns for channel 2.1, sound output 600w, power consumed 55w, price range 10000-15000, wireless are omitted. These are used as a base case for utility factor of constant b_0 . For example, in the first row that means in profile 1, it shows all the components are zero value that means in profile 1 combination doesn t represent channel-5.1, channel 4.1, sound output 100w, power consumed-38w, price range<10000, and wired-system. It only has the combination of channel 2.1, sound output-600w, power consumed-55w, price range 10000-15000, and wireless system.

After the regression analysis of the data for the participant 19 from the table 5, the results are:

Table 6: Summary statistics for data of participant 19

Summary statistics:

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
Individual 19	18	0	18	3.000	10.000	5.889	1.811
Channel-5.1	18	0	18	0.000	1.000	0.333	0.485
Channel-4.1	18	0	18	0.000	1.000	0.333	0.485
sound output-1000w	18	0	18	0.000	1.000	0.500	0.514
power consumed-38w	18	0	18	0.000	1.000	0.500	0.514
price range-<10000	18	0	18	0.000	1.000	0.500	0.514
wire system-wired	18	0	18	0.000	1.000	0.444	0.511

Table 7: Goodness of fit statistics of the participant 19

Goodness of fit statistics:

Observations	18.000
Sum of weights	18.000
DF	11.000
R^2	0.850
Adjusted R^2	0.768
MSE	0.760
RMSE	0.872
MAPE	9.713
DW	1.836
Cp	7.000
AIC	0.193
SBC	6.426
PC	0.341
Press RMSE	1.481

From the table 7, the R^2 value is 0.85, which indicates that the 85 percent of the variance in the participant s rating is explained by these variables (channel, sound output, power consumed, price range, and wire system).

RMSE means Root Mean Square Error value indicates that expected error on the rating if we use this model to predict is 0.872.

Table 8: Analysis of Variance for the data of 19th participant

Analysis of variance:

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	6	47.419	7.903	10.400	0.001
Error	11	8.359	0.760		
Corrected Total	17	55.778			

Computed against model Y=Mean(Y)

In this table 8, Mean square values were calculated by dividing the sum of square values by degrees of freedom. For model, Mean square value = (47.419/6) = 7.903.

F value was calculated by dividing the mean square of Model by mean square for error, F= (7.903/0.760) = 10.400. Here, the p value is lower than 0.05 (0.001).

Table 9: R^2 and F-Test Statistic Values With Corresponding Significance Levels

Participant	R^2	F-test stat	Significance level
60	0.851	10.451	95%
59	0.789	6.857	95%
58	0.861	11.367	95%
57	0.817	8.204	95%
56	0.850	10.400	95%
55	0.727	4.873	95%
54	0.817	8.205	95%
53	0.807	7.661	95%
52	0.755	5.660	95%
51	0.829	8.865	95%
50	0.867	11.952	95%
49	0.774	6.295	95%
48	0.850	10.400	95%
47	0.775	6.322	95%
46	0.830	8.951	95%
45	0.833	9.176	95%
44	0.890	14.785	95%
43	0.795	7.131	95%
42	0.841	9.714	95%
41	0.826	8.708	95%
40	0.874	12.749	95%
39	0.881	13.633	95%
38	0.808	7.707	95%
37	0.868	12.005	95%
36	0.777	6.403	95%
35	0.751	5.517	95%
34	0.874	12.749	95%
33	0.868	12.005	95%
32	0.858	11.100	95%
31	0.742	5.264	95%
30	0.895	15.602	95%

Participant	R^2	F-test stat	Significance level
29	0.846	10.090	95%
28	0.799	7.282	95%
27	0.817	8.204	95%
26	0.803	7.465	95%
25	0.850	10.400	95%
24	0.826	8.708	95%
23	0.863	11.514	95%
22	0.850	10.373	95%
21	0.874	12.749	95%
20	0.836	9.331	95%
19	0.850	10.400	95%
18	0.806	7.607	95%
17	0.787	6.781	95%
16	0.856	10.876	95%
15	0.850	10.400	95%
14	0.832	9.091	95%
13	0.850	10.400	95%
12	0.719	4.696	95%
11	0.816	8.152	95%
10	0.862	11.493	95%
9	0.686	4.005	95%
8	0.840	9.634	95%
7	0.733	5.042	95%
6	0.735	5.092	95%
5	0.710	4.498	95%
4	0.728	4.895	95%
2	0.685	3.993	95%
1	0.829	8.878	95%

