Consumer Decision-Making in Product Selection and Product Configuration Processes

by

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AUTHORIZATION PAGE

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Sri Hartati KURNIAWAN

This thesis is dedicated to my parents

SIGNATURE PAGE

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This is to certify that I have examined the above PhD thesis
and have found that it is complete and satisfactory in all respects,
and that any and all revisions required by
the thesis examination committee have been made.

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ABSTRACT

The study of consumer buying behavior covers various processes starting when consumers recognize a need until they purchase, consume, and dispose of a product or service. An important phase in the process mentioned above is the consumer decision-making phase. It is related to the process when consumers face a set of choices until they make their final purchasing decision. The issue addressed is not only related to the process, but also to decision quality as the outcome of the process. Understanding consumer decision-making is a crucial issue for helping consumers to obtain their desired products efficiently with rewarding experiences. Furthermore, it provides important clues for product providers to acquire insights on consumers' requirements. For years, consumer decision-making was studied in the context of product selection. A new and emerging method to facilitate consumer decision-

making, called product configuration, opens up a new avenue in consumer-provider interactions and provides a new instrument for studying consumer behavior.

This research is to compare product configuration with product selection processes, in terms of decision quality and decision making strategies, and to study their differences in decision-making time. The research involves experimental investigations of human subjects carrying out decision-making in the Web. The experimental works involve studies comparing differences between decision quality in product configuration and product selection, and explaining why these differences exist. Furthermore, differences between decision-making strategies in product configuration and product selection are sought, and relationships between decision-making strategies and decision quality are also investigated. Knowledge obtained on decision-making strategies is translated into a model to predict the amount of time required for consumer decision-making, based on information theory and other studies of Elementary Information Processes.

Results show that product configuration provides better decision quality with shorter decision-making time as compared to product selection. The differences are attributed to differences in choice representation and shopping method. As compared to representation by alternatives, representation by attributes reduces perceived choice complexity and reduces the number of products needing to be reviewed by consumers, which in turn reduces decision-making time and increases satisfaction with process. Shopping method by configuration enables consumers to choose attributes and attribute levels independently or even change attribute levels in a product. The feedback data indicates that participants experience higher enjoyment and a greater sense of involvement when using configuration, as compared to selection method. This experience leads to better satisfaction with the final decision and satisfaction with the process.

Investigation into the decision-making process showed that participants employed different decision-making strategies in product selection and product configuration processes. In product selection, participants first reduced unwanted product alternatives using elimination method and then performed overall evaluation of product alternatives by making trade-offs among attribute levels, while in product configuration, participants combined the most desired attribute levels from each attribute. Difference in learning has also been observed. In product configuration, participants acquired knowledge about their preferences towards attributes and attribute levels and made fewer trade-offs. This learning, in turn, increases satisfaction with decision and process.

A model for decision-making time was developed and then verified with additional experiments. This model predicts the range of time needed to make decisions as a function of number of attributes and number of attribute levels presented by product provider to consumers.

CHAPTER 1

INTRODUCTION

1.1 Consumer Decision-Making in a High Variety Environment

Today, consumer behavior is marked with prominence of individuality and self-expression [1], [2]. Consumers want to express themselves and demand for products that cater their individual preferences and need. In order to answer to those needs, product providers increase their numbers and types of offerings. As a consequence, there are overabundant product varieties available on the market.

This situation brings a complication for consumer in choosing products that best meet their individual requirements, especially with the current way of offering products that presents consumers with loads of information and too many products. The following sections present the problem with the current system and a remedy for this problem.

1.1.1 Conventional Consumer Decision-Making

Study of consumer buying behavior covers various processes starting when consumers recognize a need until they purchase, consume, and dispose a product or service. An important phase in the process mentioned above is alternative evaluation. It is often referred as consumer decision-making [3] – [6]. It describes the process when consumers face a set of choices until they make their final purchasing decisions. This subject is not only studied related to the process itself [3], [7], [8], but investigation of decision quality as the outcome of the process has also received much attention [4], [6], [9], [10]. Understanding consumer decision-making is a crucial issue for helping consumers to obtain their desired products efficiently with rewarding experiences. Furthermore, it provides important indications for product providers to acquire insight regarding consumers' needs and preferences.

For years, Consumer Decision-Making is studied in the context of product selection, in which consumers are faced with a number of product alternatives, and the selections are limited to these offerings. By selecting from alternatives, consumers had to compensate for the bad features of a product attribute with the good features of another product attribute.

In this case, the process means to select and compromise. In this *'take it or leave it'* situation, if consumers did not want to compromise, they had to abandon their purchasing. In many incidents, consumers left the product provider with loss and walked away from the point-of-sale because they can't find their desired products. It also leads to consumer dissatisfaction and frustration.

Currently, companies adopt a high-variety strategy in order to compete effectively in the global market [11]. With the huge number of product varieties available, the process of making a decision has become laborious. The number of product alternatives need to be compared by consumers has increased enormously. It is even getting difficult to find the exact match between the products available and consumers' preferences. Consumers still frequently end up making a compromise and buying the existing products on the shelf, in both the physical and electronic marketplace.

Also, from the product providers' point of view, when they provide the wrong products that no consumers want, the "mis-guessing" of customers' needs can be very costly in terms of inventory, obsolescence, scrap, and customer dissatisfaction.

The paradigm of making and buying products creates unfavorable situations for both consumers and product providers. Product providers face cost escalation, but are still unable to provide or even understand what consumers want. Consumers are dissatisfied, because either they cannot find what they want, or they get confused by too many product varieties offered. The problem is elevated when the consumers have little knowledge about the product and perceive high complexity of the product. When consumers experience mass confusion, they get frustrated and abandon their purchasing, leading them to dissatisfaction [12]. With this kind of situation, it becomes imperative to find ways of helping Consumer Decision-Making become more effective, which means helping consumers to get to what they want with less effort, and also to increase consumers' satisfaction. In this research, "consumers" here refers to end consumers who will make decisions for themselves in choosing products.

1.1.2 Consumer Decision Making using Product Configuration

An emerging method for end consumers to perform the decision-making is called product configuration. In business to business markets many firms already used product configuration to individualize their offerings for their clients, however, those configurators emphasis on the use of software to generate customized solutions by making modification from existing standard products [13]. In business to consumer (B-to-C) markets this is a rather new approach. End consumers can directly interact and communicate with the product provider in constructing the product according to individual needs and preferences. Namely, end consumers are able to specify their needs and preferences in terms of attributes and attribute levels, and incorporate those needs and preferences in their decision-making process.

This process is normally facilitated by a software interface called product configurator. A product configurator usually consists of configurator software and a visualization tool. The configurator software presents possible variations of attributes and their corresponding attribute levels and guides consumers through the configuration process, while the visualization tool displays products as results from the configuration process itself [14]. A sample of product configurator interface is shown in figure 1.1.

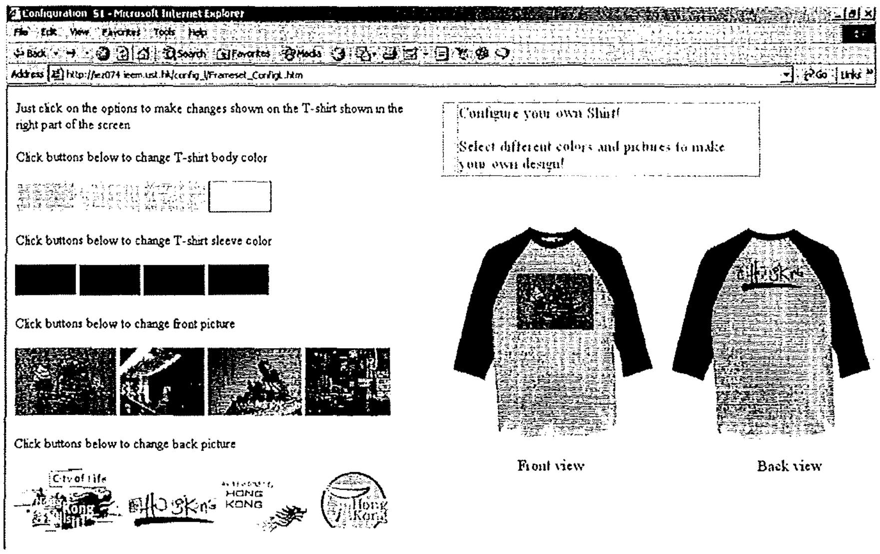

Figure 1.1 A sample of product configurator interface

In product configuration, consumers are able to select attributes and an attribute level from each attribute, and combine them into a product. The configuration process is normally done under constraints and rules set by the product provider, to ensure that the product can be manufactured and delivered to consumers.

Product configuration offers a distinct characteristic as compared to product selection. Product configuration facilitates interactive dialogues between product providers and consumers in constructing products. Using product configuration, two ways of continuing exploration and interaction between product provider and consumers can be observed, starting from understanding consumer needs, translating them into a set of manufacturing requirements, until the product provider helps consumers to make an informed choice in their decision-making. Therefore, it not only opens up a new avenue in consumer - provider interactions but also provides a new instrument for studying consumer behavior.

Beside the difference mentioned above, product configuration also enables consumers to select different attributes as well as different attribute levels independently. It means that understanding of consumers' needs and preferences can be investigated at attribute level. Using product selection, those understanding have to be derived from knowledge about needs and preferences in product alternatives. Due to the presentation of attributes and attribute levels independently, product providers are able to offer higher number of possible products with less amount of information presented to consumers, as compared to product selection. Product configuration can also be extended to customization, in which an attribute can consist of almost infinite number of attribute levels (e.g. personal photograph, colors in a continuous scale).

With inherent differences between product configuration and product selection, there is a question about whether these differences will influence decision quality, decision-making strategies, and decision-making time. The following section presents the research questions and direction.

1.2 Problem Statement and Research Question

1.2.1 Problem Statement

The previous section highlights differences between product configuration and product selection. Product configuration enables selection of attributes and attribute-levels independently and interactively. This research is to compare differences between consumer decision-making in product configuration and product selection. Decision-making here points to the decision-making process, exhibited in decision-making strategies employed by consumers, as well as decision quality as the outcome of decision-making. Decision quality can be further explained using the notion of satisfaction with decision and process, and performance in accuracy and effort. Furthermore, various factors causing the difference between satisfaction and performance in product configuration and product selection also need to be investigated. To date, research investigating the difference between consumer decision-making in product configuration and product selection is scarce.

1.2.2 Research Question

This thesis attempts to answer some research questions related to consumer decision-making when faced with product configuration and product selection. Mainly, the research questions can be further specified as follows:

- What are the differences in decision quality between product configuration and product selection?
- What cause differences mentioned above?
- Are there any significant differences between decision-making strategies in product configuration and product selection?
- Are there any correlations between decision quality and decision-making strategies?
- Is it possible to predict decision-making time?

Despite the importance of understanding issues related to consumers' behavior, relatively little research has been done in the area of product configuration [14]. Previous research in understanding consumer decision-making has focused on consumer decision-making in product selection [3], [4], [6], [7]. However, very little research attempts to compare consumer decision-making in product configuration and product selection processes.

1.3 Objectives and Scope of the Research

In line with the research question stated above, the objectives of the research can be further stated as follows:

1. To compare decision quality and decision-making time resulting from product configuration and product selection processes. Furthermore, this thesis also attempts to investigate different factors causing differences in the decision quality mentioned above by linking these phenomena with various theories related to consumer decision-making and consumer information processing
2. To compare consumer decision-making strategies in product configuration and product selection processes
3. To predict range of decision-making time in product configuration and product selection processes

This research studies end consumers in choosing configurable consumer products in non-impulsive buying situations. Furthermore, attributes being investigated are aesthetic attributes. Justifications are presented as follows:

- Products under investigation are configurable, consumer products focusing on aesthetic attributes in the products. Consumer products are chosen simply because consumers are going to use them for personal usage. It is expected that it will induce more accountability. Aesthetic attributes are chosen to avoid influence of product knowledge. Aesthetic attributes such as color, shape and pictures are simple attributes, in which consumers have knowledge or their personal preferences in choosing and deciding among attribute levels. Whereas with functional attributes, different consumers may have different levels of knowledge.
- In this research the investigation is limited to configurable products, means that product provider has determined a set of modules or attributes with their corresponding attribute levels that consumers can choose and combine into a product. Consumers are not offered unlimited (or almost unlimited) possibilities resulted from continuous attribute levels, such as continuous color, or length; which will be categorized as product customization. In the product customization, product provider basically offered unlimited amount of possibilities and has no control over the number of product offered to the consumers.
- "Consumers" here refers to the end consumers buying products for personal use with their own money. It is expected that consumers are willing to spend effort, time, and considerations in buying products for themselves rather than buying for others.

- It is assumed that no impulsive buying and no buying under discount incentive are involved because in impulse buying, consumers often do not require an extensive decision-making process, while discount incentives can heavily influence the decision-making process based solely on price considerations. This thesis focuses on extensive problem solving in alternative evaluation. It means that consumers perform rigorous evaluation process and use multiple criteria to evaluate product alternatives.

1.4 Organization of the Thesis

The main theme of this research is to investigate consumer decision-making in product configuration, as compared to the conventional way of product selection. Therefore, the flow in this thesis is organized as follows: Problem identification – Literature reviews – Experimental Study –Analysis and discussion – Model establishment - Conclusion.

Chapter one explains the background on problems associated with consumer decision-making using product selection, especially in a high-variety environment, and points out potential advantages using product configuration. The problems will be identified and these problems lead to challenges in understanding consumer decision-making in product configuration and product selection.

The second chapter is a literature review chapter. This chapter presents a review of research related to Product Configuration, Product Selection, Consumer Decision-Making Process (CDMP) and decision quality.

The third chapter presents the hypotheses and explains the overview of research work to investigate consumer decision-making in product configuration and product selection.

The fourth chapter describes the details of experimental works to investigate the difference between decision quality and decision-making time in product configuration and product selection. Further analyses are conducted in order to explain causes of the differences mentioned above.

The fifth chapter presents a discussion based on experimental study and relates it to existing theories and findings in Consumer Decision-Making Process and Consumer Information Processing fields.

The sixth chapter explains the details of experimental works to investigate the difference between decision-making strategy in product configuration and product selection, and present the Cognitive Task Analysis to describe cognitive requirements in performing decision-making strategies both in product selection and product configuration.

The seventh chapter presents a model predicting range of decision-making time in product configuration and product selection processes as functions of number of attributes and attribute levels.

The eighth chapter consists of conclusions, contributions, limitations, and further works of this thesis.

The outline of the thesis is illustrated in figure 1.2.

Introduction:
- Provides background of this research
- Post research questions and objectives
- Sets research scope

↓

Literature review:
- Provides reviews of related topic, including: definitions of product selection and product configuration, consumer decision making process, and decision quality
- Identifies research gap

↓

Experimental works to study of decision quality and decision-making time in product configuration and product selection:
-Finds differences between decision quality and decision-making time in product configuration and product selection processes
- Causes of differences are choice representation, shopping method, and number of product offered

↓

Experimental work to investigate decision-making strategies in product configuration and selection processes:
- Finds differences between decision-making strategies in product selection and product configuration
- Finds relationships between decision quality and decision-making strategies

↓

Model establishment for predicting range of decision-making time in product configuration and product selection:
- Successfully establishes a model to predict range of decision-making time as function of number of attributes and attribute-levels
- Compares decision-making time from prediction and experimental results and find no significant differences between them

↓

Summary and conclusion:
- Provides conclusions, contributions, limitations, and suggested future research direction

Figure 1.2 Outline of the thesis

CHAPTER 2

LITERATURE REVIEW

2.1 Definitions of Product Selection and Product Configuration

A product, or also known as a product alternative [3], [7], can be defined as *"anything that can be offered to a market for attention, acquisition, use, or consumption that might satisfy a want or need"* [15]. A product consists of several product attributes. Product attributes are *"those factors which buyers and sellers typically take into account in determining the suitability of a product or service to satisfy a felt need"* [16]. Each product attribute consists of an attribute level, which is a value that can be selected by consumers for a particular attribute.

To better illustrate the definitions above, an example will be given as follows: A T-shirt can be regarded as a product. The T-shirt has several attributes, such as sleeve color, body color and picture. Each attribute has its level, such as sleeve color is equal to black, body color is equal to white, and picture is equal to scenery picture.

With the clarifications above, definitions of product selection and product configuration can be better presented. Product selection can be defined as: (consumers perform) selection of one or more product alternatives from competing product alternatives in the same product category (modified from [17]). Using the example presented above, a consumer may face a choice set consists of several T-shirts and at the end select one or more T-shirts.

Product configuration is: (consumers perform) selection of attributes and attribute levels from sellers' defined set and arrange them into a product, under given constraints set by the seller, to ensure the products can be produced and delivered. Using same example, a consumer can select attributes (s)he wants to configure, and choose attribute levels, for example blue sleeve color, grey body color, and scenery picture.

By definitions above, it can be inferred that there are two main differences between product configuration and product selection processes. The first difference is related to choice representation. In product configuration process, product provider presents a set of attributes and their corresponding attribute levels, while in product selection process; product provider presents a set of product alternatives. Another difference lies in the shopping method. In product configuration, consumers select multiple attributes and attribute levels, and combine them into a product [17]. This is known as configuration shopping method. This shopping method enables interactive dialogue between consumers and product providers when consumers construct their products. While in selection method, consumers can only choose from available product alternatives [17].

2.2 Consumer Decision-Making

There are two major areas of study in consumer decision-making, the process and the outcome. The process here refers to a series of actions performed by consumers in order to lead to a final purchasing decision, including comparing and evaluating information and making decisions about which product is to be chosen. The outcome refers to the consumers' final decision in terms of product finally chosen, and associated satisfaction accompanying the decision made. In the following section, both parts will be reviewed.

2.2.1 Consumer Decision-Making Process

Decision-Making Process refers to the process of how people make preferential choices among alternatives [5]. It has been defined and studied extensively in the fields of psychology and economy for more than four decades. Between 1950 and 1980, the Decision-Making Process was mostly studied and modeled as the process of making choices among alternatives based on sets of predetermined preferences (e.g., [18] – [20]). From the 1980's onwards, some researchers favor the approach of modeling the Decision Making Process as an adaptive information processing in which consumers construct their trade-off strategies according to their interactions with the environment (e.g., 'Constructive Consumer Choice Processes', [6]).

The term Consumer Decision-Making Process (CDMP) refers to the process of how consumers make selections when faced with different product alternatives. The CDMP process here includes processes of observing, comparing, eliminating, and selecting from alternatives. Sometimes it is also referred to alternative evaluation [21] or decision process [22].

Most of the time, decision-makers cannot evaluate and consider all alternatives at one time. Evidence shows that search of product alternative is often incomplete. It is initially conducted by attributes and uses those attributes as criteria to eliminate product alternatives. Then decision-makers focus their attention on a small number of product alternatives under a consideration set as the choice processes extends in time [3], [7]. It is because decision-makers often perceive high task complexity in their decision tasks. Therefore, decision-makers need to employ decision-making strategies to help them reduce the task complexity. Decision-making strategy is defined as: *"sequence of operations used to transform an initial knowledge into a final goal state of knowledge where the decision maker views the particular decision problem as solved"* [5]. It is noted from the definition that a strategy is used to solve a decision problem. A strategy can consist of several rules combined together.

There are many different decision-making rules have been identified. Bettman and his colleagues reviewed the literature and identified several decision-making rules that are commonly used in consumer behavior research [6]:

- **Lexicographic** [23]. In this rule, attributes are ranked according to their importance. The product offering best attribute level on the most important attribute is selected. If there is more than one product remaining, the procedure is repeated with the next most important attribute, and so on.

- **Elimination-by-Aspects** [24]. Similarly, using this rule, attributes are ranked according to their importance. A threshold is specified for the most important attribute and a product is eliminated if the level of its most important attribute is below the threshold. If there is more than one product remaining, the process is repeated for the next most important attribute, and so on.

- **Satisficing** [18]. Decision-maker specifies thresholds for every attribute. Product alternatives are eliminated if they have one or more attribute levels that are below the corresponding thresholds.

- **Weighted Addition**. Under this rule, a consumer will assign weightings to individual attributes according to their relative importance. Then the total weighted utility values of all the attributes belonging to the same products are summed to be the weighted total utility values. The alternative with the highest weighted total utility value will be selected.

- **Frequency of Good or Bad** [25]. In principal, attributes of each product are classified into two clusters: good and bad clusters, according to some predetermined thresholds. The alternative(s) with the maximum number of 'Good' attribute levels will be selected.

Besides reporting various decision-making rules, researchers also attempted to systematically characterize those rules, such as how decision-makers evaluate attractiveness of attributes, level of effort spent, and level of accuracy obtained from decision-making strategies [4], [6], [19]. A most comprehensive characterization is to divide the rules into two main categories, namely ***compensatory*** and ***non-compensatory*** rules. Compensatory rules refer to the rules in which decision-makers would compare products by considering the merits and disadvantages of two or more attributes at the same time. During this process of evaluation, a disadvantage associated with an attribute of a product can be compensated by an advantage of another attribute of the same product and vice-versa. In non-compensatory rules, decision-makers would only consider one attribute at a time. By comparing levels of that attribute among alternatives, decision-makers would select or eliminate a product solely based on the level of that single attribute.

In order to capture consumers' decision-making process, researchers attempt to understand the amount of attention directed towards attributes and product alternatives, patterns of search, and time spent in each attributes and product alternatives. In order to capture these data, in the past, experimenters used "information board" to presents each piece of information in a physical card. Participants of their experiment were required to retrieve those cards, reveal the product information, and put the card back on the board before advancing to the next card [3], [7], [19].

Previous research also offered many findings that decision-making could be explained as adaptive information processing. Researchers identified the two major factors that influence decision-making strategies, namely ***task effect*** and the ***context effect*** [5]. Context in context effect refers to particular values of the objects in particular decision sets while the task effect refers to the influence of different characteristics of tasks that the consumers are facing [5].

Many research works show that context variables are influencing decision-making, for example bias of evaluation towards a given value, known as anchoring [26], increase / decrease of valuation of an alternative when there are comparison alternatives, known as context effect [27] and overemphasis of information that consumers think is related at a particular time, known as saliency [27]. This thesis will emphasis on the task effect and investigate how different ways of presenting task to the consumers will influence the decision-making process. Among the task variables that are of interest in this thesis are task complexity and information display.

The task complexity in the decision-making problem refers to the number of alternatives and attributes presented to the decision-maker. Research shows that the task complexity influences the decision-making strategies used by consumers. The higher the number of alternatives presented, the more likely people will use non-compensatory rules, and when faced with fewer alternatives, people will use compensatory rules (e.g. [3], [7], [8], [28]). A study showed that when the number of alternatives is four or more, participants would use non-compensatory decision-making rules [28]. There are also indications that when facing a set of alternatives, people will switch between non-compensatory and compensatory decision-making rules to form a multi-stages strategy [7], [28]. Meanwhile, the effect of number of attributes on the decision-making strategies is less clear. Payne [3] and Olshavsky [7] did not find the effect of number of attributes on the decision-making strategies. It was found that the increase of number of attributes would increase the participants' confidence in their judgment and increase the variability in participants' responses [29].

The information display variables are concerned with how information is displayed to the decision-maker. Findings suggested that participants process information according to the formats in which this information is displayed [30]. When the choices were displayed in alternative-based format as in the supermarket, the participants used alternative-based processing, and when the choices were displayed in attribute-based format (i.e. put the attribute in the front cover of a booklet, and under each attribute, information on different brands can be found), the participants used attribute-based processing.

Other factors within the task effect are also recognized as determinants of decision-making strategy selection. Under a time pressure, participants accelerated their decision-making process and used non-compensatory rules such as Lexicographic or Elimination-by-Aspects [31], [32]. It appears that quickly examining more product alternatives is more efficient rather than examining only portion of total alternatives available [6]. Inter attribute correlation also leads to different decision-making rules. It is closely related to the notion of dominance. The more negative the correlations means the more decision makers have to give up something on an attribute in order to get more on another attributes. It is found that negative inter attribute correlations induce more compensatory and alternative-based rules [33].

Consumer-related factors also influence to the decision-making strategies. Increased negative emotion due to difficult trade-offs leads to more attribute-based processing

[34]. Consumers were found to use more non-compensatory rules when making high-stake decisions [35]. Personal relevance between the decision-maker and the product also influence the selection of rules. When there is a personal relevance between the decision-maker and the product (i.e. choosing a product for himself instead of for other people), decision-makers use more compensatory decision-making rules [36].

2.2.2 Consumer Learning

It is suggested that consumers learn through their decision-making process [12]. The word 'learning' here refers to the discovery of consumer expertise obtained through different type of experiences [37]. Among various types of consumer learning, the type of learning that is most relevant to consumer decision-making is learning about relationship among and between products, attributes, and benefits [38]. Consumers learn and construct their preferences and priority in selecting the best product. Literature suggests that there are three types of learning that can be acquired when consumers perform decision-making process.

The first type is to learn about consumers' within attribute preferences. Research in consumer decision-making claims that most consumers don't know exactly what product they want, but they often have preferences towards certain attribute levels, such as favorability of blue rather than green color [6]. Meanwhile, experts know about their preferences for different levels within attributes, such as know which color, shape, and material they want.

It is desirable for consumers to learn their within-attribute preferences. Consumers who know about their within-attribute preferences are able to selectively attend to relevant product information, and thus able to process more information [37].

The second type is to learn about across-attribute preferences. Consumers learn about attribute importance relatively to each other. A product alternative consists of several attributes. In order to evaluate a product alternative or a set of them, consumers have to decide which attribute to be evaluated first, second, and so on. Often, consumers do not have enough mental capacity to evaluate all attribute levels in all attributes offered [3], [7], [28]. Consumers usually start with the most important attribute and proceed based on the order of attribute importance [23], [24].

The third type of learning is about making trade-offs within a product alternative. The conventional way of offering products via product selection poses a drawback that the attribute levels are 'hard-wired'. Consumers have to accept the product as it is, or decide to choose another product. If consumers like all attribute levels in a product except one or two, then they have to make trade-offs to compensate good features of the product by bad features of the same product [4], [19].

2.2.3 Decision Quality

The second aspect of consumer decision-making is related to the outcomes. The outcomes of decision-making process are the decision made and subjective feelings accompany the decision. The decision made is whether consumers decide to select and buy the product, or decide not to buy anything. Investigation and recording decision-made in terms of products and their corresponding attributes provide insights in understanding consumers' preference towards products and their features. It gives feedbacks for product provider in order to decide what to produce and what not to produce. Consumer decision-making cannot be understood simply by studying final decisions. The perceptual and emotional aspects of decision-making must be studied in order to gain an adequate understanding of consumer decision-making [19].

Subjective feelings accompany the decision indicate consumers' thoughts and perceptions towards decision-making process and decision made. Study of this aspect has attracted increasing attention because it reflects consumers' feeling and satisfaction about the products and shopping process, which is known as the driver for consumers' loyalty and repeat buying. One of the focus in this thesis is to study the subjective feelings accompany the decision, and hence this section provides review related to it rather than related to decision-made in the forms of products and their attributes.

The degree to which a decision-maker is able to achieve the goal of decision-making is known as decision quality [39]. The goal includes subjective feelings that indicate how good the decision-making process and outcome. In this thesis decision quality is further explained using several terms, which are consumer satisfaction related to decision made, consumer satisfaction related to shopping process, closeness between expectation prior to buying and final decision, and effort spent in making decision.

The following sections review different items in decision quality, as mentioned above.

2.2.3.1 Consumer Satisfaction

Consumer satisfaction in general is a very important issue for every product provider. It gives feedback to the product provider about how successful the marketing decision made by the product provider has been and it is also recognized as a key influence in the consumers' intention to do repeat buying [40]. Consumer satisfaction also generates positive word-of-mouth [41]. Consumer satisfaction can be regarded as a key issue for creating and maintaining the key competitive advantage of a company [42].

While consumer satisfaction is widely accepted as a measurement of how successful the product provider has been in serving consumers, the definition and measurements of this are difficult. Some representative definitions of satisfaction include: *"buyer's cognitive state of being adequately or inadequately rewarded for the sacrifices he has undergone"* [43], *"an emotional response to the experiences provided by, associated with particular products or service purchased, retail outlets, or even molar patterns of behavior such as shopping and buyer behavior, as well as the overall marketplace"* [44], *"an evaluation that the chosen alternative is consistent with prior beliefs with respect to that alternative"* [45], and *"the summary of psychological state resulting when the emotion surrounding disconfirmed expectations is coupled with the consumer's prior feelings about the consumption* *experience"* [10]. Based on the definitions provided above, it can be seen that actually satisfaction can be further categorized into two types of satisfaction, which are satisfaction related to decision made [9], [46], [47] and satisfaction related to experience or choice process [48].

While consumer satisfaction is very important, measurements are not easy. Consumers determine what factors influence their satisfaction, and these might differ from one consumer to another [49]. Commonly, satisfaction is measured using questionnaires employing Likert scales, indicating different degrees of satisfaction perceived by consumers.

Satisfaction related to Decision Made

Many research studied consumer satisfaction have focused on the development and measurement of satisfaction related to the product decided on / bought.

There are two streams of research in product satisfaction, one related to long term experience in using or consuming the product bought [50], [51], and the other to disconfirmation between expectation prior to buying compared to product bought / decided on [9], [46], [47], [52]. This thesis focuses on satisfaction related to decision made, but not related to long-term consumption of the product.

Previous research also argues that product satisfaction is a major determinant of overall consumer satisfaction [47]. Product satisfaction has to cover both satisfactions on overall product and on product attributes [47]. Satisfaction on product attribute refers to the consumer's subjective satisfaction judgment resulting from observations of attribute performance [53]. The overall satisfaction is associated with the product as a whole.

In determining product satisfaction, many researchers refer to disconfirmation-of-expectation model [9]. It is showed that the disconfirmation of expectation significantly influences satisfaction [9]. Consumers have certain expectations for a product. Expectation is beliefs about performance benefits that will occur with a specified product [46]. After purchasing a product, consumers make a comparison between actual performance and expectation of the product. Consumer satisfaction increases when the ratio of product performance / expectation increases [9], [47]. Disconfirmation is the degree to which consumers' expectation about the product is not being met. Normally the disconfirmation is expressed in terms of disconfirmation of attributes' functionality / aesthetic values, such as: product durability, color, etc.

Satisfaction related to Shopping Process

Satisfaction in purchase experience has also been identified as a major determinant of overall satisfaction and can lead to continued interests that might lead to repeat purchasing [53] – [55]. It is argued that disconfirmation-of-expectation model can also be applied in the service process [54]. Consumers also have expectations about service process, and will compare expectation of service process with service encounter experienced during the whole process. The comparison between expected and experienced service process can lead either to dissatisfaction or satisfaction.

Shopping has been viewed as a hedonistic activity, which entails social activity and enjoyable experience [56]. Unfortunately, less attention has been given to investigating satisfaction related to the choosing process [48]. Research suggests that decision process satisfaction is influenced by the difficulty of information processed by consumers and the availability of relevant information for making the decision [48]. Their study showed that when processing of information is easy and consumers have needed information available, the degree of satisfaction increases.

Currently, business models have shifted to the mode emphasizing service as experience as their revenue source. Companies are not only required to provide consumers with products that suit their personal preferences and needs, but also to provide excellent services and experiences for each consumer. Often the price premium the consumer pays is coming from the two sectors mentioned above [1].

2.2.3.2 Performance in Decision-Making

A common measurement of how good decision-making is by measuring effort spent and accuracy [4], [5]. Literature suggested that the most common way to define accuracy is by comparing the decision outcome selected by consumers with decision outcome resulted from a normative decision rule, which is compensatory in nature [5], [6]. The accuracy of a choice can be defined by a normative model, which specifies how individuals can best reflect their preferences on the choice [5], [57]. It reflects the closeness between the decision made by decision maker compared to ideal decision having the highest utility that is resulted from applying the normative model. This normative model is usually extensive, compensatory in nature, and utilizing all relevant information in order to make a decision [58]. By taking this point of view, it acknowledges that consumers are somehow have a certain level of preferences in mind, and consumers would like to choose a product consistent with their preferences. The closer the product with initial preferences, the higher the accuracy would be.

Effort refers to amount of cognitive effort spent in the decision-making. A base model to estimate the effort is by measuring the amount of information searched during decision-making [59]. In decision-making research, a very important goal is to maximize product accuracy while minimizing effort spent [4], [5], [6], [59]. The next subsections explain the concept of accuracy and effort in decision-making.

Closeness between Expectation Prior Buying and Final Decision

To certain degrees, consumers have certain prior buying expectations toward the product. One form of expectation is to choose accurate products that best reflect their preferences towards certain product or attribute levels. Preferences are context-dependent. Consumers can have a well-defined and well-articulated preference when they have very good expertise and experience regarding the product, however most of the time consumers do not have a well-defined preference for the product. In most cases, preferences or expectation can be constructed when consumers making their decision. While there is no well-defined preferences in product level, consumers often have preferences toward certain attribute levels, for example a like or dislike of blue, black, or white [6]. In this thesis, the accuracy is approached by the closeness between expectation prior to buying and final decision.

Measurement of accuracy can be done by subjective measurement of closeness between expectation prior to buying and final decision in terms of overall products or attribute by attribute.

As indicated, accuracy indicates the degree of correctness of a decision relative to the best answer. In reality, the best answer is not always obvious or exists in every decision problem especially when the products considered involve attributes that are heavily depending on personal preferences such as colors, shape, and other aesthetic attributes.

Besides the measurement of accuracy mentioned above, an overall evaluation on the product should also be assessed. By investigating the correlation between closeness between accuracy and overall evaluation of final product, it will provide an indication whether consumers' preferences are actually constructed or they are previously well defined.

Effort spent in decision-making process

The mental effort refers to the cost of thinking in making a decision. The effort can be seen as the total elementary processes performed in the decision-making process, including reading information, comparing two pieces of information, subtracting, adding, switching attention, eliminating and choosing an alternative. These mental activities are known as Elementary Information Processes (EIPs) [59]. Measurement of Elementary Information Processes is difficult. It requires a special setting of the experiment in which the experimenter can tap into very detailed level of cognitive activities of participants, such as presenting each piece of information using cards (physical or using computer interface). Furthermore it also has a drawback since the decision-making environment no longer approaches the real buying situation.

A more common way to measure effort is just simply measure the amount of information searched by the consumers [7], [28], [59]. Using this method, it is easier to measure explicit information acquisition behavior of participants [59]. Decision-making time is also studied in conjunction with the amount of information searched due to linear correlation between these two items.

2.2.4 Past Conceptual Models on Consumer Decision-Making

Various models conceptualizing consumer behavior in decision-making and buying behavior have been proposed [21], [22], [43], [60]. Although very different in detail, in general those models describe changes in consumers' internal state that will later cause overt decision [43]. Specifically, those models describe how external inputs such as product information and task-related information influence consumers' mental state in perceiving information, evaluating product information and making decisions, and to observe outcomes in terms of consumers' satisfaction, closeness between initial preference and final decision, amount of information searched, and decision-making time.

The following reviews constructs that are of interest in this research.

Product information consists of information about attributes of the product offered by product provider [61]. These can be of functional attributes or aesthetic attributes. Task-related information is influenced by different factors induced by product provider, such as number of product alternatives and attributes offered [3], [7], choice representation [30], and shopping method [12].

It is very unlikely that consumers are able to make decisions instantly [62]. Instead, consumers will analyze the current situation faced and form perceptions of choice and task. Perceptions can result from distorted cognitive elements contained in the information intake to make them congruent with consumers' own frame of reference [43]. As a result, consumers can experience negative perception, such as perception of difficulty, choice and process complexity, or they can experience positive perception, such as a like towards product, involvement, or enjoyment.

Consumers will employ various rules to integrate or eliminate information, such as using certain thresholds to eliminate alternatives [18], [24], simply counting the number of good and bad features in the product [25], or performing two-by-two comparisons to retain better alternatives in each comparison process [63]. All these rules lead to another iteration of information search or lead to a decision. Decision here refers to decision to choose one or more products, or even decision not to choose any product. After consumers make their decision, they can judge how good their decision and decision-making processes are. Consumers might feel satisfied or dissatisfied with their decision and with the decision-making they have gone through. These important constructs are illustrated in figure 2.1.

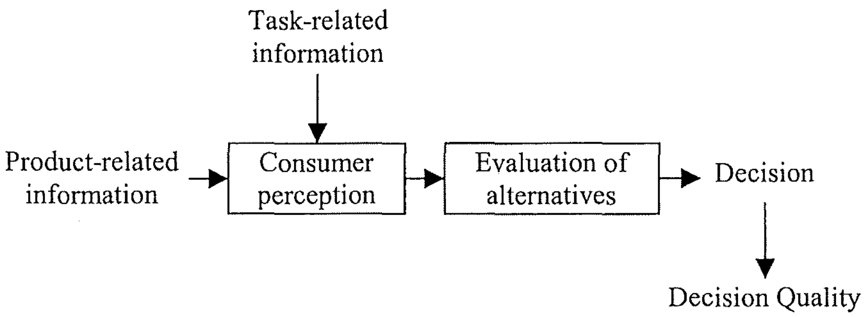

Figure 2.1 Important constructs in consumer decision-making study

The simplified flow chart of alternative evaluation can be presented in figure 2.2. The letter P refers to a process while the letter D refers to decision to be made.