5.6.2 Attribute Part Worth Values

Table 10: Model parameters for the participant

Model parameters:			
Source	Value	Standard error	t
Intercept	2.641	0.524	5.044
Channel-5.1	2.897	0.508	5.702
Channel-4.1	2.000	0.503	3.974
sound output-1000w	-0.500	0.416	-1.203
power consumed-38w	1.000	0.416	2.406
price range-<10000	1.500	0.416	3.609
wire system-wired	1.385	0.419	3.306

In this table 10, the values indicates the part worth utilities for attribute levels channel-5.1, channel 4.1, sound output-1000w, power consumed-38w, price range<10000, and wired-system. Here intercept which is the b_0 value, is the constant corresponding to the utility of the base case (channel 2.1, sound output 600w, power consumed 55w, price range 10000-15000, wireless).

Equation of the model:

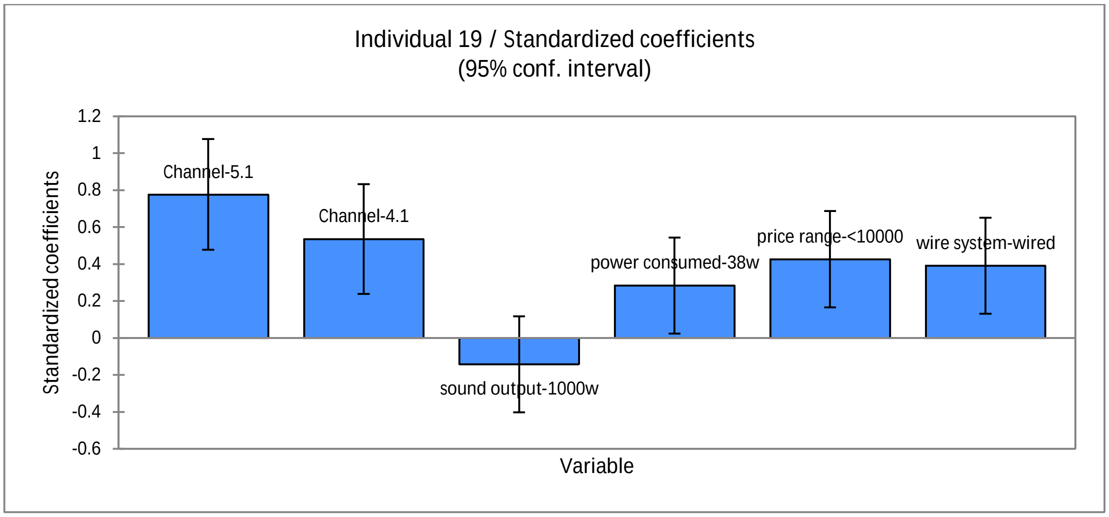
Individual 19 = 2.64102564102564+2.8974358974359*Channel-5.1+2*Channel-4.1-0.5*sound output-1000w+1*power consumed-38w+1.5*price range-<10000+1.38461538461539*wire system-wired

5.6.3 F-Test and R^2 Values

The F-Test shows the probability that relationship between the observed and predicted results were obtained by chance. The F-Test for this experiment (participant 19) had 6 degrees of freedom as shown in the table 8.

The R^2 values (coefficients of determination) show the degree to which the model explains the preference data. Specifically, R^2 represents the fraction of the total variation of the data around the mean that is explained by the predictions of the regression line (i.e. how close the data are to the regression line). The R^2 equation is: R^2 = explained variation / total variation. The greater the R^2 value, the better the model explains the variation.