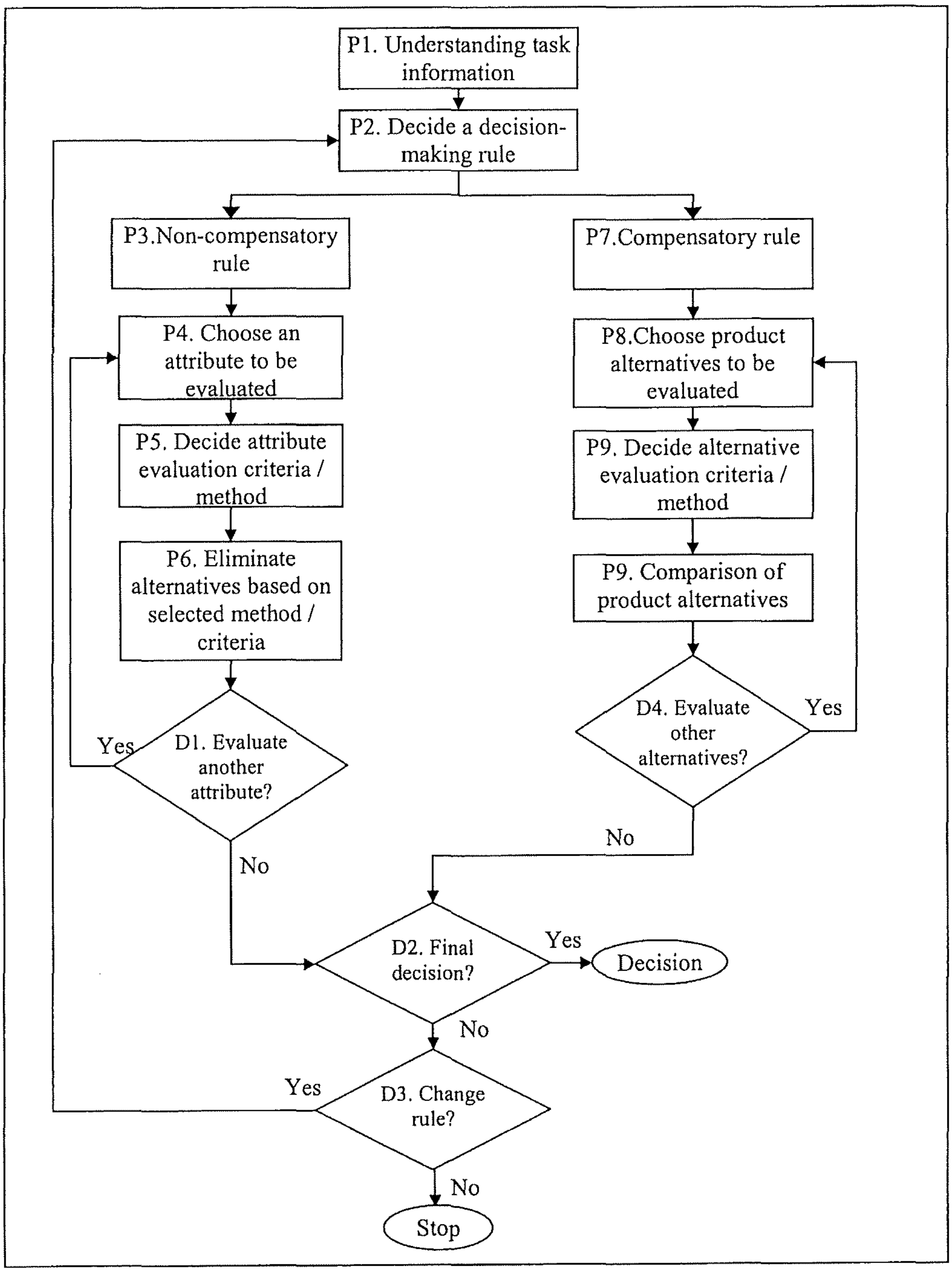

Figure 2.2 Alternative evaluation flowchart

2.2.5 Consumer decision-making in situations similar to product configuration

Product configuration is relatively new compared to product selection. However, research has identified purchasing situations similar to or using product configuration, such as the use of product configuration in mass customization [64] – [67], design by customers [68], consumer co-production [69], and consumer self-service [70]. Existing research focuses on consumers' perception and decision quality in product configuration or situations similar to it, but there is lack of research examining consumer decision-making process in those situations. This research can be further categorized in two streams. The first stream of research measures different levels of consumer perception and decision quality in product configuration or situations similar to it. The second one analyzes different factors influencing consumer satisfaction in product configuration or situations similar to it.

The first stream of research indicates positive evaluation towards product configuration. It is found that mass customization is able to bring relatively higher enjoyment and less perceived difficulty [64], [65]. Consumers' decision to mass customize is determined by the balance between product utility and process complexity [67]. Dellaert and Stremersch find that using a personal computer as the product also shows that consumers' expertise and the extent to which consumers are able to mass customize their products influence both product utility and process complexity. Extent of customization here refers to the level of heterogeneity – number of attributes and number of attribute levels, individual pricing of each attribute, and the presence of base product (i.e. the most or least expensive product) [71]. In customizing their products, consumers perform "learning by doing" by testing a large number of variants before deciding on the final product [72]. Franke and Piller found a relatively high level of consumer satisfaction with process (2.5 out of 7 scale, with 1 being the highest level of satisfaction) and satisfaction with product (2.4 out of 7 scale, with 1 being the highest level of satisfaction). Surprisingly, with at least 650 million possible Swatch-type wristwatches offered, most participants thought that the configurator did not offer enough design freedom [72].

A limited amount of research comparing product selection and product configuration via mass customization found that mass customization is able to provide better satisfaction with process [12], [66] and ease the navigation process to find the most desired product [66].

The second stream of research analyzes factors influencing satisfaction in product configuration or in similar situations. In mass customization, several factors are found to influence consumer satisfaction, such as different ways in which consumers input their preferences, different ways of presenting choices [12] and sense of involvement [66]. In a co-production process, in which consumers are able to jointly produce the product together with the product provider, offering options of co-production make consumers more willing to be accountable for their decision [69]. In self-service situations, consumers become more satisfied when they find the system is easy to use and saves their time [70].

2.3 Research Gap

To date research studying consumer decision-making is mostly found in the context of product selection [3], [4], [6], [7]. As reviewed in this chapter, the five decades of research in consumer decision-making has made a great deal of contribution in defining decision-making strategies and investigating various factors influencing selection of decision-making strategies [5], [6]. Existing research also contributes to the performance measurement in general consumer behavior and consumer decision-making in product selection, including effort and accuracy [4] and satisfaction with decision and process [9], [46].

To date, research investigating consumer decision-making in product configuration has received very little attention. Some research gaps are identified. Firstly, there is a lack of comparison between consumer decision-making in product configuration and product selection. Most studies investigating product configuration are done independently without comparison with product selection. Secondly, the factors driving consumer satisfaction and perception towards product configuration have not been fully explored. The existing studies made their contributions by pioneering the measurement of consumer satisfaction and perception in product configuration or situations similar to it without comparing it to product selection nor attempting to explore the influencing factors [64], [65]. Thirdly, studies investigating consumer decision-making strategies in product configuration have not been found. Consequently, the relationship between decision-making strategies and decision quality cannot be explored and studied.

The research gaps presented above amplifies the need to answer research questions previously posted in the first chapter. The next chapter will present a set of hypotheses and research methodology in order to close the research gaps and answer the research questions.

CHAPTER 3

HYPOTHESES CONSTRUCTION AND RESEARCH PLAN

3.1 Hypotheses construction

In order to answer the research questions, a set of hypotheses are constructed followed by a research plan in order to prove or disprove the proposed hypotheses. Specifically, the hypotheses attempts to formulate initial prediction related to consumer decision-making in product configuration. The first set of hypotheses attempts to predict the decision quality in product configuration as compared to decision quality in product selection influenced by different factors. The second set of hypotheses attempts to predict decision-making strategies in product configuration as compared to strategies in product selection.

3.1.1 Hypotheses related to decision quality

3.1.1.1 Decision quality as a function of choice representation

There are two ways to present choice to consumers. The first one is what is normally seen in the marketplace, in which choice is represented by alternative. Customers are shown several product alternatives, such as several T-shirts or several bags. The second one is to represent choice by attribute. Consumers are shown with a set of attributes and their corresponding attribute levels, such as a range of colors, several different shapes, materials, etc.

The concreteness principle suggests that decision-makers tend to use only information that is explicitly displayed to them, and will only use those pieces of information in the form in which they are displayed [73]. A study conducted by Bettman and Kakkar showed that information acquisition would proceed in a fashion consistent with the information display format [30]. When decision-makers were presented products arranged in alternative-based format (similar to a supermarket), alternative-based information acquisition and processing were observed. On the other hand, when information display was changed into an attribute-based format, attribute-based information acquisition and processing were observed. It can be observed that different ways of choice representation changed consumers' perception and decision-making process. Presenting choice by attribute is in essence presenting less information as compared to presenting choice by alternative and hence should enable consumers to better understand the range of available choice and to process information, within a shorter time. When consumers are able to better process the information, they should be able to find a better product too. It is hypothesized that choice representation will influence decision quality by offering different levels of satisfaction, accuracy and effort.

H1a: Choice representation by attribute will lead to shorter time spent in comparison with choice representation by alternative.

H1b: Choice representation by attribute will lead to better decision quality in comparison with choice representation by alternative.

3.1.1.2 Decision quality a function of shopping method

In product configuration, consumers have to construct their own products by combining different attribute levels into a product. In product selection, consumers can only select from available offerings. Research shows that consumers become more satisfied when they spent effort in building their own products [66].

Recently the importance of various hitherto neglected variables in consumer behavior study such as consumers' emotion, need for fun and pleasure, and hedonic experiences, have gained more and more attention [74]. A newer version of marketing has emerged; namely, it focuses on consumers' experiences rather than merely studying consumers as they solve a decision problem [1], [74]. These experiences come from communication and interaction with product providers, explosion of subjectivity in decision-making, as well as the increase of product personalization and customization [1]. When consumers customize their products, they also focus on hedonic and experiential aspects of consumption [74]. Consumers have to go through a process of discovery in defining their own products. When consumers experience challenges but have control over the buying process, it makes the experience more compelling [75]. This experiential shopping and control involve a lot of subjectivity, in which consumers feel more involved and feel more personally attached to the products. Consumers also view their decision-making process as a way to perform communication and interaction with the product provider. These types of experiences provide higher values to consumers [1] and should increase consumer satisfaction. It is hypothesized that different shopping methods will influence the decision quality. When consumers build their own product, they should be involved in the process, since there is a personal relevancy to the process and product. Previous research investigated the effect of involvement and found that consumers spent more effort to process information when the decision problem had a personal relevancy to them [76]. When consumers spend more effort, the time spent should also increase.

H2a: Shopping method by configuration will lead to greater satisfaction in comparison with shopping method by selection.

H2b: Shopping method by configuration will lead to greater number of products seen in comparison with shopping method by selection.

H2c: Shopping method by configuration will lead to longer time spent in comparison with shopping method by selection.

3.1.1.3 Decision quality as a function of number of products offered

Consumers are faced with decision-making and choices in shopping situations. The choice exists because of two reasons. The first is that product providers do not know what consumers want. Offering choices enables product providers to increase the probability of providing the right product to their consumers and helps product providers to capture consumers' preferences. The second is that consumers themselves may not know exactly what they want. The existence of choices helps consumers to compare and anchor their decision based on other products. In the end, consumers may not be able to get the best product in the market, but may be able to get the best product among available choices.

While choices help in connecting and matching consumers' preferences and product providers' offerings, they may also bring drawbacks when the situation becomes too much to be handled. Previous research has found a limit to human processing capability. People can handle about seven, plus or minus two, chunks of information at a time [77] People can be overloaded with information when presented with too many products [5].

Research in decision-making has investigated effects of differing numbers of product alternatives on decision-making. It was found that people changed their decision-making strategies when the number of product alternatives increased [3], [7], [8], [78]. The decision-making strategies are deployed in order to reduce the complexity of the decision-making problems caused by too much information involved. Information overload itself can create confusion and lead to dissatisfaction [12].

A counterargument to the statement above exists. Presenting more products will increase the possibility of consumers getting what they want [11]. When consumers get what they want, the level of satisfaction should increase. However, we do not predict that the counterargument holds for products with multiple attributes, simply because there will be too much information needing to be processed by consumers.

Prior research showed that consumers have difficulty in evaluating products using more than two attributes [79]. It is also found that when evaluating more than four non-similar product alternatives involving different attribute levels for each alternative, consumers resort to decision-making strategies to help them simplify the decision-making problems [28].

Given the condition that there are numbers of product alternatives to compare, and the amount of information is beyond human capability in processing information, it is hypothesized that fewer products offered will lead to less confusion and thus lead to better satisfaction with process and decision.

H3: Given that the amount of information is beyond human capability in processing information, making a decision among fewer products will lead to better decision quality compared to among a greater number of products.

3.1.1.4 Influence of interaction between shopping method and choice representation on decision quality

Cognitive fit theory suggests that when the way a problem is represented matches with the requirement of a problem solving task, cognitive fit will occur, which produces consistent representation for problem solving, and hence leads to faster and more accurate performance in decision-making [80], [81].

In the context of consumer information processing, it has been shown that, although participants can process information in any way they choose, they tend to do it in ways consistent with information representation, whether it is processing by attribute or by alternative [30]. It is argued that consumers do this in order to reduce cognitive strain in transforming or ignoring some information, storing it, and then later on integrating the information together.

Usually product configuration and product selection presents choice differently. Product configuration presents choice by attribute, while product selection presents choice by alternative. Accordingly, the method used in product configuration is consistent with presentation by attribute because in the product configuration process, the consumer only needs to select attribute levels and combine them together, while in product selection, the method used is also consistent with the choice representation by alternative because consumers need to compare and select among alternatives. Consistency between choice representation and shopping method should lead to a cognitive fit, hence facilitate easier processing and help consumers to find their desired products. When consumers can find their desired product in an easier manner, this should also lead to better satisfaction with process and decision.

H4a: Configuration with choice representation by attribute will lead to better consumer satisfaction compared to configuration with choice representation by alternative.

H4b: Selection with choice representation by alternative will lead to better consumer satisfaction compared to selection with choice representation by attribute.

3.1.1.5 Influence of interaction between shopping method and number of products offered on decision quality

There are two conflicting perspectives regarding the effect of number of product alternatives on consumer satisfaction. The first perspective states that increasing the number of product alternatives offered will increase the likelihood of consumers getting what they want and thus increase consumers' satisfaction [11]. On the contrary, the second perspective states that increasing the number of product alternatives will lead to an effortful decision-making process [3], [7], [78], increase perceived choice complexity, and make consumers feel overwhelmed, frustrated, and dissatisfied [12].

Huffman and Kahn argued that even though the number of product varieties increases, providing a right way for consumers to choose their products can help reduce perceived complexity and increase satisfaction [12]. Their research showed that even with relatively complex products with a very large number of possible products (i.e. sofa consists of 18 attributes and hotel consists of 19 attributes, both have 4 levels in each attribute), the configuration method reduces perception of complexity and in the end increases consumer satisfaction more than the selection method. Thus, it is hypothesized that in product selection, increasing the number of products offered will lead to the phenomenon of mass confusion and lead to less consumer satisfaction. It is also hypothesized that increasing the number of products in product configuration will not lead to the decrease of satisfaction, since product configuration enables the structuring of information presented to consumers.

H5: Increasing the number of products offered will have negative impact on consumer satisfaction in product selection but will not have negative impact on consumer satisfaction in product configuration.

3.1.2 Hypotheses related to decision making strategies

As seen in the marketplace, product configuration normally displays choice by attribute, while product selection displays choice by alternative. The inherent differences between the two tasks include task complexity and choice representation. As discussed in the literature review chapter, task complexity and information display format influence consumer decision-making strategy. Previous research in decision-making indicated that decision-making strategies were adaptive and task dependent [5], [6].

In terms of task complexity, product configuration with choice representation by attribute presents less information compared to product selection that displays all possible product alternatives. Even though the number of possible products can be the same, the amount of information is imbalanced. Product configuration only displays each piece of information once in the forms of different attribute levels. Product selection displays all possible products, leading to repetition of attribute levels presentation.

A large amount of support from consumer decision-making research indicates that as the amount of information increases, consumers tend to use multi-stage decision-making strategies to first eliminate unwanted choices then evaluate the remaining choices more thoroughly [3], [5], [6], [7].

In product configuration, the presentation of attribute levels makes it easier for consumers to directly compare attribute levels to each other, known as attribute-based information processing. This type of attribute-based processing should lead to non-compensatory decision-making rules in which consumers are able to eliminate unwanted product alternatives possesing unwanted attribute levels.

Due to differences in task complexity and choice representation, it is hypothesized that consumers will change their decision-making strategies depending on the task, whether it is a product configuration or product selection process.

H6a: Product selection will lead to multi-stage decision-making strategies while product configuration will lead to strategies utilizing elimination rules.
H6b: Product configuration will lead to more attribute-based information processing compared to product selection.

3.2 Modeling of decision-making time

This thesis also attempts to predict decision-making time in product configuration and product selection. Decision-making time modeling will be established based on knowledge about decision-making strategies and other established notions about elementary cognitive activities performed when making a decision.

3.3 Research plan

This section presents the research plan in order to prove or disprove the hypotheses and to answer research questions posted. The thesis starts with seeking differences between product configuration and product selection in terms of decision quality and decision-making time. An experiment is conducted in order to investigate various factors hypothesized to be the drivers that differentiate decision quality and decision-making time in product selection and product configuration. These factors are the shopping method (by configuration or by selection), the choice representation (by attribute or by alternative), and the number of product alternatives offered (low versus high). Furthermore, this research also seeks reasons to explain the above-mentioned differences.

In the study of decision-making, normally the process is described by how consumers apply different strategies to solve decision problems. To achieve this purpose, two experiments are conducted in order to study decision-making strategies in product configuration and product selection processes. Furthermore, relationships between decision-making strategies and decision quality are also sought.

The decision-making strategy can be further decomposed into smaller Elementary Information Processes (EIPs) with each EIP having its standard time. The next step of this research will apply knowledge in the decision-making strategy to predict the decision-making time, both in product configuration and product selection processes. The decision-making time also provides a quantitative measure for the decision-making process that can be modeled mathematically. This study concludes by establishing a model, which predicts the range of decision-making time in product configuration and product selection. The model is validated using additional experiments.

To summarize the discussion, an overview of this research work is illustrated in figure 3.1.

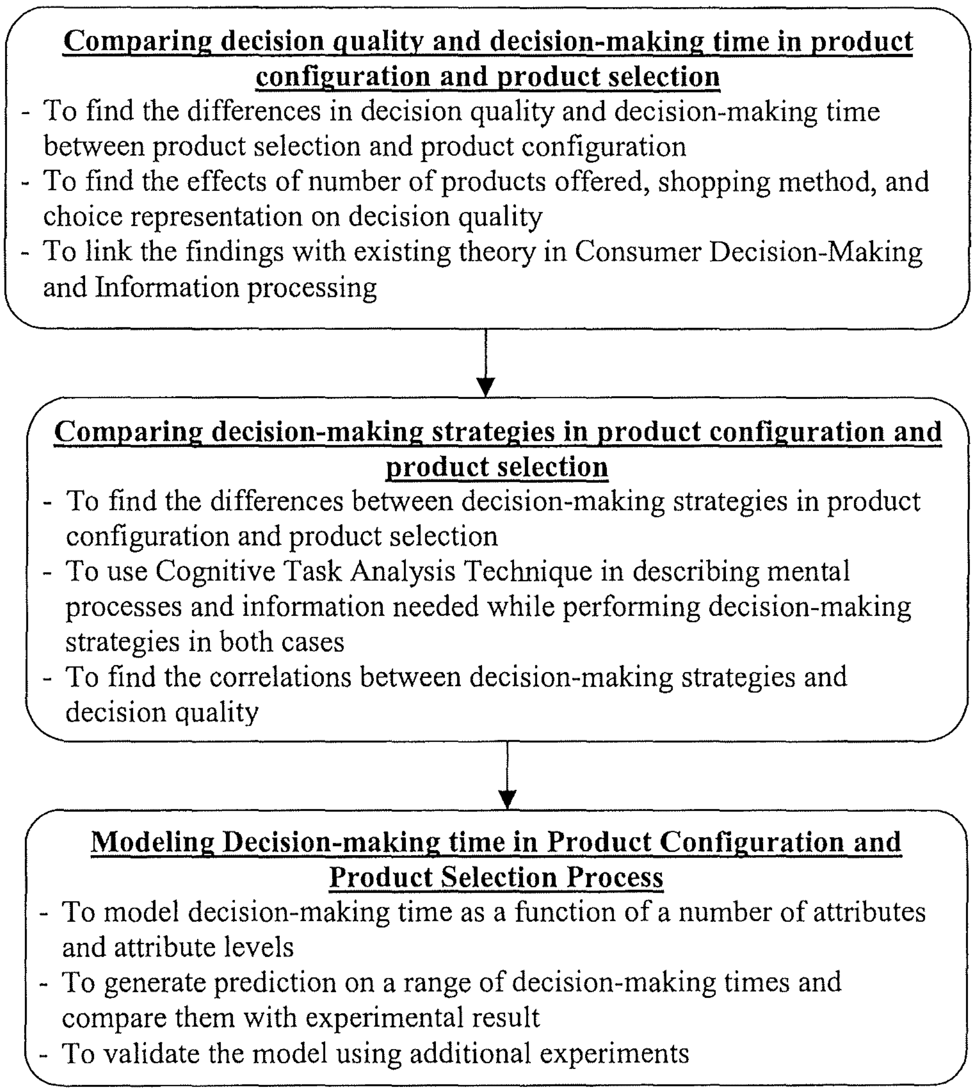

Figure 3.1 Overview of the Experimental and Modeling Work

CHAPTER 4

DECISION QUALITY AND DECISION-MAKING TIME IN PRODUCT CONFIGURATION AND PRODUCT SELECTION

4.1 Introduction

Decision quality reflects satisfaction associated with decision and process as well as efforts and accuracy from the decision-making. While literature reported various studies measuring decision quality in various shopping conditions only recently that the measurements of decision quality in product configuration are conducted [65] – [67]. Furthermore, the measurements are only limited to the satisfaction, either satisfaction in general or satisfaction with product or process. Also with those limited measurement, the comparison between decision quality in product configuration and product selection is scarce. Besides measuring the decision quality itself, it is also crucial to investigate various factors influencing the decision quality. By understanding the factors influencing the decision quality, product providers are able to anticipate those factors in order to better satisfy their customers and help them to find accurate products with less effort spent.

This chapter presents experimental work studying the difference between decision qualities in product selection and product configuration, as functions of various influencing factors. The design of experiment and results will be presented.

4.2 Experimental variables

4.2.1 Independent variables and task generation

The independent variables of this experiment are choice representation, shopping method, and number of products offered to participants. Choice representation and shopping method are identified as two major differentiators between product configuration and product selection, while number of products offered is also hypothesized to influence decision quality.

Overall, independent variables and their corresponding levels are listed below:

- Choice representation: by attribute or by alternative
- Shopping method: by configuration or by selection
- Number of products offered: 16 or 256 products

The tasks assigned to participants are created by exhausting the combinations of levels of independent variables. There are three independent variables with two levels each, creating eight different tasks for the participants. The combinations are shown in table 4.1 with manifestation of the tasks shown in figures 4.1 to 4.4

Table 4.1 Task list

		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	Configuration tasks showing different attributes and one product as visualizator (see figure 4.1)		Configurations task showing different product alternatives and possibility of changing attribute levels (see figure 4.2)	
	By selection	Selection tasks showing the possibilities in attribute levels (see figure 4.3)		Selection tasks showing different product alternatives (see figure 4.4)	

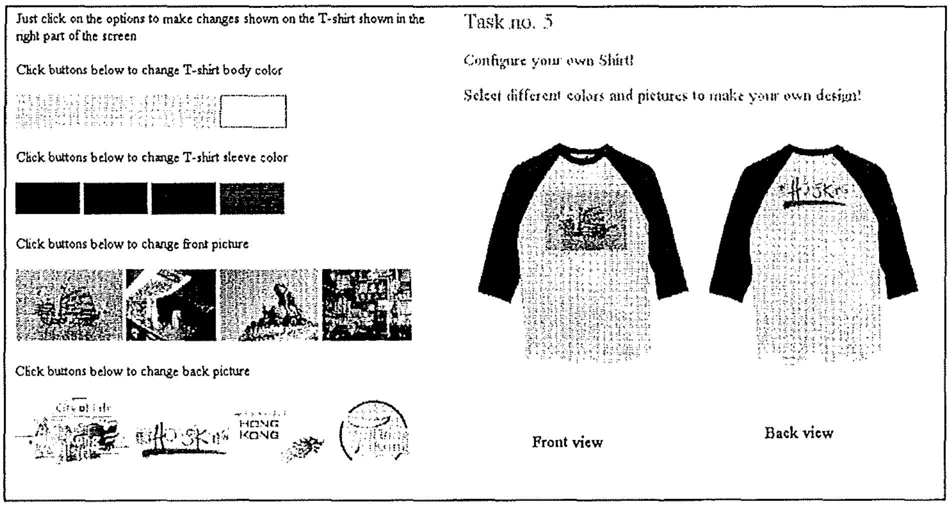

Figure 4.1 Configuration task with presentation by attribute and number of products offered is equal to 256

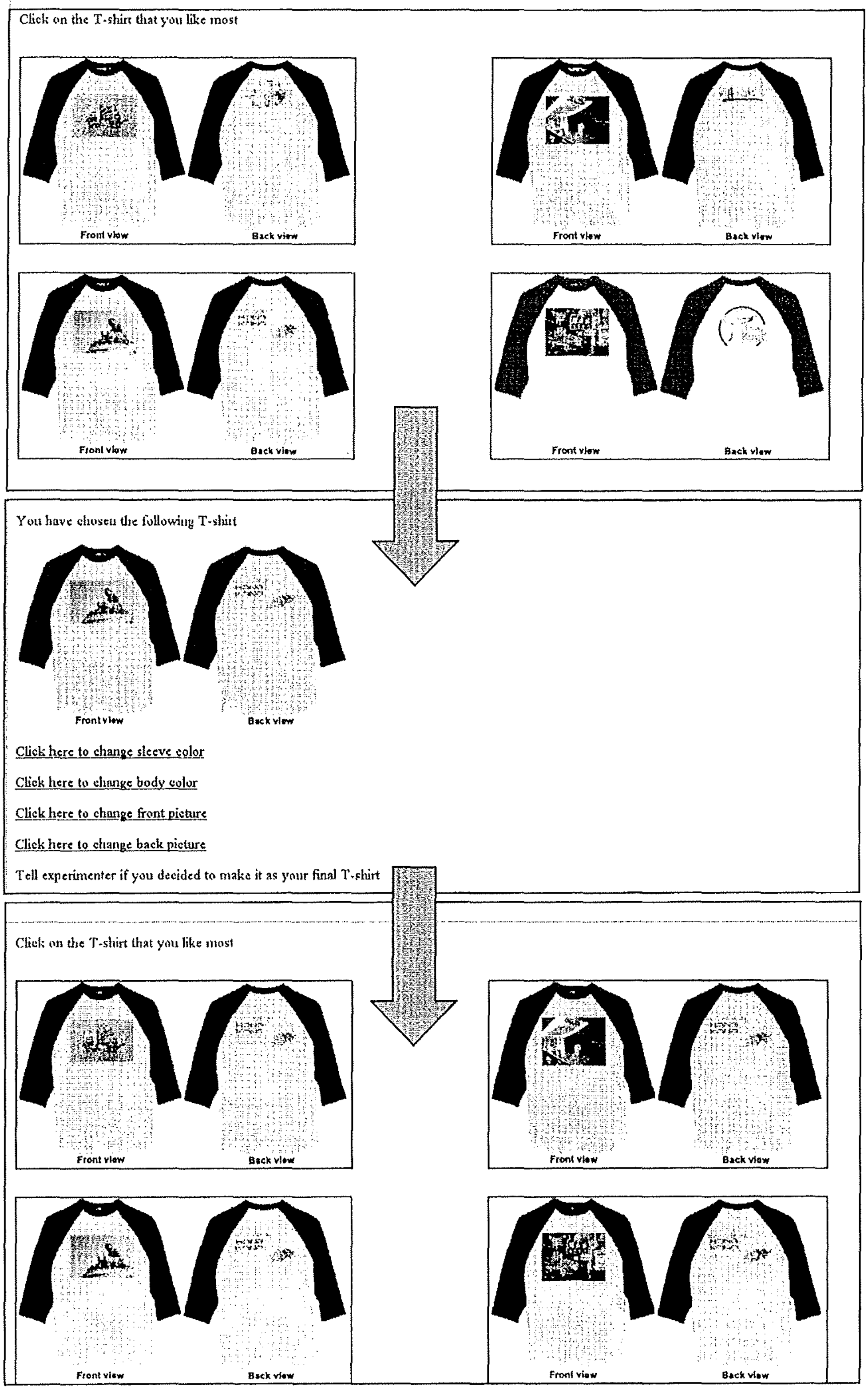

Figure 4.2 Configuration task with presentation by alternative and number of products offered is equal to 256

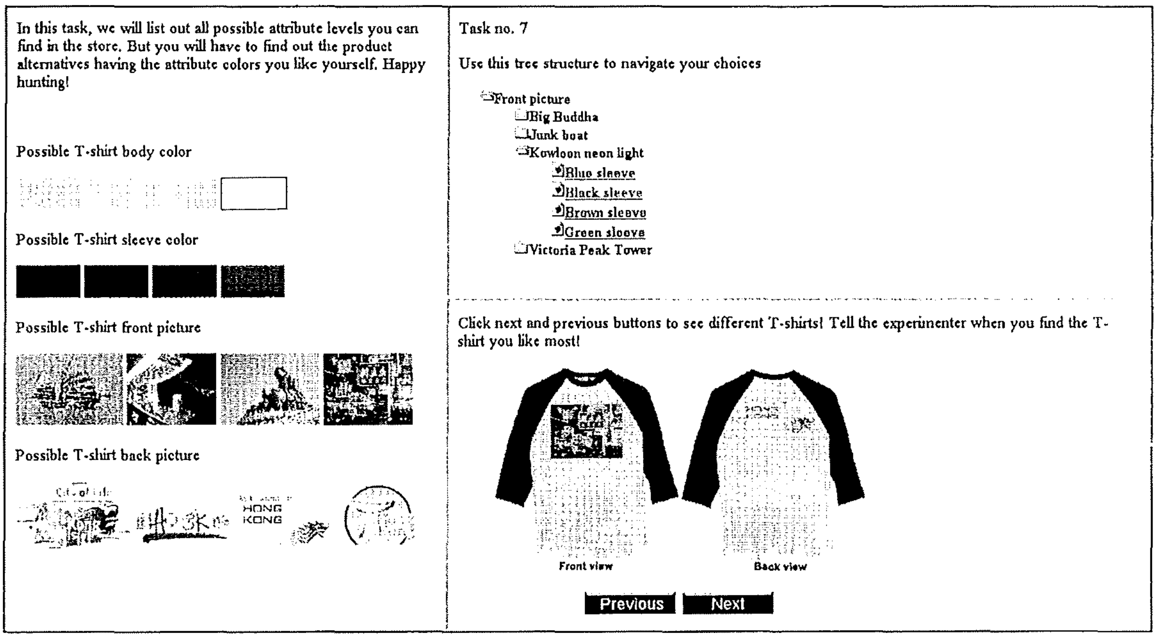

Figure 4.3 Selection task with presentation by attribute and number of products offered is equal to 256

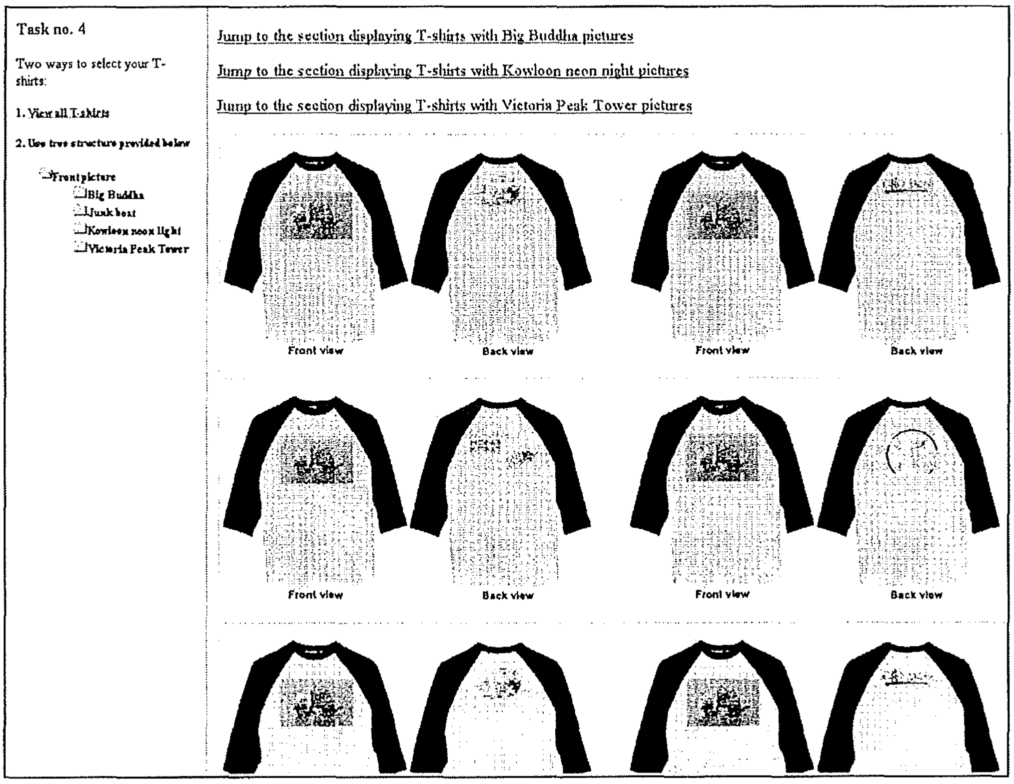

Figure 4.4 Selection task with presentation by alternative and number of products offered is equal to 256

Figure 4.1 shows a typical product configuration interface in which consumers are allowed to choose different attributes and attribute levels. The product resulting from combining different attribute levels will be viewed using a vizualizator. The initial attribute levels displayed in the visualizator is chosen randomly. Figure 4.4 shows a typical product selection interface in which a set of product alternatives is displayed. Consumers can only select a product from available offerings. However, as seen in table 4.1, in order to compare these two conditions, there are two interacting variables, which are the choice representation and the shopping method. Two intermediate scenarios are introduced, which are displayed in figure 4.2 and 4.3 respectively.

Figure 4.2 describes a scenario for presenting choice by alternative and providing shopping method by configuration. In this scenario, participants are allowed to configure their products by changing any undesirable attribute levels from a product alternative and continue until they find the most desirable product alternative. The initial set of products displayed contains all possible attribute levels, which are all possible sleeve colors, body colors, front pictures, and back pictures. While assignments of different attribute levels into each product are chosen randomly in such way that no same attribute levels be displayed more than once.

Figure 4.3 illustrates a scenario for presenting choice by attribute and providing shopping method by selection. In this scenario, participants are able to see the variation of products by observing different attribute levels; however they still need to employ product selection method in order to choose the best product. The selection of initial product alternative displayed is chosen randomly. In this condition, participants are allowed to access the choice through a tree structure. It is analogous with categorizing products based on their attribute levels. It is a common arrangement to place products having same attribute level, such as same color, in the same area. There are two levels of tree structure employed, which are the front picture and sleeve color attributes.

In order to provide a better illustration of the interface, the Web interfaces are provided online and can be accessed through: http://iez102.ieem.ust.hk/ling/

4.2.2 Dependent variables

The dependent variables are decision quality, decision-making time, and consumers' perceptions of choice and process. Below are list of items and measurements in the decision quality:

1. ***Consumer satisfaction with decision made***. This item is measured using scale developed to measure satisfaction with brand selection [82]. This item is a seven-point Likert scale with scale 1 indicating lowest level of satisfaction and scale 7 indicating highest level of satisfaction.
2. ***Consumer satisfaction with process***. To measure this item, satisfaction with activity scale from Fisher and Price is adopted [83]. This item is a seven-point Likert scale with scale 1 indicating lowest level of satisfaction and scale 7 indicating highest level of satisfaction.

3. ***Closeness between expectation prior to buying and end product.*** This item is measured using scale developed to measure disconfirmation [46]. This item is a seven-point Likert scale ranging from 'Worse than I expected' (scale 1) to 'Better than I expected' (scale 7)
4. ***Number of products seen before making a decision***. This measurement is obtained from clicking history and verbal protocol data from participants when selecting / configuring their T-shirts.

Decision-making time is measured from the time participants start a shopping task until they make a final decision on a T-shirt. This measurement excludes time to perform verbal protocol that is not done concurrently with the tasks. Verbal protocol requires participants to verbalize their thinking process while performing the task concurrently. In reality, it is not easy to be done. It needs substantial amount of training, participants often forget to speak out, and sometime the verbal protocol are more of justification about what they have done rather than concurrently verbalize their thoughts. When participants forgot to verbalize their thought and the experimenter reminded them to speak out, often participants mentioned previous activities that have been conducted without the verbal protocol, For example after a participant chose a blue body color, he mentioned: "I examined the T-shirts and liked the one with blue body color". Verbal protocol time that is not done concurrently with decision-making process (e.g. move or click the mouse) is eliminated.

Measurements of consumers' perceptions of choice and process are also conducted in order to provide explanations on what causes differences between decision quality in both product configuration and product selection. Consumers' perceptions of choice and process are further explained using several items:

- Perception of process
    1. ***Perceived process complexity***. This item is measured using scale developed to measure process complexity in mass customization [65]. This item is a seven-point Likert scale with scale 1 indicating lowest level of perceived process complexity and scale 7 indicating highest level of perceived process complexity.
    2. ***Perceived difficulty***. This item is a seven-point Likert scale used to measure perceived difficulty participants' decision-making, ranging from 1 (lowest level of difficulty) to 7 (highest level of difficulty).
    3. ***Perceived trade-offs.*** This item is a seven-point Likert scale used to measure whether participants feel they need to trade in attribute levels they like for attribute levels they don't like. This scale ranges from 1 (strongly disagree) to 7 (strongly agree). In this case, participants were not told that there are equal number of possible products can be generated from configuration and selection method. Perceived trade-offs can also arise because of task setting and decision-making process that influence the difficulty of participants finding their desired products.
    4. ***Perceived enjoyment***. To measure this item, shopping value scale from Babin and Darden is adopted [84]. This item is a seven-point Likert scale with scale 1 indicating lowest level of enjoyment and scale 7 indicating highest level of enjoyment.

- Perception of choice

    1. ***Perceived choice complexity***. This item is measured using scale developed to measure choice complexity in mass customization [12]. This item is a seven-point Likert scale with scale 1 indicating lowest level of perceived choice complexity and scale 7 indicating highest level of perceived choice complexity.
    2. ***Perceived favorability towards end product.*** This item is a seven-point Likert scale employed to measure likeness towards end product ranging from 1 (lowest level of likeness) to 7 (highest level of likeness).