Figure 2: Coefficient-graph of attribute levels



This graph indicates the coefficients of the attribute levels for the participant 19. From this graph it was clearly understandable that channel-5.1 was the most preferred level among the attribute levels.

Similarly the coefficients of the attribute levels for the participant 60 are given below:

Figure 3: Coefficient graph of participant 60

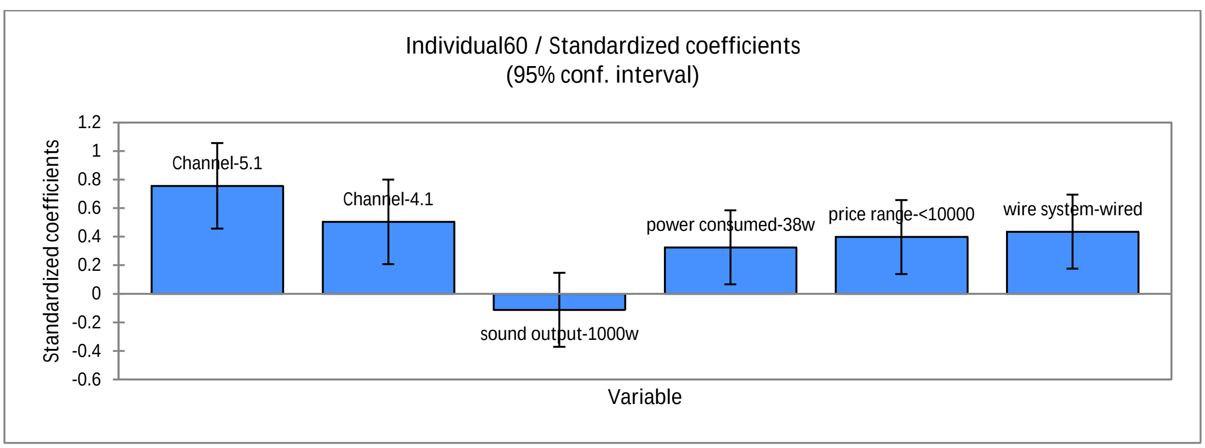


Table 11: Predicted value of participant s ratings

Observation	Channel-5.1	Channel-4.1	sound output-1000w	power consumed-38w	price range-<10000	wire system-wired	Adjusted Pred.
Obs1	0.000	0.000	0.000	0.000	0.000	0.000	2.438
Obs2	0.000	0.000	1.000	1.000	0.000	1.000	4.885
Obs3	1.000	0.000	0.000	0.000	0.000	0.000	5.802
Obs4	1.000	0.000	0.000	0.000	1.000	0.000	7.061
Obs5	0.000	0.000	0.000	0.000	0.000	1.000	4.040
Obs6	0.000	0.000	0.000	1.000	1.000	1.000	6.885
Obs7	0.000	1.000	1.000	0.000	1.000	1.000	7.043
Obs8	0.000	0.000	1.000	1.000	1.000	0.000	4.438
Obs9	0.000	1.000	1.000	0.000	1.000	1.000	7.727
Obs10	0.000	0.000	1.000	0.000	1.000	0.000	3.395
Obs11	1.000	0.000	0.000	1.000	1.000	1.000	8.949
Obs12	1.000	0.000	1.000	0.000	0.000	1.000	5.127
Obs13	1.000	0.000	1.000	1.000	1.000	0.000	7.802
Obs14	1.000	0.000	1.000	1.000	0.000	0.000	6.659
Obs15	0.000	1.000	0.000	1.000	0.000	1.000	7.043
Obs16	0.000	1.000	1.000	1.000	0.000	0.000	4.553
Obs17	0.000	1.000	0.000	1.000	1.000	0.000	6.553
Obs18	0.000	1.000	0.000	0.000	0.000	0.000	5.003

This table shows the predicted ratings for each observation by participant 19. From the table 5, ratings for observations 1, 2, 3, 4 were 3, 4, 5, 7 respectively, and in table 11, it shows the predicted values of ratings for observations 1, 2, 3, 4 are 2.438, 4.885, 5.802, 7.061 respectively. So, it indicates that there are very less differences between these two types of values, that means analysis of this model was good.