Some variables in this experiment are controlled, such as: type of interface, type of attribute, time pressure, and participant group. This experiment is performed on the Web. It uses only one type of product and focuses on aesthetic attributes with number of attributes and attribute levels being controlled. No time pressure is applied when participants perform their decision-making process. Participant groups and gender are also controlled.

4.3 Participants and experimental setting

Forty-eight female and male local university students participated in the experiment. They were given tasks to configure and select T-shirts for themselves, and were offered two T-shirts they selected or configured as their reward for participating in the experiment. This experiment was a full factorial study in which each participant was asked do all eight tasks resulting from exhausting combinations of independent variables. A self-conjugating Latin square design with six repetitions per condition was employed. Within subject and between subject designs are known with their own advantages and disadvantages. Within subject design requires less number of participants in collecting same amount of data compared to between subject designs. It also eliminates variability caused by participant differences.

During their decision-making, participants were asked to verbalize their thoughts by performing a "think aloud" method. Subsequently, various data recorded by video-taping and log file recording were also taken during participants' decision-making tasks. After each decision task, participants were asked to fill subjective questionnaires related to decision quality and perceptions of process and of choice. The questionnaires can be found in Appendix B.

A T-shirt was chosen as the product participants selected or configured since it is a simple product that all participants had previous experience in buying for themselves. In this experiment, attributes offered focused on aesthetic attributes. Four attributes were varied: sleeve color, body color, front picture, and back picture. All other attributes were held constant, for example all T-shirts were the same style and made from the same material. The purpose of offering T-shirts as a reward was to increase accountability in the participants' decision-making process. At the end of the experiments, participants were allowed to choose between two types of reward, either to receive the two T-shirts they selected or configured or to receive HK$ 60 in cash. A more detail explanations about the experiment can be found in Appendix C1 and Appendix C2 of this thesis.

4.4 Results in Decision Quality and Consumer Perception in Product Configuration and Product Selection Processes

In this chapter, experimental results are presented, while in the next chapter, discussions about results will be presented, in conjunction with previous findings and theories in related field of study.

4.4.1 Decision quality in product configuration and product selection

The data are tested for normality test. If the data are not normally distributed, non-parametric tests are conducted in order to investigate the main effects; otherwise, ANOVA analyses are conducted. A complete statistical analyses and data are presented in Appendix A. In the main body of the thesis, only important summaries will be presented.

Results related to decision quality as a function of independent variables is tabulated in tables 4.2 and 4.3. The first column of table 4.2 shows statements indicating better decision quality, which are: better satisfaction with decision, better satisfaction with process, closer between expectation and final product, and fewer products seen, which is considered as fewer efforts in decision-making. Table 4.3 presents median and inter quartile range values of decision quality items. A complete set of data and analysis are presented in Appendix A.

Compared with presenting choice by alternative, presenting choice by attribute significantly increases satisfaction with process ($W(191)$, $Z=-2.421$, $p<0.05$), and participants reviewed fewer numbers of products (W(191), Z=-7.667, p< 0.0001). There are no significant differences between satisfaction with decision (W(191), Z=-1.82, p>0.05) and closeness between expectation prior to buying and final product (W(191), Z=-1.392, p>0.1) between two modes of choice representation.

Shopping method by configuration is superior to shopping method by selection. It provides significantly better satisfaction with process (W(191), Z=-9.936, p< 0.0001), better satisfaction with decision (W(191), Z=-9.026, p< 0.0001) and helps participants obtain products closer to their expectation prior to buying (W(191), Z=-5.093, p< 0.0001).

Providing a higher number of products requires participants to examine more products (W(191), Z=-8.448, p< 0.0001); however it provides greater satisfaction with process (W(191), Z=-5.511, p< 0.0001) and decision (W(191), Z=-5.822, p< 0.0001) and helps participants to obtain products closer to their expectation prior to buying (W(191), Z=-6.494, p< 0.0001). This is simply because there are more options to choose and the possibility of getting what participants want is higher as compared to the condition in which a lower number of product alternatives is available.

There is no significant difference between male and female participants in any aspect of decision quality (all p values > 0.1). A possible explanation is because the tasks assigned to participants are simple tasks and both male and female participants are familiar with T-shirt as the object of selection. The type of T-shirt offered is not oriented to a specific gender.

Table 4.2 Summary of decision quality

	No. product		Shopping method		Choice representation	
Summary of results	16	256	Configuration	Selection	By attribute	By alternative
Higher satisfaction with decision		***	***			
Higher satisfaction with process		***	***		*	
Higher closeness with preferences		***	***			
Fewer number of products seen	***		***		***	

* denotes significance at 0.05

** denotes significance at 0.01

*** denotes significance at 0.0001

Table 4.3 Median and inter quartile ranges of decision quality

	No. of product		Shopping method		Choice representation	
Summary of results	16	256	Config.	Selection	By attribute	By alternative
Satisfaction with decision	(3.50, 4.50, 5.50)	(4.00, 5.00, 6.00)	(4.50, 5.00, 6.00)	(3.50, 4.00, 5.00)	(4.00, 5.00, 5.50)	(4.00, 4.50, 5.50)
Satisfaction with process	(3.00, 3.75, 5.00)	(3.00, 4.50, 5.50)	(4.00, 5.00, 6.00)	(2.50, 3.00, 4.00)	(3.00, 4.50, 5.50)	(3.00, 4.00, 5.00)
Closeness with expectation prior to buying	(3.50, 4.00, 4.81)	(4.00, 4.50, 5.00)	(4.00, 4.50, 5.00)	(3.75, 4.25, 4.75)	(3.75, 4.38, 5.00)	(3.75, 4.50, 5.00)
Number of products seen	(13.00, 20.00, 36.00)	(20.00, 35.00, 59.00)	(12.00, 20.00, 30.00)	(20.00, 44.50, 69.75)	(11.25, 20.50, 37.00)	(18.00, 32.00, 63.75)

(d, e, f) indicates (25th quartile, median, 75th quartile)

Figures showing comparisons of each factor investigated as function of number of products, shopping method, choice representation, and gender can be found in appendix A.

Table 4.4 presents interaction results among number of product, choice representation, and shopping method. Some significant interactions between shopping method and choice representation are observed. It confirms that participants prefer different choice representations in different shopping methods. The number of products seen is not merely depends on the number of product offered, but also contingent to shopping method and choice representation.

Table 4.4 Interaction tables for decision quality

Factors investigated	N*M	N*R	M*R
Satisfaction with decision	F(1, 376)=1.893, p=0.017	F(1, 376)=0.001, p=0.972	F(1, 376)=4.447, p=0.036
Satisfaction with process	F(1, 376)=13.966, p< 0.0001	F(1, 376)=1.642, p=0.201	F(1, 376)=51.911, p< 0.0001
Closeness between expectation and final product	F(1, 376)=0.910, p=0.341	F(1, 376)=0.518, p=0.472	F(1, 376)=2.447, p=0.119
Number of product seen	F(1, 376)=12.513, p< 0.0001	F(1, 376)=4.735, p=0.03	F(1, 376)=60.688, p< 0.0001

N = number of product
M = shopping method
R = choice representation

4.4.2 Consumer perceptions in product configuration and product selection

Results regarding participants' perceptions on process and choice are tabulated in tables 4.4 and 4.5. Similar to findings on decision quality, configuration-shopping method is superior compared to selection shopping method. Using configuration, participants perceive less difficulty (W(191), Z=-8.463, p< 0.0001), less process and choice complexity (W(191), Z=-8.969, p< 0.0001), fewer trade-offs (W(191), Z=-6.026, p< 0.0001), greater enjoyment (W(191), Z=-8.106, p< 0.0001) and like the end product better (W(191), Z=-7.38, p< 0.0001), as compared to selection method.

Increasing the number of products does not increase perceived difficulty (W(191), Z=-0.851, p>0.1), process complexity (W(191), Z=-0.944, p>0.1), and choice complexity (W(191), Z=-1.986, p>0.1). A possible explanation is that in this experiment, products offered are arranged using a systematic method employing tree structure. Products are categorized based on different attribute levels. For example T-shirts having the same front pictures are grouped together. This tree structure helps participants compare and find products they like more easily. Because of the tree structure, participants can handle both 16 and 256 products and perceive no difference in difficulty, process complexity, and choice complexity level.

It was also found that offering a greater number of products resulted in greater enjoyment and more products seen as compared to offering fewer products (W(191), Z=-5.601, p< 0.0001). Results showed that participants appreciate knowing that there are high numbers of products available for them to choose. They can see more variety, and the possibility of finding a product closer to expectation prior to buying is higher when the number of products offered is also higher.

Presenting choice by attribute provides greater enjoyment (W(191), Z=-2.615, p<0.001), increases favorability towards product and also reduces perception of choice complexity (W(191), Z=-2.697, p<0.01). Again, there is no significant difference in perception on choice and process between male and female participant groups (all p values > 0.1).

Table 4.5 Summary of perception related to process and choice

	No. product		Shopping method		Choice representation	
Summary of results	16	256	Configuration	Selection	By attribute	By alternative
Higher perceived enjoyment		***	***		**	
Lower perceived process complexity			***			
Lower perceived difficulty			***			
Lower perceived trade-offs		***	***			
Higher perceived favorability towards product decided		***	***		*	
Lower perceived choice complexity			***		**	

* denotes significance at 0.05

** denotes significance at 0.01

*** denotes significance at 0.0001

Table 4.6 Median and inter quartile ranges values of perception of task

Summary of results	No. of product		Shopping method		Choice representation	
	16	256	Config.	Select	By attribute	By alternative
Perceived enjoyment*(a,b)	(3.79, 1.19)	(4.22, 1.25)	(4.55, 1.13)	(3.46, 1.09)	(4.13, 1.36)	(3.88, 1.09)
Perceived process complexity	(2.50, 3.00, 4.00)	(2.25, 3.25, 4.00)	(2.00, 2.63, 3.25)	(3.00, 3.75, 4.75)	(2.00, 3.00, 4.25)	(2.75, 3.25, 3.75)
Perceived difficulty	(3.00, 4.00, 5.00)	(3.00, 4.00, 5.00)	(2.00, 3.00, 4.00)	(4.00, 5.00, 5.00)	(3.00, 4.00, 5.00)	(3.00, 4.00, 5.00)
Perceived trade-offs	(3.00, 4.00, 5.00)	(2.00, 4.00, 5.00)	(2.00, 3.00, 5.00)	(3.00, 5.00, 5.00)	(3.00, 4.00, 5.00)	(3.00, 4.00, 5.00)
Perceived favorability towards product decided	(3.00, 5.00, 5.00)	(4.00, 5.00, 6.00)	(4.25, 5.00, 6.00)	(4.00, 4.00, 5.00)	(4.00, 5.00, 6.00)	(4.00, 5.00, 5.00)
Perceived choice complexity	(2.67, 3.33, 4.67)	(2.33, 3.33, 4.33)	(3.33, 4.00, 5.00)	(2.00, 2.67, 3.33)	(2.00, 3.00, 4.33)	(2.67, 3.59, 4.46)

* Numbers presented are mean values because data is following normal distribution

(a, b) indicates (mean, standard deviation)

(d, e, f) indicates (25th quartile, median, 75th quartile)

Table 4.7 presents interactions among number of product, shopping method, and choice representation in different aspects of consumer perception. From the table, it can be seen that participants have different perceptions toward configuration and selection shopping method, depends on how the choice is represented. Participants perception of enjoyment, favorability towards end product, and perception of choice complexity towards different number of product also being influenced by different shopping method associated with them.

Table 4.7 Interaction tables for consumer perception

Factors investigated	N*M	N*R	M*R
Perceived enjoyment	F(1, 376)=9.799, p=0.002	F(1, 376)=0.016, p=0.898	F(1, 376)=37.647, p< 0.0001
Perceived favorability of end product	F(1, 376)=6.215, p=0.013	F(1, 376)=0.657, p=0.418	F(1, 376)=11.945, p=0.001
Perceived choice complexity	F(1, 376)=4.896, p=0.028	F(1, 376)=1.764, p=0.185	F(1, 376)=42.386, p< 0.0001
Perceived process complexity	F(1, 376)=3.368, p=0.067	F(1, 376)=4.544, p=0.034	F(1, 376)=54.819, p< 0.0001
Perceived trade-offs	F(1, 376)=3.114, p=0.078	F(1, 376)=0.589, p=0.443	F(1, 376)=41.538, p<0.0001
Perceived difficulty	F(1, 376)=2.035, p=0.155	F(1, 376)=0.127, p=0.722	F(1, 376)=31.544, p< 0.0001

N = number of product

M = shopping method

R = choice representation

4.5 Time Spent in Product Configuration and Product Selection

The total time spent and average time spent per product as functions of number of products, shopping method, and choice representation is tabulated in tables 4.8 and 4.9. It can be seen that offering fewer products leads to less time spent rather than offering more products (W(191), Z=-7.315, p< 0.0001). Shopping method by configuration also leads to less total time spent rather than using selection shopping method (W(191), Z=-6.329, p< 0.0001). Presenting choice by attribute leads to significantly less time spent compared to presenting choice by alternative (W(191), Z=-3.074, p<0.01).

Results related to average time spent per product show that when offered fewer number of products participants spend longer time per product as compared to higher number of products (W(191), Z=-2.364, $p<0.05$). Shopping method by configuration also results in longer time spent per product compared to shopping method by selection (W(191), Z=-5.772, $p< 0.0001$). Choice representation by attribute also leads to longer time spent per product compared to choice representation by alternative (W(191), Z=-5.09, $p< 0.0001$).

Table 4.8 Summary of time measurement

	No. of product		Shopping method		Choice representation	
Summary of results	16	256	Config.	Selection	By attribute	By alternative
Total time spent	***		***		**	
Average time spent per product	*		***		***	

* denotes significance at 0.05

** denotes significance at 0.01

*** denotes significance at 0.0001

Table 4.9 Median and inter quartile ranges of time measurement

	No. of product		Shopping method		Choice representation	
Summary of results	16	256	Config.	Selection	By attribute	By alternative
Total time spent	(64.25, 96.00, 131.75)	(90.00, 137.50, 195.00)	(67.25, 100.00, 140.00)	(81.00, 130.50, 191.50)	(69.25, 105.00, 155.00)	(80.00, 122.50, 174.25)
Average time spent per product	(2.79, 4.66, 7.32)	(2.39, 3.94, 5.90)	(3.61, 5.00, 8.06)	(1.92, 3.12, 5.51)	(3.47, 5.00, 8.11)	(1.92, 3.33, 5.82)

* All conclusions drawn with p value < 0.05

(d, e, f) indicates (25^{th} quartile, median, 75^{th} quartile)

In this study, it is found that total time spent is negatively correlated with satisfaction with process (correlation coefficient = -0.17 with $p < 0.01$) and with number of product seen (correlation coefficient = -0.234 with $p < 0.01$). On the contrary, satisfaction with process increases as the time spent per product increases (correlation coefficient = 0.163 with $p < 0.01$) and as level of enjoyment increases (correlation coefficient = 0.804 with $p < 0.01$). The findings show that participants are not willing to spend their effort to search for product information, however are more satisfied when they have enough time to evaluate each product they seen thoroughly.

Table 4.10 presents interactions among number of product, shopping method, and choice representation in time spent. The only significant interaction is between shopping method and choice representation in terms of average time spent per product. The other interactions are not significant.

Table 4.10 Interaction tables for time spent

Factors investigated	N*M	N*R	M*R
Total time spent	$F(1, 376)=0.121$, $p=0.728$	$F(1, 376)=1.136$, $p=0.287$	$F(1, 376)=2.645$, $p=0.105$
Average time spent per product	$F(1, 376)=0.403$, $p=0.526$	$F(1, 376)=0.237$, $p=0.627$	$F(1, 376)=4.541$, $p=0.034$

N = number of product
M = shopping method
R = choice representation

4.6 Discussion

Results from experiments presented above indicate advantages of product configuration over product selection. In this thesis, choice representation and shopping method both contribute to the favorability of product configuration over product selection. Results from this experiment find partial support for hypotheses 1b. Choice representation only affects satisfaction with process and number of products seen. This finding shows support for hypothesis 1a. In representation by attribute condition, participants spent less time than in representation by alternative condition.

Shopping method by configuration leads to greater satisfaction with process and decision, fewer products seen, and leads to a closer relationship between expectation prior to buying and final product. These results show support for hypothesis 2a. However, there is no support for hypotheses 2b and 2c. Using the configuration shopping method, participants evaluate fewer products and hence spend less time. Participants are able to quickly find their desired products and need to evaluate fewer products and therefore use less time.

Consistent with previous research, offering a higher number of product alternatives increase the possibility of participants finding a product closer to their expectations prior to buying, thus increasing their satisfaction with decision made [11]. Thus, hypothesis 3 is not supported, except for the result that shows offering fewer products leads to fewer products seen by participants.

Significant interactions between shopping method and choice representation in terms of satisfaction with decision and satisfaction with process are observed. Configuration with choice representation by attribute leads to better consumer satisfaction with decision and process compared to configuration with choice representation by alternative. Selection with choice representation by alternative leads to better consumer satisfaction with process compared to selection with choice representation by attribute. These findings provide support for hypotheses 4a and 4b.

There are significant interactions between number of products and shopping method in satisfaction with decision and satisfaction with process. This finding provides support to hypothesis 5. Increasing the number of products offered in product selection will lower consumer satisfaction with product and process. On the contrary, increasing the number of products offered in product configuration will increase consumer satisfaction with process and decision.

Choice representation and shopping method not only influence decision quality, but also influence various perceptions of choice and process, such as perception of difficulty, perception of choice complexity, perception of process complexity, and perception of enjoyment.

Effects of choice representation on consumer decision-making are studied by presenting either attribute or product alternatives to participants, and asking participants to make a decision on a product alternative [30]. In the study by Bettman and Kakkar, participants cannot choose attributes and attribute levels independently. The study finds different outcomes than this study. Findings indicate that participants spend a significantly longer time in the condition of presentation by attribute. This is because for both conditions, participants had to make a decision on which product alternative to choose. Even for the conditions in which participants are shown attributes and their levels, they still had to search which product alternative possess those attributes and attribute levels.

However, in the current study, when participants can make decisions on which attribute to choose independently, the outcome is reversed. Participants spend significantly less time in the condition of choice representation by attribute rather than by alternative.

Success of the configuration shopping method compared to selection shopping method has been found in a limited number of studies related to mass customization [12], [66]. These studies found that participants are more satisfied when asked to customize their products rather than merely perform product selection.

The current study also found that there is a significant correlation between the perceived favorability toward final product and accuracy (correlation coefficient = 0. 581, $p < 0.0001$). It indicates that the closer the final decision with expectation prior to buying, the higher the perceived favorability towards final product. Significant correlations were also found between accuracy and satisfaction with decision (correlation coefficient = 0.616, $p < 0.0001$) as well as between favorability towards final product and satisfaction with decision (correlation coefficient = 0.742, $p < 0.0001$). These findings indicate when participants are able to get a product closer to the expectation prior to buying, the more they will like the final product. The accuracy and favorability towards the final product in turn influence satisfaction with decision made.