Table 12: Example of An Individual Participant s Utility Value Calculation Table

Partworth for Individual 19										
Channel		**Sound output**		**Power consumed**		**Price range**		**Wire system**		
Level	Partworth	Level	Partworth	Level	Partworth	Level	Partworth	Level	Partworth	
Channel-2.1	0.000	600w	0.000	55w	0.000	10000-15000	0.000	Wireless	0.000	
Channel-4.1	2.000	1000w	-0.500	38w	1.000	<10000	1.500	Wired	1.385	
Channel-5.1	2.897									**Total**
ΔUtility	2.897		0.500		1.000		1.500		1.385	7.282

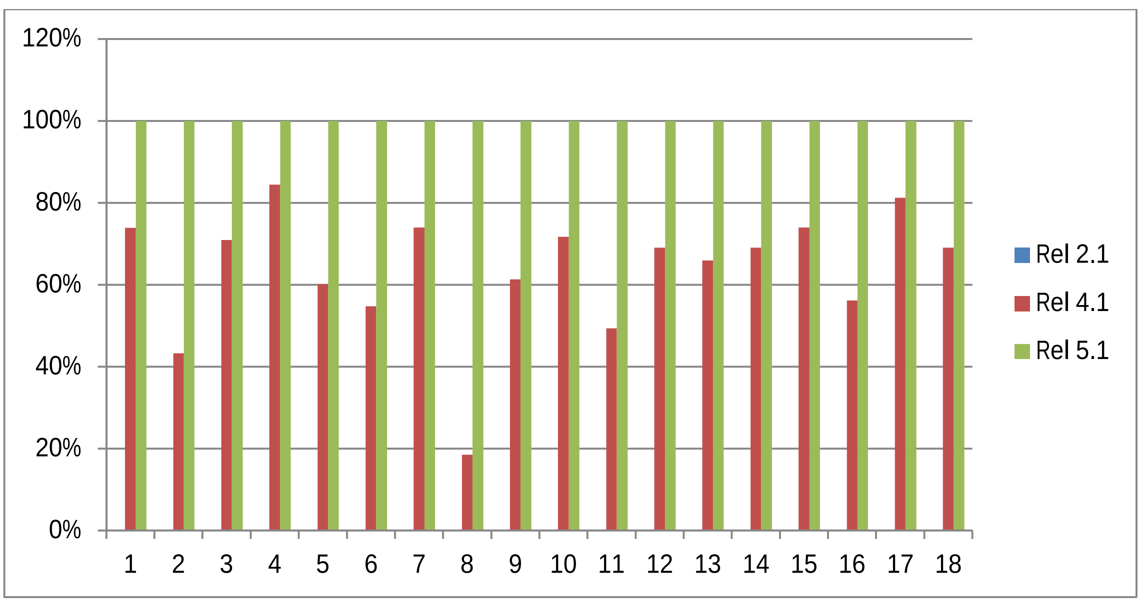
From those calculations, the ΔUtility was calculated by subtracting the minimum part worth value from the maximum part worth value of each attribute s levels (see example in Table 12). Total ΔUtility was then calculated by adding each ΔUtility value for all attributes. For example, here for attribute channel, minimum part worth value is 0.000(for channel 2.1) and maximum partworth value is 2.897(for channel 5.1). So, the ΔUtility for channel is 2.897. Similarly all ΔUtility values were calculated and then Total ΔUtility was calculated which is shown in Table 12. After that a %Total ΔUtility was calculated by dividing the attribute ΔUtility values by the Total ΔUtility value. The resulting percentages describe the relative attribute importance for the individual participants.