It is deemed necessary to further explore reasons why choice representation and shopping method are able to enhance participants' decision quality. Previous findings indicate that the effects of positive feelings on decision-making are not only substantial, but also facilitative. They lead to improved decision-making by providing motivations for decision-makers to be more thorough in making their decision, but at the same time able to solve their decision problems in a shorter time [85]. The next chapter will provide discussions in order to analyze relationship among items in decision quality and various perceptions of choice and process.

4.7 A note on Generalizability of the Experimental Result

This chapter presents an experimental works conducted in order to study decision quality in product configuration and product selection. A natural question arise is related to generalizability of the experimental results, or generally known as external validity. External validity is the degree to which the conclusions in your study would hold for other persons in other places and at other times [86]. Despite its simple concept, achieving external validity is a very tough. In this study, some steps are taken to improve external validity, such as:

1. **Simulating real shopping environment versus controlled laboratory research.**

   It is normally a trade-off whether to choose a controlled laboratory research or to conduct experiment in real shopping experiment. In a controlled laboratory research, variables other than variables being studied are being controlled in order to minimize random effects. However the environments are usually artificial and can only capture limited phenomena. On the other hand, in a real shopping environment, there are random unobservable effects. However it provides closer situation to real shopping.

   This experiment attempts to approach real shopping environment by providing interface for web shopping. Some variables are being controlled such as participant groups, number of male and female participants, number of attributes and attribute levels related to the product, and Web interface outlook. It is hoped that the effects studied are obtained from experimental setting in which it is close to real situation.

2. **Sampling and randomization**

   The sample from this experiment is drawn from local university student obtained randomly across university. Participants come from different departments and different years of study. Once started, participants' drop out rate is zero, means that no participants quit in the middle of the experiment. The assignment of participants to different tasks uses balanced randomization, following a Latin square design. The reason of performing balanced randomization is to prevent the sample coming from one specific class of population.

This experiment employs a within-subject self-conjugate Latin square design [87. The arrangement of participants to the tasks has been considered to enable the between-subjects design analysis. This experiment consists of eight different tasks resulting from exhausting all possible levels in independent variables. The 48 participants of this experiment are divided into 8 different groups, with each group consists of 6 participants. These groups are assigned different sequence of the tasks. The first group will start with the first task followed by the second, third and so on, the second group will start with the second task, etc.

By analyzing only the first task data from each participant, the analysis become similar to the between subjects design analysis. In this regard, participants have no interference from other tasks. Table 4.11 and 4.12 explains the findings from analyzing only first data obtained from each participant.

Table 4.11 Summary of decision quality in between subject analysis

	No. product		Shopping method		Choice representation	
Summary of results	16	256	Configuration	Selection	By attribute	By alternative
Higher satisfaction with decision		**	**			
Higher satisfaction with process		**	***		*	
Higher closeness with preferences		***	***			
Fewer number of products seen	**		**		**	

* denotes significance at 0.05

** denotes significance at 0.01

*** denotes significance at 0.0001

Table 4.12 Median and inter quartile ranges of decision quality in between subject analysis

Summary of results	No. of product		Shopping method		Choice representation	
	16	256	Config.	Selection	By attribute	By alternative
Satisfaction with decision	(3.00, 4.00, 4.25)	(4.00, 4.75, 5.75)	(4.50, 5.00, 6.00)	(3.00, 3.75, 4.00)	(3.00, 4.00, 5.00)	(3.75, 4.50, 5.25)
Satisfaction with process	(2.75, 3.50, 4.00)	(3.75, 4.00, 5.00)	(4.00, 5.00, 5.75)	(2.50, 3.50, 4.00)	(3.25, 4.75, 5.50)	(3.00, 3.50, 4.00)
Closeness with preferences	(3.00, 3.75, 4.25)	(4.25, 4.75, 5.00)	(4.25, 4.75, 5.00)	(3.00, 3.75, 4.25)	(3.63, 4.25, 4.88)	(3.63, 4.25, 4.63)
Number of products seen	(11.50, 17.00, 35.50)	(25.5, 36.00, 96.00)	(11.50, 21.00, 33.50)	(17.50, 46.00, 96.00)	(9.50, 17.00, 35.50)	(27.00, 35.50, 68.00)

(d, e, f) indicates (25th quartile, median, 75th quartile)

The tables 4.11 and 4.12 can be compared with tables 4.2 and 4.3 to show that results of analyzing only first data from each participant present same conclusions as results obtained from analyzing full set of data obtained from within-subject design.

3. Choice of product type

The type of product chosen is simple product in which participants have knowledge and experience in buying them, in order to prevent different behavior caused by discrepancy in participants' knowledge and experience level. In this study, products of interest are products having aesthetic attributes rather than functional attributes, since in configuration, functionality is normally correlated with price issue.

4.8 Summary

This experiment shows that difference between product selection and product configuration process is caused by two factors, which are the shopping method and the choice representation. These two factors influence participants' perception of choice and process, and also influence decision quality related to satisfaction and perception. Number of possible product alternatives also brings out differences in both participants' perception and decision quality. In the next chapter, further analyses and discussion will be presented.

CHAPTER 5

FACTORS INFLUENCING DECISION QUALITY AND DECISION-MAKING TIME IN PRODUCT SELECTION AND PRODUCT CONFIGURATION PROCESSES

The previous chapter presented results indicating significant differences between decision quality and decision making time in product configuration and product selection. These differences were influenced by choice representation, shopping method, and number of products offered. In this chapter, causes of differences will be analyzed by relating them to measurements of participants' perception of choice and process, and with various findings in the literature of Consumer Decision-Making and Marketing research.

5.1 Effects of choice representation

As compared to presenting choice by alternative, presenting choice by attribute has two implications for information presentation to participants. The first is that it involves smaller chunks of information, which is easier for consumers to process [88]. Each product alternative consists of several attribute levels. To evaluate a product alternative means to process several chunks of information whereas to evaluate an attribute level only involves one chunk of information at a time.

The second implication is that it enables presentation of all possible attribute levels in the choice set using less information. In choice representation by attribute, each possible attribute level is presented only once, while in choice representation by alternative, information about attribute levels needs to be repeated in order to fully explore all product possibilities (e.g. to display two T-shirts with same blue color means repeating information about blue attribute level twice).

As an example, in the experiment conducted in this study, to present 4 different attributes with 4 attribute levels each in choice representation by attribute means to show 16 different attribute levels to participants. To present the same number of attributes and attribute-levels embedded in product alternatives means to present 256 different product alternatives.

With presentation of smaller chunks and less information, participants will only need to review less information before they make their decisions. It is also confirmed in this experiment that the number of products reviewed in choice represented by attribute is significantly lower as compared to when choice is represented by alternative ($W(191)$, $Z=-8.448$, $p< 0.0001$). Median and inter quartile ranges of numbers of products seen in choice representation by attribute and alternative are (11.25, 20, 37) and (18, 32, 63.75) respectively. Therefore, the total time spent in the condition of choice representation by attribute is also significantly lower compared to choice representation by alternative ($W(191)$, $Z=-7.315$, $p< 0.0001$). Median and inter quartile ranges of total time spent in choice representation by attribute and alternative are (69.25, 105.00, 155.00) and (80.00, 122.50, 174.25).

Because the amount of information needing to be processed is less in the condition of choice representation by attribute as compared to choice representation by alternative, consumers perceive different levels of choice complexity. Consumers can perceive higher complexity simply because there are numerous options to consider [79].

A study conducted to evaluate the effects of choice representation towards consumer satisfaction was conducted in the context of offering mass-customized products as compared to offering standard products [12]. Results of this study indicate that choice representation by attribute lowers participants' perceived choice complexity and increases participants' satisfaction because they do not have to answer too many questions in order to specify what they want. However, it is worth noting that there is a subtle difference between the study conducted by Huffman and Kahn and the study conducted in this thesis. In their study, the number of pieces of information shown was exactly equivalent in the conditions of choice representation by attribute and by alternative. This makes the number of product alternatives available become imbalanced. Differently, this thesis aims at presenting the same number of product alternatives offered to the participants, in order to avoid interference of the effects of the number of product alternatives offered on participants' perceived feelings and satisfaction. The number of product alternatives offered has long been recognized as an important driver in differentiating consumer decision-making [3], [7], [19]. Therefore, this factor has to be controlled to be equivalent across different experimental conditions.

As an example, suppose that there are 16 pieces of information to be shown to the participants, with 4 attributes involved. In the study conducted by Huffman and Kahn, in choice representation by attribute, this means showing 4 attributes and 4 attribute levels, while in choice representation by alternative, it means showing 4 product alternatives only [12]. However, it is known that showing 4 attributes and 4 attribute levels can possibly lead to 256 different product alternatives.

Experimental results from the current study find that perceived choice complexity is significantly lower when choice is represented by attribute rather than by alternative (W(191), Z=-1.986, $p < 0.05$). Measurement of perceived choice complexity using a 7-scale Likert (7 being the highest choice complexity) indicates that median and inter-quartile ranges of perceived choice complexity in choice representation by attribute and by alternative are (2, 3, 4.33) and (2.67, 3.59, 4.46) respectively. It is also found that there is a significant correlation between perceived choice complexity and satisfaction with process (correlation coefficient = -0.623 with $p < 0.01$). Presenting choice by attribute lowers participants' perception of choice complexity hence it also increases participants' satisfaction with the process.

Choice representation by attribute also enables the organization of information in a more structured manner. This will allow consumers to easily differentiate and focus on salient attributes. By focusing on salient attributes, consumers are able to give their attention to relevant information. Previous studies also identify that when objects are placed in a less competitive environment (i.e. fewer objects competing for participants' attention), participants' viewing time of those objects increases [89].

The study in this thesis finds a significant difference between average time spent per product in choice representation by attribute and by alternative. In the choice representation by attribute condition, the median and inter quartile ranges for time spent per product are (3.47, 5.00, 8.11), as compared to the condition of choice representation by alternative (1.92, 3.33, 5.82). The comparison shows that there is a significant difference between the two conditions mentioned above ($W(191)$, $Z=-2.364$, $p<0.05$). This time per product spent in turn affects satisfaction with process. The correlation between time per product spent and satisfaction with process is significant (correlation coefficient = 0.163, $p < 0.001$). This finding implies that because choice representation by attribute provides a less competitive and less crowded environment for information display, therefore it facilitates more effective information search; participants are able to evaluate choices more thoroughly, and lead to greater satisfaction with process.

A possible drawback of choice representation by attribute is the need for consumers to imagine previously selected or configured products, if they want to compare those products to the currently displayed product. Alternatively, consumers have to go back and forth among compared products. Given this limitation, somehow participants in this experiment still experience greater satisfaction with process using choice representation by attribute rather than by alternative. This indicates the advantages of evaluating less information are greater than the effort of going back and forth among products.

The benefit of representing choice by attribute can be extended when the products offered are functional products. Functional products are difficult to be evaluated, mainly because they are normally represented in a long list of product specifications. As an example, in Yahoo! Shopping website, each cellular phone contains over 30 pieces of information explaining its features and specifications [90]. Due to the large amount of information, it would be beneficial if information can be presented by attribute rather than by alternative, since choice representation is able to minimize the amount of information presented to consumers.

Inarguably, with the advance of Information Technology, storing information in an electronic format is becoming cheaper and cheaper. As a consequence, currently there is a plethora of information available, easily accessible by consumers through the Web. However, due to the limitations of human information processing capacity, limiting the amount of information presented to consumers is desirable in order to avoid consumers being overloaded with too much information.

5.2 Effects of shopping method

It is found that differences in decision quality are also caused by different shopping methods, which are configuration and selection methods. In this section, causes of differences will be analyzed in relation to consumers' perception of process, including perceived enjoyment, ease of use, and sense of involvement.

5.2.1 Enjoyment and ease of use in configuration and selection method

Previous studies investigated consumers' perception and satisfaction in product configuration and concluded that product configuration brings several benefits for consumers. It generated a relatively higher level of enjoyment for participants (mean value of 3.7 out of 5, with 5 being the highest enjoyment) and participants found it easy to design their own product using a configurator interface (mean = 4.1 out of 5, with 5 being the easiest) [64]. Similar findings were provided by Piller, which confirmed moderate perceived difficulty in product configuration (mean = 4.72 out of 7, with 7 being easy) [65]. Studies mentioned above only investigated effects of product configuration towards consumer perception, without comparison with product selection.

This study extends previous studies by comparing product configuration with product selection and confirms findings mentioned above. It is found that perception of enjoyment is significantly higher using configuration method as compared to selection method ($W(191)$, $Z=-8.106$, $p< 0.0001$). Measurement of enjoyment using a 7-scale Likert indicates that means and standard deviation of perceived enjoyment using configuration and selection methods are (4.55, 1.13) and (3.46, 1.09) respectively.

Participants' perception of difficulty is also significantly lower in configuration rather than selection method ($W(191)$, $Z=-8.463$, $p< 0.0001$). Measurement of perceived difficulty using a 7-scale Likert indicates that median and inter-quartile ranges of perceived difficulty using configuration and selection methods are (2.0, 3.0, 4.0) and (4.0, 5.0, 5.0) respectively.

Further analyses indicate a significant correlation between perceived difficulty and satisfaction with process (correlation coefficient = -0.637 with $p < 0.01$) as well as correlation between perceived enjoyment and satisfaction with process (correlation coefficient = 0.804 with $p < 0.01$). It can be deducted that, as compared to selection, configuration method provides better satisfaction with process because participants perceive lower difficulty and higher enjoyment.

The following explanations argue that there is an indirect relationship between perception and satisfaction, mediated by the decision-making process. Previously, it was assumed that affects could only influence decision-making in an irregular and unusual manner. Studies from a growing body of research indicate a significant relationship between affects and consumer decision-making [85]. Two studies investigating consumers' decision-making in choosing cars and medical students' decisions in analyzing patients were conducted in order to test influence of positive affects toward decision-making [91], [92]. Results showed that participants in the positive-affect condition exhibit a more effective decision-making process. They spend significantly less time than those in control conditions, but at the same time display less redundancy in search patterns. Participants in the positive-affect condition also show less confusion when making their decisions and are able to evaluate information in a more thorough way.

This thesis finds that positive affects accompany the configuration-shopping method. This method also enables participants to search for fewer products and spend less time as compared to product selection, resulting in greater satisfaction with process and decision. The positive affects mentioned above are found to have significant correlations with total time spent and number of products seen. Perceived enjoyment negatively correlates with total time spent (correlation coefficient = -0.127, $p < 0.05$) and number of products seen (correlation coefficient = -0.166, $p < 0.01$) while perceived difficulty positively correlates with total time spent (correlation coefficient = 0.231, $p < 0.01$) and number of products seen (correlation coefficient = 0.244, $p < 0.01$). Satisfaction with process negatively correlates with total time spent (correlation coefficient = -0.170, $p < 0.01$) and number of products seen (correlation coefficient = -0.234, $p < 0.01$) while satisfaction with decision negatively correlates with the number of products seen (correlation coefficient = -0.142, $p < 0.01$). So when participants perceive higher enjoyment and less difficulty, they spend less time and search for fewer products, thus inducing greater satisfaction, compared to participants with lower perceived enjoyment.

5.2.2 Sense of involvement in configuration and selection method

A study performed by Kamali and Loker investigated level of involvement in designing apparel online using a product configuration [66]. Their studies found out that participants' interest in getting involved in designing their own T-shirt using a configurator web site was high (average of 7.13 out of 9-scale, with 9 being the highest involvement). In this study, the question related to involvement was stated as "I would rather choose my own components of a T-shirt on a Web site than to buy one that has been pre-chosen for me". When participants were given opportunities to configure a T-shirt, their general satisfaction increased compared to merely select a T-shirt from a range of available T-shirts ($p < 0.05$).

This research confirms the presence of involvement in using configuration method. After finishing all tasks, participants of this experiment were asked to choose the method they liked the most. About 89.6% (43 participants) chose configuration method as the method they preferred. From the total number of people who chose configuration as the preferred method, 65.1% stated that the reason for this was because they were able to choose their own selected colors and pictures, and incorporate those selected colors and pictures into a T-shirt. Because participants are able to select best attribute levels according to their own preferences, in the end they perceive higher favorability towards the end product ($W(191)$, $Z=-7.38$, $p< 0.0001$) and are able to find products closer to their expectation as compared to using selection method ($W(191)$, $Z=-5.093$, $p< 0.0001$). As a result, configuration method provides better satisfaction with decision as compared to selection method ($W(191)$, $Z=-9.026$, $p< 0.0001$).

In fact, consumer involvement has been studied previously in relation to consumer decision-making process. Involvement refers to consumers' overall subjective feeling of personal relevance towards products, processes, or situations. It influences cognitive process such as attention and comprehension, as well as overt behavior [93].

It was found that when consumers chose products for themselves rather than for other people, they felt more involved, thus they have greater motivation to attend and comprehend to salient information. These consumers allocated greater cognitive resources to their attention and comprehension of process information [93], [94]. Findings also determined that highly involved consumers processed information in a more detailed manner [76].

Studies conducted to evaluate consumers' decision-making in selecting PC and tennis products show that participants in a high involvement condition pay a significantly greater amount of attention to the decision-making by spending a longer time to evaluate relevant product information compared to participants in low involvement condition [36], [93]. These results show that participants are willing to spend effort to process relevant information more thoroughly.

In agreement with the findings mentioned above, the current study found that the time spent per product is greater using configuration compared to selection method ($W(191)$, $Z=-5.772$, $p< 0.0001$). A measurement of time spent per product seen, as showed in table 4.8, indicates that median and inter-quartile ranges of time spent per product seen using configuration and selection methods are (3.61, 5.00, 8.06) and (1.92, 3.12, 5.51). This finding indicates that in using selection method, participants pay less attention to each product seen, and quickly switch from one product to another product, while when using configuration method, participants process information in a more detailed manner.

5.3 Interaction between shopping method and number of products offered

In this study, it is found that there is a significant interaction between the possible number of products and shopping method in terms of satisfaction with decision ($F(1, 376)=1.893$, $p<0.05$). It is also found that there is a significant interaction between the possible number of products and shopping method in terms of satisfaction with process ($F(1, 376)=13.966$, $p< 0.0001$). The phenomena mentioned above are described in figures 5.1 and 5.2 respectively.

This study found that providing a shopping method with configuration increases satisfaction with decision and satisfaction with process as the number of products increases. On the other hand, providing a shopping method with selection will decrease satisfaction with decision and satisfaction with process as the number of products increases.

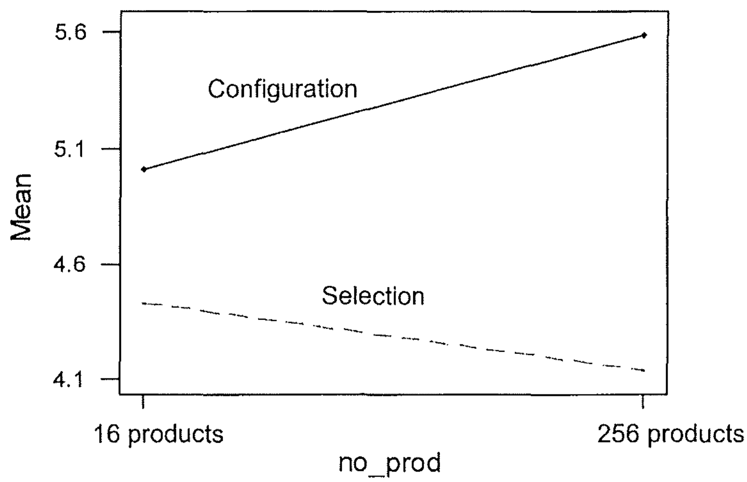

Figure 5.1 Effect of interaction between number of possible products and shopping method on satisfaction with decision

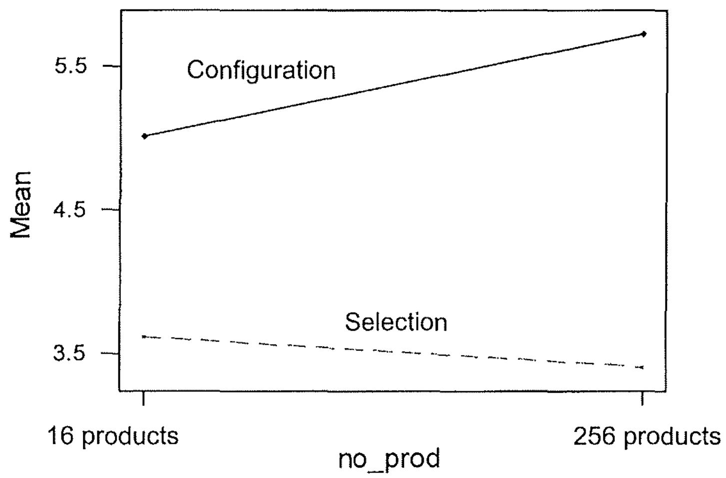

Figure 5.2 Effect of interaction between number of possible products and shopping method on satisfaction with process

With the analyses mentioned above, it is inferred that with the increase in number of products offered, the use of configuration method is even more needed in order to avoid mass confusion and consumers' dissatisfaction. Using configuration method will help achieve better consumer satisfaction with decision and process.

5.4 Interaction between shopping method and choice representation

Usually product configuration and product selection presents choice differently. Product configuration presents choice by attribute, while product selection presents choice by alternative. Accordingly, the method used in product configuration is consistent with presentation by attribute because in product configuration process, the consumer only needs to select attribute levels and combine them together, while in product selection, the method used is also consistent with the choice representation by alternative because consumers need to compare and select among alternatives.

In this experiment, it is found that there is a significant interaction between choice representation and shopping method in terms of satisfaction with decision ($F(1, 376)=4.447$, $p < 0.05$). It is also found that there is a significant interaction between choice representation and shopping method in terms of and satisfaction with process ($F(1, 376)=51.911$, $p< 0.0001$). It is also found that when there is inconsistency between choice representation and shopping method; the satisfaction with decision and satisfaction with process are worse than when the representation is consistent with shopping method. Satisfaction with decision and satisfaction with process are both lower in configuration method using choice representation by alternative compared to that done by attribute. Non-parametric tests show differences in satisfaction with decision ($W(95)$, $Z=-3.973$, $p < 0.0001$) and satisfaction with process ($W(95)$, $Z=-6.523$, $p < 0.0001$) are significant. Satisfaction with process is lower in selection method using choice representation by attribute rather than by alternative ($W(95)$, $Z=-2.828$, $p < 0.01$) while satisfaction with decision between choice representation by attribute and alternative using selection method is not significantly different ($W(95)$, $Z=-0.833$, $p > 0.1$).

The satisfaction with decision and process plot describing interaction between shopping method and choice representation can be seen in figures 5.3 and 5.4.

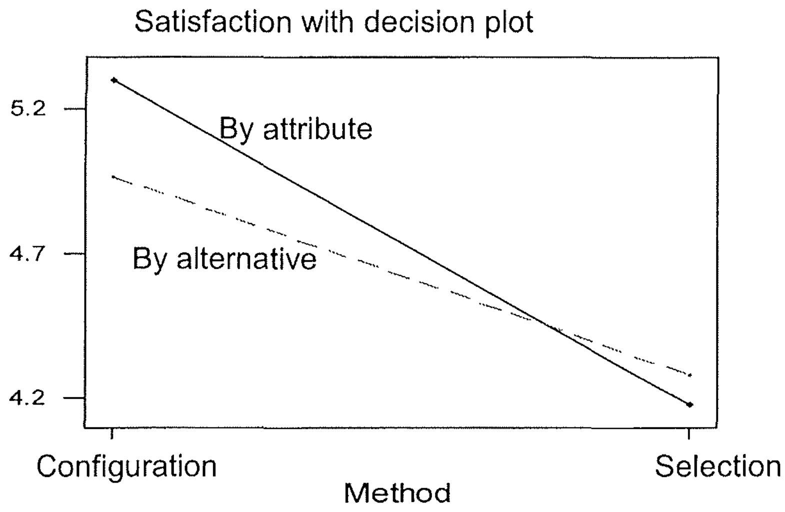

Figure 5.3 Effect of interaction between choice representation and shopping method on satisfaction with decision

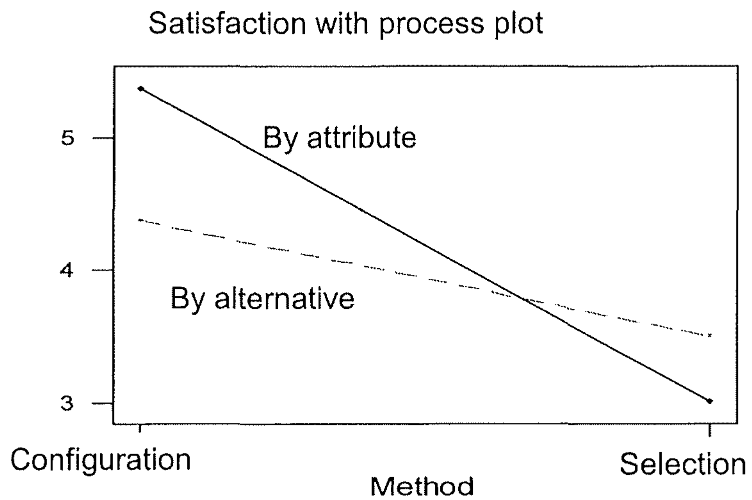

Figure 5.4 Effect of interaction between choice representation and shopping method on satisfaction with process

In the context of consumer information processing, it has been shown that, although participants can process information in any way they choose, they tend to do it in ways consistent with information representation, whether it is processing by attribute or by alternative [30]. It is argued that consumers do this in order to reduce cognitive strain by transforming or ignoring some information, storing it, then later on integrating the information together.

A general discussion will be presented as follows. The benefits of configuration method can be extended by analyzing its contributions to shopping for functional products. When implemented in shopping for functional products, configuration-shopping method will allow consumers to build a product according to their own specifications. Moreover, each function is usually linked to price. As an example, in personal computers, the size of the storage is directly linked to price. By allowing consumers to configure their functional products, they can adapt their products to the price specification as well as getting all the necessary functions and avoiding functions that are not important for consumers.

Presenting configuration method offline does not provide more benefits than presenting configuration method on the Web. The Web technology enables a real-time visualization of products built via a configuration method. However, the Web also has the disadvantage that consumers may not be able to physically touch and try the product.

From the product provider's point of view, providing configuration method allows the product to be designed by consumers, sold, and then made, rather than the old paradigm of design-make-sell. The paradigm of design-make-sell has several disadvantages of inventory, price markdown, scrap and waste, if the product provider is offering wrong products to consumers.

5.5 Summary

In this chapter, discussion about how consumers' perception of choice and process influence decision quality and decision-making time in product configuration and product selection are presented. Choice representation by attribute reduces the amount of information presented to participants. This in turn decreases participants' perceived choice complexity and increases satisfaction with process. Use of configuration method reduces perceived difficulty and increases perceived enjoyment as well as giving a greater sense of involvement in constructing participants' own products. As a result, participants feel more satisfied with the process and are also more satisfied with their decisions, as compared to using selection method.

As previously discussed, decision quality and decision-making process are two important factors in the study of consumer decision-making. The next chapter presents a study related to consumer decision-making process. The process is manifested in decision-making strategy employed by participants when faced with different decision tasks. Furthermore, the next chapter also seeks to find the relationship between decision quality and decision-making strategies.

CHAPTER 6

DECISION-MAKING STRATEGIES IN PRODUCT CONFIGURATION AND PRODUCT SELECTION

6.1 Introduction

It has been reported previously that in the decision-making process, consumers employed different decision-making strategies in order to help them search through the decision space, evaluate alternatives, and make their decision. Decision-making strategies in product selection have been the subject of studies for over five decades [3], [5], [6], [7], [18], [24]. However, to date, decision-making strategies in product configuration have not been investigated yet. As clarified in the literature review, a decision-making strategy is used to solve a decision problem. Consumers might combine several rules, such as Lexicographic, Elimination-by-aspects, Weighted Addition, in order to form a multi-stages decision-making strategy.

Understanding how consumers make decisions and the corresponding strategies used has been a major interest in consumer decision-making research. The literature identifies process tracing methods, particularly those based on information acquisition processes, as the most commonly used methods to collect data reflecting consumers' cognitive processes in making their decisions [3], [7], [95].

Several methods have been used in process tracing, such as presenting information in an information board, using a computer-based information board, verbal protocol and eye-tracking methods. Presenting information using physical cards (each card representing an attribute level of a product) in an information board required participants to manually retrieve cards in envelopes, and the participants had to put them back on the board in order to read the information. Russo found out that the overt action of selecting and reading a card required 15-20 seconds [95]. Using a computer-based information board, participants needed about 1-2 seconds to select and read the information, whereas eye-fixation methods required 0.2 – 0.4 seconds to acquire the same piece of information [95] – [97]. Eye-tracking is a method that best represents a natural way of information search since the information about the product does not need to be represented in text format printed in different cards, but can be displayed using graphical representations, even using setting presented in Web store. Today, with the advances in Information Technology, process tracing can also be done by recording consumers' log-files while browsing on the Web.

In this chapter, the experimental works investigating consumer decision-making strategies in both product configuration and product selection processes are presented. The goal of these experiments is to explore decision-making strategies in product configuration and to compare them the decision-making strategies in production selection. The nature of this study is an exploratory study, in order to provide initial understanding about decision-making strategies in product configuration, as compared to strategies in product selection. The interest in this chapter is to compare product configuration and product selection in settings commonly found in the marketplace, which are: configuration method with choice representation by attribute as illustrated in figure 4.1, and selection method with choice representation by alternative, as illustrated in figure 4.4.

Investigation of the consumers' decision-making strategies involves two experiments. The first one is the initial investigation of decision-making strategies via verbal protocol and log files. The second one is to confirm findings from the first experiment using a more accurate measurement via eye-movement tracking.

6.2 Variables of the experiments

6.2.1 Independent variable

Both experiments manipulated same variable. The independent variable of these experiments is type of task. The type of task consists of two levels: product selection and product configuration task. In the product selection task, a set of product alternatives is displayed. Participants can choose the best product alternative according to their preferences. In the product configuration task, a number of attributes and attribute levels can be chosen by participants in order to construct their own products. In this experiment, number of product offered and choice representation are not manipulated.

6.2.2 Dependent variables

The dependent variable in these experiments is decision-making strategies employed in product selection and product configuration processes. During product selection, based on previous studies, decision-making rules can be categorized into Compensatory (C) and Non-compensatory (NC) rules [5], [6]. These rules can be combined into a multi-stages decision-making strategy. Consistent with previously mentioned explanation in literature review, a decision-making rules is considered a compensatory rule if participants compare products by considering the advantages and disadvantages of two or more attributes at the same time, and perform trade-offs analyses between those attributes. A decision-making rule is considered a non-compensatory rule if participants only consider one attribute at a time and select or eliminate a product solely based on the level of that single attribute. Decision-making strategies in product selection can be a combination of different rules to form a multi-stages decision-making strategy.

To date, research data investigating decision-making strategies in product configuration task is not available in the literature. Therefore, the decision-making strategies in product configuration will be explored in this study.

6.3 Experimental settings and procedures

6.3.1 The first experiment

This experiment is in fact the same experiment described in chapter 4 for studying decision quality and consumer perception. Participants were asked to configure and select the most preferable T-shirts on the Web.

Forty-eight male and female local university students participated in this experiment on a voluntary basis. While performing their decision-making processes, they were asked to perform verbal protocol to verbalize their thinking process. Videotaping and log-files recording were also taken in order to provide additional insights of participants' decision-making process. This was a full factorial design, with each participants performed both tasks. Half of them performed product configuration followed by product selection, while the other half performed product selection followed by product configuration.

6.3.2 The second experiment

In this experiment, participants were asked to configure or select their most preferred mobile phone cover on the Web. The product configuration and selection interfaces for this experiment are illustrated in figures 6.1 and 6.2 respectively.

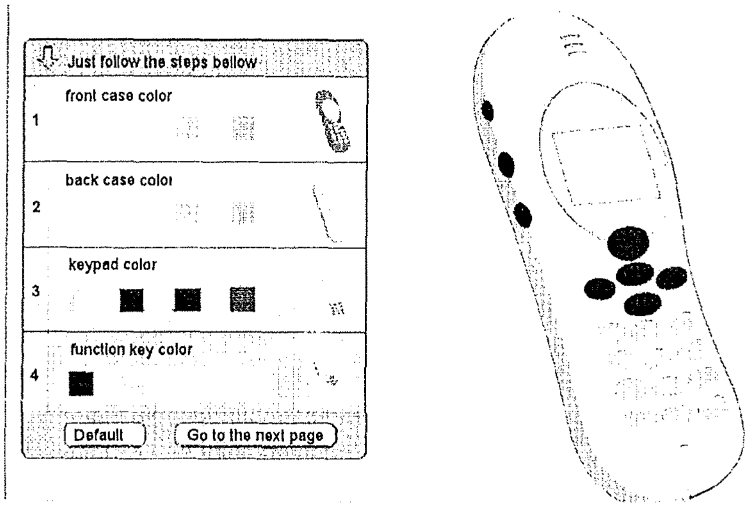

Figure 6.1 Product Configuration Interface

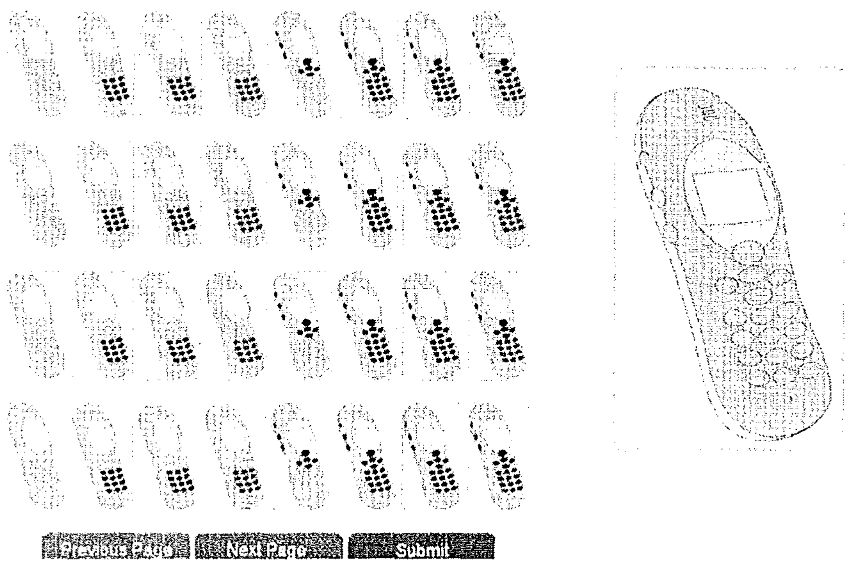

Figure 6.2 Product Selection Interface

The choices consist of four different attributes: front cover, back cover, keypad color, and function key color. Each attribute consists of four levels, except the last attribute consists of two levels. The total possible products generated are 128. In the product configuration interface, the choices can be presented in a single page. While in product selection interface, each page consists of 32 products, and there are 4 Web pages in total. The choices in product selection are grouped based on sequence of attribute presented in product configuration scenario, which are front cover, back cover, keypad color, followed by function key color. The starting points for both product configuration and product selection are selected randomly. In this experiment, it is very important to fix the Web page such that no vertical and horizontal scrolling is possible. The data collection using eye-movement tracking will record absolute coordinates of the screen the participants gaze as functions of time. However it is unable to track the coordinates of an object when the position of the object relative to the screen has moved. The interfaces are available online in the http://iez102.ieem.ust.hk/ling2/ and http://iez102.ieem.ust.hk/ling3/.

Figure 6.3 shows the eye-movement tracking device. The apparatus consisted of a camera and two lighting systems mounted on the monitor of the PC. The camera recorded the participants' eye gaze data. Those data were further translated into information about product attributes and product alternatives being evaluated by the participants using a separate computer program. Another computer program was used to record and track mouse click sequences. Participants were seated in a special chair equipped with a headrest designated to minimize the head movement, as shown in figure 6.4. The experimental setting is illustrated in figure 6.5.

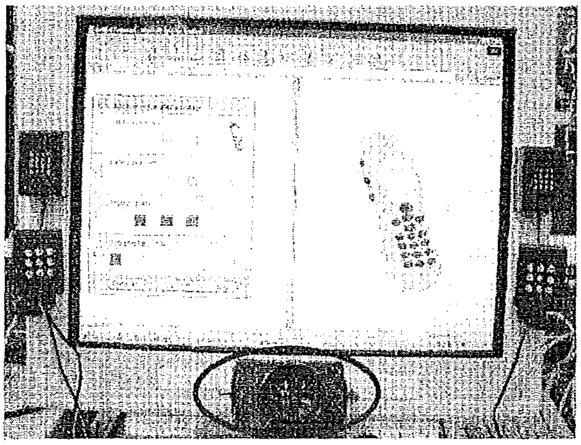

Figure 6.3 QuickGlance hardware

Figure 6.4 Participants wearing headrest

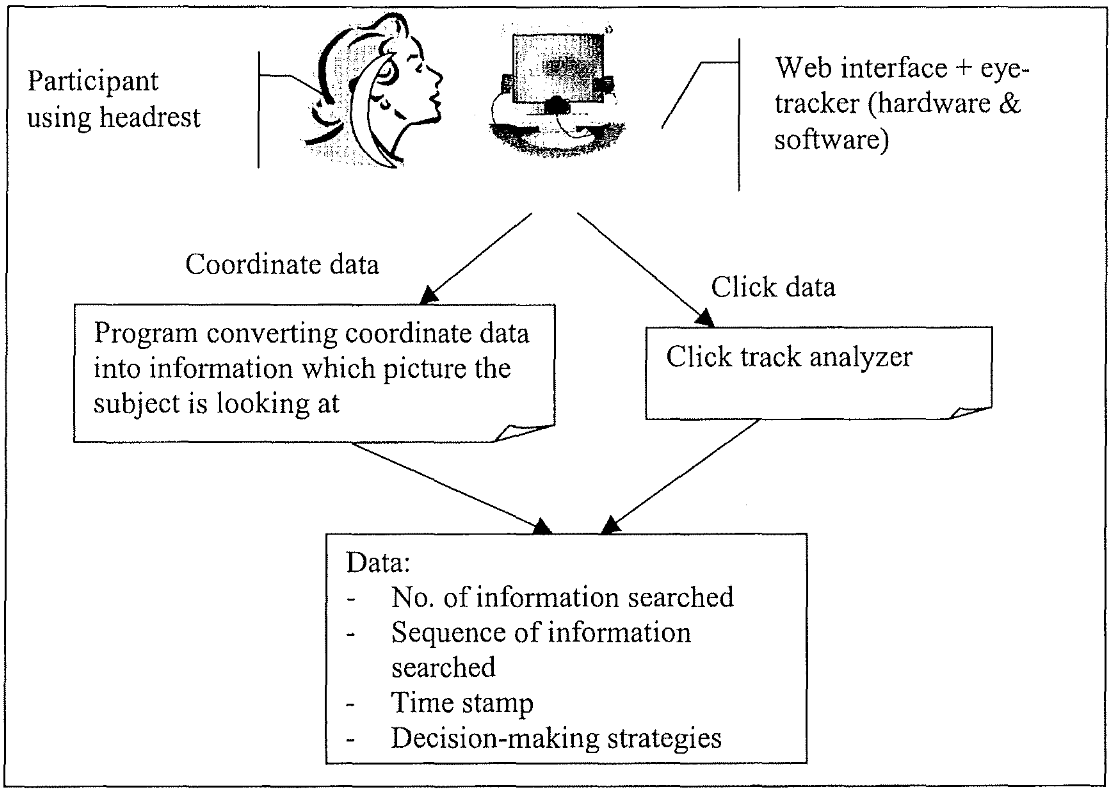

Figure 6.5 Experimental Setting

Forty male and female local university students participated in this experiment. This experiment was based on a full factorial design. Each participant was given both product configuration and product selection tasks. Assignment of the task sequence was using balanced randomization (half of total participants performed product configuration followed by product selection task, while the other half performed product selection followed by product configuration).