Table 13: Relative preference levels for attribute Channel

Participant	2.1	4.1	5.1	Δchannel	Rel 2.1	Rel 4.1	Rel 5.1
1	0	1.667	2.256	2.256	0%	74%	100.00%
2	0	1.167	2.699	2.699	0%	43%	100.00%
3	0	1	1.41	1.41	0%	71%	100.00%
5	0	1.667	1.974	1.974	0%	84%	100.00%
6	0	1.167	1.942	1.942	0%	60%	100.00%
7	0	1.333	2.436	2.436	0%	55%	100.00%
8	0	2	2.705	2.705	0%	74%	100.00%
9	0	0.5	2.699	2.699	0%	19%	100.00%
10	0	1.667	2.718	2.718	0%	61%	100.00%
11	0	1.833	2.558	2.558	0%	72%	100.00%
12	0	1.167	2.365	2.365	0%	49%	100.00%
13	0	2	2.897	2.897	0%	69%	100.00%
14	0	1.5	2.276	2.276	0%	66%	100.00%
15	0	2	2.897	2.897	0%	69%	100.00%
16	0	2.167	2.929	2.929	0%	74%	100.00%
17	0	1.5	2.673	2.673	0%	56%	100.00%
18	0	2.333	2.872	2.872	0%	81%	100.00%
19	0	2	2.897	2.897	0%	69%	100.00%

Table 13 is showing the participants preferences for the levels of attribute channel . This table is only showing results of 19 participants. It indicates that the most preferred level is 5.1-channel.

Figure 4: Participants preference for levels of Channel-attribute



This graph is showing the participants preferences for levels of the attribute channel . From this figure it is understandable that 5.1 channel was preferred more than the others.

Table 14: Relative preference levels for attribute sound output

Participant	600w	1000w	Δsound output	Adj 600w	Adj 1000w	Rel 600w	Rel 1000w
1	0	1.091	1.091	0	1.091	0%	100%
2	0	-0.227	0.227	0.227	0	100%	0%
3	0	-0.205	0.205	0.205	0	100%	0%
5	0	0.432	0.432	0	0.432	0%	100%
6	0	0.591	0.591	0	0.591	0%	100%
7	0	0.523	0.523	0	0.523	0%	100%
8	0	-0.364	0.364	0.364	0	100%	0%
9	0	0.932	0.932	0	0.932	0%	100%
10	0	-0.114	0.114	0.114	0	100%	0%
11	0	-0.455	0.455	0.455	0	100%	0%
12	0	0.409	0.409	0	0.409	0%	100%
13	0	-0.5	0.5	0.5	0	100%	0%
14	0	1.182	1.182	0	1.182	0%	100%
15	0	-0.5	0.5	0.5	0	100%	0%
16	0	-0.295	0.295	0.295	0	100%	0%
17	0	-0.955	0.955	0.955	0	100%	0%
18	0	-0.477	0.477	0.477	0	100%	0%
19	0	-0.5	0.5	0.5	0	100%	0%

In this table adjusted levels are calculated by adding the positive value(equal to the negative value number) to each of the elements(600w and 1000w) of the row which contains negative value. Based on the average of all 59 participants preference values, it showed that 600w level was more preferred than 1000w. Corresponding graph of relative levels of sound output is given below:

Figure 5: Participants preference for levels of sound output-attribute

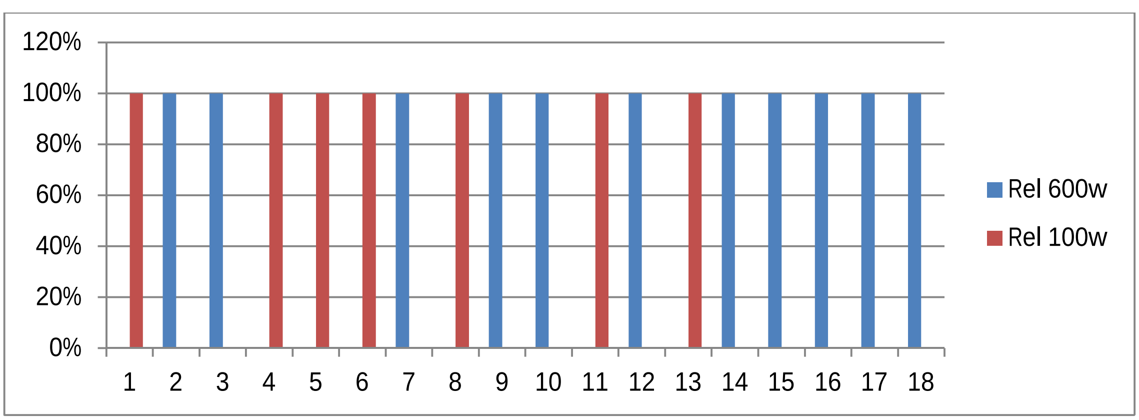


Table 15: ΔUtility and %Total ΔUtility Values For Few Participants

				Delta Utility						% Total delta utility					
Participant	R^2	F-test stat	Significance level	channel	Sound output	Power consumed	Price	Wire system	Total	channel	Sound output	Power consumed	Price	Wire system	Max %
60	0.851	10.451	95%	2.750	0.386	1.114	1.364	1.500	7.114	39%	5%	16%	19%	21%	39%
59	0.789	6.857	95%	2.609	0.136	0.864	1.364	0.654	5.627	46%	3%	15%	24%	12%	46%
58	0.861	11.367	95%	2.423	0.455	1.295	1.795	1.538	7.506	32%	6%	17%	24%	21%	32%
57	0.817	8.204	95%	2.712	0.386	0.864	1.614	1.269	6.845	40%	6%	13%	23%	18%	40%
56	0.850	10.400	95%	2.897	0.500	1.000	1.500	1.385	7.282	40%	7%	14%	20%	19%	40%
55	0.727	4.873	95%	2.699	0.023	0.727	1.477	1.192	6.118	44%	0.376 %	12%	24%	19.483 %	44%
54	0.817	8.205	95%	2.564	0.273	0.977	1.477	1.385	6.676	38%	4%	15%	22%	21%	38%
53	0.807	7.661	95%	2.404	0.341	0.659	1.409	1.423	6.236	39%	5%	11%	22%	23%	39%
52	0.755	5.660	95%	2.724	0.568	0.682	1.432	1.346	6.752	40%	8%	11%	21%	20%	40%
51	0.829	8.865	95%	2.558	0.409	1.091	1.591	1.346	6.995	37%	6%	15%	23%	19%	37%
50	0.867	11.952	95%	2.936	0.295	1.205	1.455	1.615	7.506	39%	4%	16%	19%	22%	39%
49	0.774	6.295	95%	2.385	0.159	0.341	1.091	1.308	5.284	45%	3%	6%	21%	25%	45%
48	0.850	10.400	95%	2.897	0.500	1.000	1.500	1.385	7.282	40%	7%	14%	20%	19%	40%
47	0.775	6.322	95%	2.423	0.045	1.045	1.545	1.538	6.596	36.73438	0.682232	15.84294	23.42329	23.31716	36.7
46	0.830	8.951	95%	2.596	0.295	1.205	1.455	1.577	7.128	36%	4.%	17%	21%	22%	36%
45	0.833	9.176	95%	2.571	0.432	0.818	1.068	1.423	6.312	41%	7%	13%	17%	22%	41%

Chapter 6

Results

6.1 F-Test and R^2 Values

Based on the F-Test, the multiple linear regression models for 59 participants sampled were statistically significant. The use of the 95% level of significance was suitable for the experiment when the time and scope of the study were considered.

This result demonstrates that the model used represents the actual preference behavior for the 59 participants included for further analysis. The R^2 values for these participants range from 0.685 to 0.895, which means that the model explains 68.5% to 89.5% of the variability of the data, depending on the participant responding.

6.2 Relative Attribute Importance

The calculations of the attribute part worth values by individual degree provide insight concerning the relative importance of the attributes. It was observed that all the participants valued the more importance to a single attribute.

Based on the average relative value of the attributes for all participants, which showed a stronger preference toward Channel, And based on the average of attribute levels for all participants it showed that there was a higher preference for 5.1 channel level.

Chapter 7

Summary and Conclusions

7.1 Notable Findings

At the conclusion of the study, the research questions were answered based on the results of the conjoint analysis experiment:

1. Do attributes i.e., channel, sound output, power consumed, price range, wire system impact preference for customers of home theatre sound system?

   It was determined that the presented attributes do impact the preference for a home theatre system at varying degrees of importance to the respondents. The F Test results concluded that statistically significant preference existed for all 59 participants, at a significance level of at least 95%.

2. If so, what attributes have salient impact on the users preferences?

   The overall most impactful attribute was Channel . Sound output was the second most preferred attribute, price and wire system were preferred almost at same rate, though price was preferred slightly above the wire system.

3. If a most-salient attribute can be identified, are there differences in preference among the respective levels?

   The channel attribute was investigated further to determine if preference differed among the levels of 5.1, 4.1, 2.1 channels. It was concluded that preference existed for the 5.1, 4.1, and 2.1 channels, while almost all of the participants who primarily preferred channel as an attribute preferred the 5.1. Between the three channel levels, a higher preference for 5.1 channel was discovered.

7.2 Challenges, Limitations, and Considerations

The design of the profiles provided a challenge for the researcher, as he employed a best effort to find a compromise between the flexible nature of and inherent interactions between design decisions and the need to keep the variables separated for the sake of the experiment. It was very hard to select the attributes, there were other variables present for a design of home theatre system. With the development of new technologies new variables will feature for the design but at the current situation the selection of attributes was quite appropriate.

7.3 Suggestions for Further Research

The researcher would be interested to see this type of study conducted by a home theatre company, with profiles created by the sound system design team and populated with the home theatre s actual content. Participants could be sourced from that actual home theatre users pool so that the preference data has the opportunity to generate guidance to the designers about its users design preferences.

It would be interesting to see if preferences for a participant change based on the many factors like size of the room where the system is in, which kind of sound they want like stereo or surround etc . It would also be interesting to see the new combinations of attributes with the development of new technologies.

7.4 Contributions and Conclusions

Upon conclusion of the study, the researcher does not believe there is one specific combination of design variables that would create the perfect overall sound system setup for a specific kind of users. Within the scope of this experiment, most of the respondents did give the more preference to the channel attribute. Considering the current situations of home theatre system design, it is nearly impossible to please everyone, and will continue to become more difficult to do with the development of new technology and the difference in people s demand. Instead, the researcher believes this thesis experiment provides a useable model for determining preference and attribute importance for home theatre system marketing. Using this framework, a company would have the ability to shed light on design variables that a user or customer may get more attracted toward and allow for designers to take those findings into consideration when designing or making new home theatre system. It is the researcher s hope that the preference findings from this experiment draw the interest of home theatre making companies.

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Appendix A: Ellicited List of Potential Variables

Channel (2.1, 4.1, 5.1,7.1-channel)

3D

Bluetooth

FM Radio

Sound Output (100w-300w, 500w, 600w, 1000w)

Remote system

Smartphone control

Power consumption

Wire system (wired, wireless)

Connectivity (AUX, HDMI, USB)

Price range

Dolby digital sound system

Appendix B: Experiment Survey

1. Please write your name.

2. Where do you live (Location)?

3. How old are you?

4. Have you used home theatre system prior to this experiment?

5. Which brand of home theatre system you are using?

6. Which attributes are important to you? Tick those attributes.

7. Profile 1 Preference Rating:
   1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest
8. Profile 2 Preference Rating:
   1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest
9. Profile 3 Preference Rating:
   1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest
10. Profile 4 Preference Rating:
    1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest
11. Profile 5 Preference Rating:
    1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest
12. Profile 6 Preference Rating:
    1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest
13. Profile 7 Preference Rating:
    1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest
14. Profile 8 Preference Rating:
    1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

15. Profile 9 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

16. Profile 10 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

17. Profile 11 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

18. Profile 12 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

19. Profile 13 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

20. Profile 14 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

21. Profile 15 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

22. Profile 16 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

23. Profile 17 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest

24. Profile 18 Preference Rating:

1-Lowest , 2, 3, 4, 5, 6, 7, 8, 9, 10-Highest