At the end of experiment, each participant received HK$50 cash as their reward. The instruction and experimenter guideline are included in Appendix D1 and D2 of this thesis.

6.4 Results

6.4.1 Decision-making strategies in product selection and product configuration

In this section, results regarding consumer decision-making strategies are presented. First, simple descriptions on decision-making strategies are presented. Consumer decision-making strategies are identified based on participants' explicit behavior and verbal protocol. Participants' explicit behaviors include eye-movement patterns and mouse click sequence patterns, while verbal protocol data are verbal statements made by the participants when performing their decision-making process.

Decision-making strategies in product configuration have not been studied previously. Therefore, decision-making strategies in product configuration will be explored and defined in this study. The data collected include participants' observed behaviors or verbal protocol indicating selection of attributes to be evaluated, selection of attribute levels within an attribute, matching among several attribute levels across different attributes, and decision whether to change pre-selected attribute levels.

Decision-making strategies in product selection have been defined and studied for years. Participants are classified as using non-compensatory decision-making rule if they exhibit comparisons of several product alternatives using a particular attribute and followed by elimination of product alternatives that do not possess the selected attribute levels. Participants are classified as using compensatory decision-making rule if they reveal comparisons of several product alternatives based on several attributes, followed by an overall worth assessment of each product alternatives. A more detailed data analysis method is explained in appendix D3.

In order to present the strategies in systematic manners, Cognitive Task Analysis of the decision-making strategies are conducted. Task analysis is a study of what operator is required to do to achieve a system goal [98]. It identifies mapping from tasks to human components and thereby to define the scope of human factors for any particular application [99]. An extension of task analysis that focuses on mental process, strategies, and use of information that underlie observable task performance is known as Cognitive Task Analysis (CTA) [100], [101]. CTA focuses on describing and representing cognitive elements underlying the task, rather than observing explicit behavior that is usually conducted in general task analysis.

Task description will be represented using information flow chart method. Information flow chart is a fairly simple and widely used method. It can provide a very clear presentation of a task, with the diagrammatic format facilitating comprehension [98].

6.4.1.1 Consumer Decision-Making Strategy in Product Configuration

In essence, in product configuration, participants perform within attribute comparisons to select attributes and attribute levels that match their personal preferences. The decision-making strategy in product configuration can be further categorized into two different types.

In the first type of strategy, participants started with an attribute by choosing the best attribute level within the attribute. After that, the participants evaluated the second attribute and chose an attribute level in the second attribute that had best match with previously chosen attribute level. Participants would then evaluate the third attribute, and similarly chose an attribute level in the third attribute that had best match with previously chosen attribute levels. This process continued until each attributes had been evaluated once.

The decision-making strategy in product configuration is very close to a pure non-compensatory strategy by utilizing Lexicographic rules. This strategy emphasizes selection of an attribute level within an attribute and elimination of all product alternatives that do not posses the selected attribute level. If more than one product alternative remains, consumers will then proceed to the next attribute and perform same procedure. Previous study revealed that Lexicographic rule is generally perceived as less effortful than other decision-making strategies. It is also able to provide the quickest and accurate decisions in its execution [102], [59].

In product configuration, participants choose an attribute to start with, and then choose an attribute level within the attribute. By performing this step, participants actually eliminate all possible product alternatives that do not contain the selected attribute level. Participants then select the second attribute, and choose an attribute level that best match with previously selected attribute level. Again, participants eliminate all possible product alternatives that do not contain the two selected attribute levels. This process continues until participants finish evaluating each attribute once.

In the second type strategy, participants started with an attribute and selected the best attribute level within the attribute. After that, the participants moved to the next attribute and selected the best attribute level. After two attribute levels were selected, the participants evaluated the suitability between the two attribute levels. If participants were not satisfied with the matching, they would change one of the attribute levels until they found the best match for the two attribute values. The participants then continued to add another attribute to the combination they had, evaluated suitability of the matching, preferred to change the attribute levels or not, and so on, until the participants decided to stop the configuration process.

The second decision-making strategy in product configuration involved back and forth process in evaluating attributes. Participants can evaluate each attribute more than once. In principal, each time participants decide to select an attribute level; they eliminate all possible product alternatives, which do not posses the selected attribute level. However, in this case, participants can go back and change their minds about which attribute level will be selected.

There are variation of strategies occurred in product configuration are tabulated in tables 6.1 and 6.2.

Table 6.1 Variation of product configuration strategies in T-shirt experiment

T-shirt 16 products			T-shirt 256 products		
The first strategy		Percentage of occurrence of the second strategy	The first strategy		Percentage of occurrence of the second strategy
Percentage of occurrence in which participants evaluate attributes based on the sequence of display	Percentage of occurrence in which participants evaluate attributes based on the perceived attribute importance		Percentage of occurrence in which participants evaluate attributes based on the sequence of display	Percentage of occurrence in which participants evaluate attributes based on the perceived attribute importance	
58.33%	12.50%	29.17%	52.08%	8.33%	39.58%

Using the first strategy, there are 4 attributes evaluated, in which each attributes are evaluated once. Using the second strategy, each attribute can be evaluated either once or more than once. The inter quartile ranges for total number of repeated attribute evaluation for the second strategy in 16 products and 256 products are (6, 7.5, 9) and (5, 6, 9).

Table 6.2 Variation of product configuration strategies in mobile phone cover experiment

The first strategy		Percentage of occurrence of the second strategy
Percentage of occurrence in which participants evaluate attributes based on the sequence of display	Percentage of occurrence in which participants evaluate attributes based on the perceived attribute importance	
55.0%	7.5%	37.5%

The inter quartile ranges for total number of repeated attribute evaluation for the second strategy is (4.5, 7, 8).

Using Cognitive Task Analysis, decision-making strategies in product configuration are illustrated in figures 6.6 to 6.9. The first type is described in figure 6.6. The second type strategy is described in figure 6.7. Figure 6.8 shows how the consumers choose the attribute to be configured. Figure 6.9 shows how the consumers perform within attribute comparison to compare different attribute levels in one attribute. In those figures, the letter P indicates process, while the letter D indicates decision to be made.

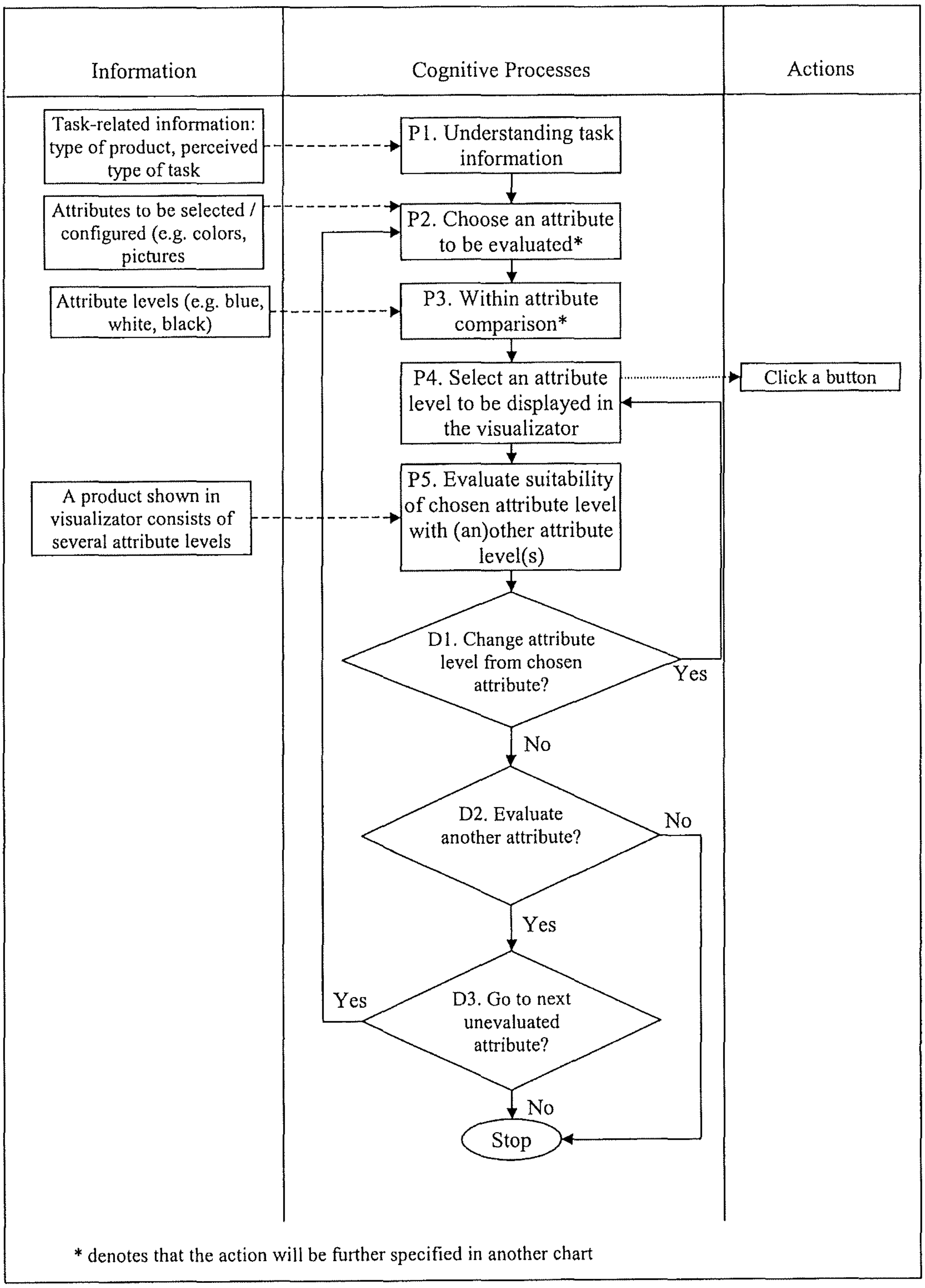

Figure 6.6 CTA in Product Configuration using first type strategy

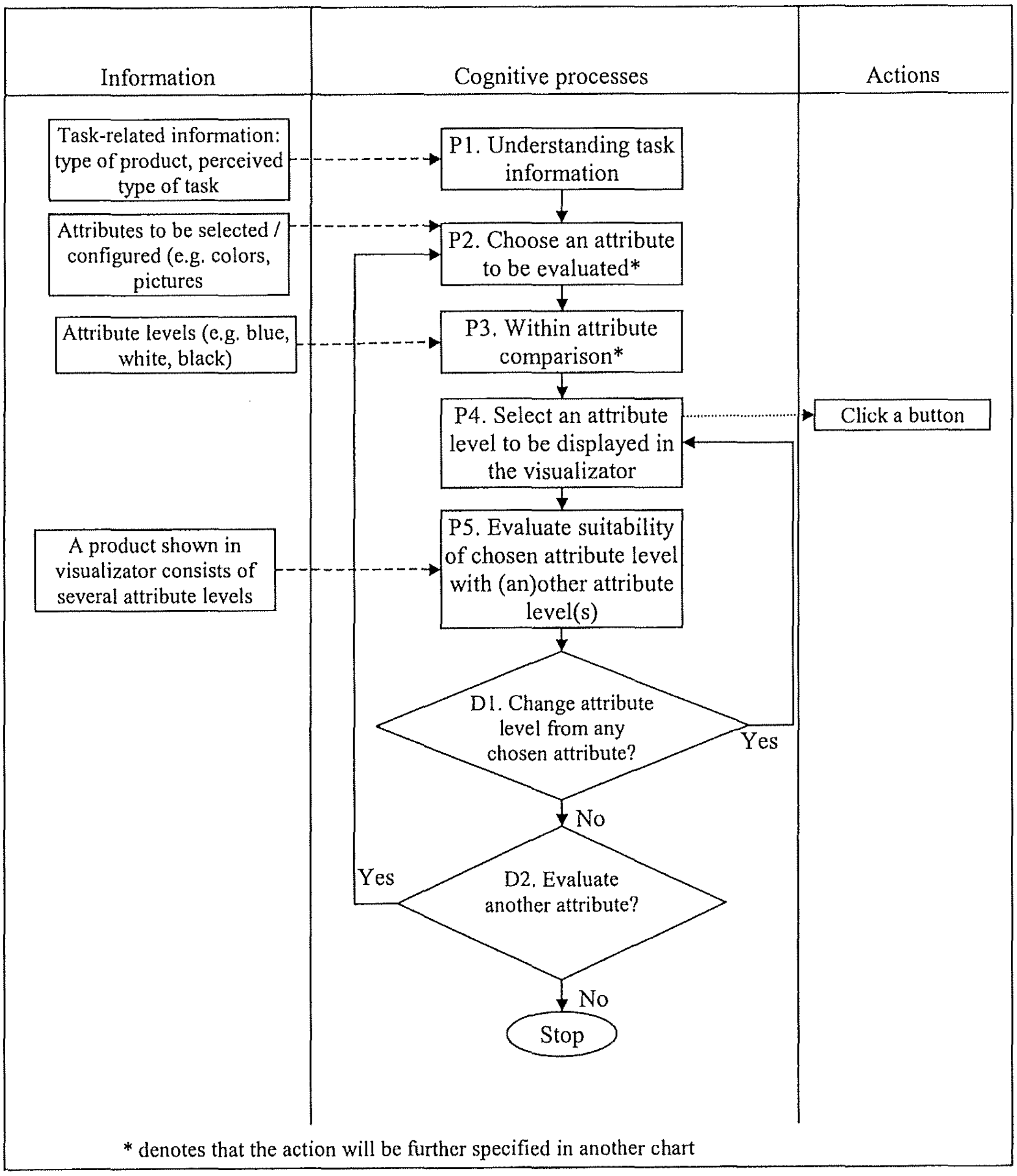

Figure 6.7 CTA in Product Configuration using second type strategy

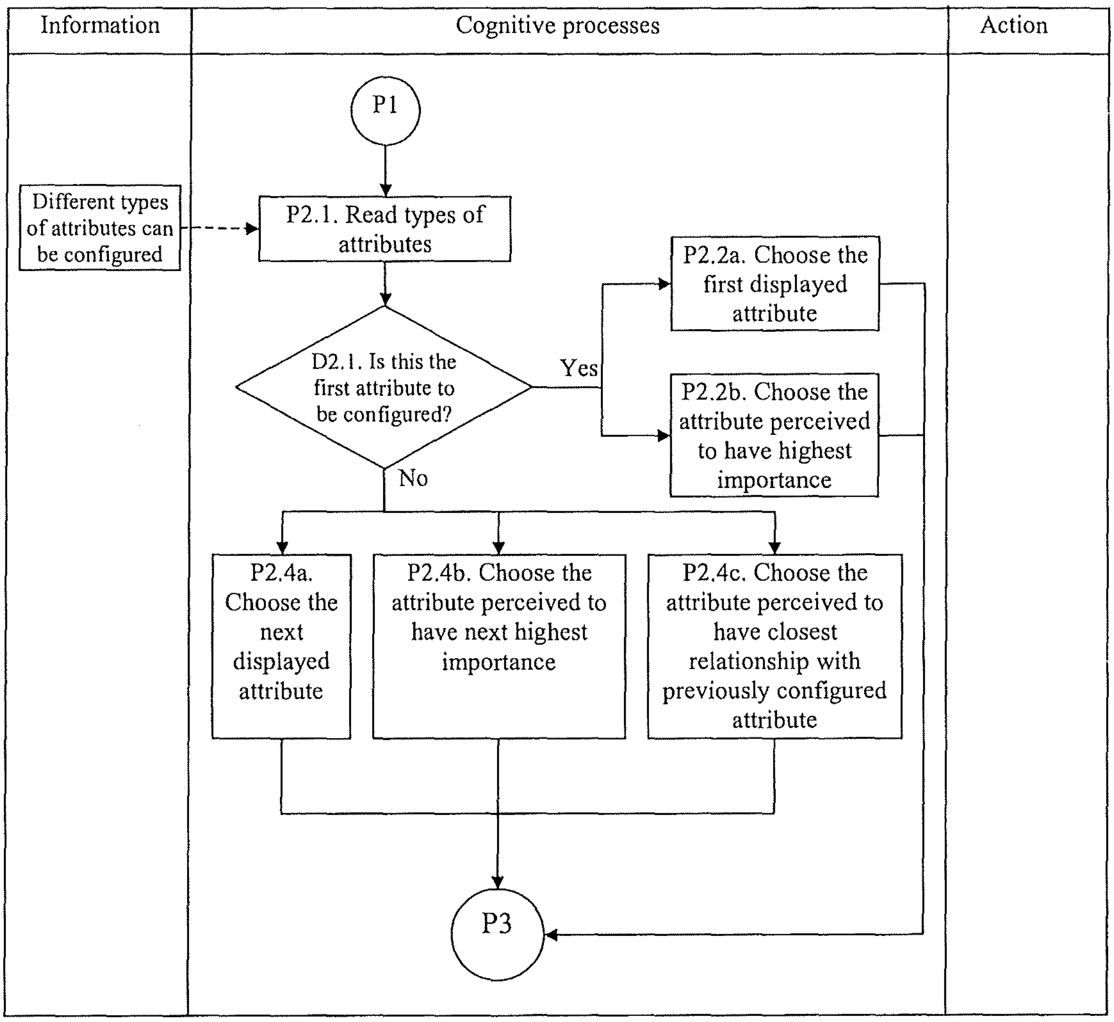

Figure 6.8 Choosing attribute type to be configured

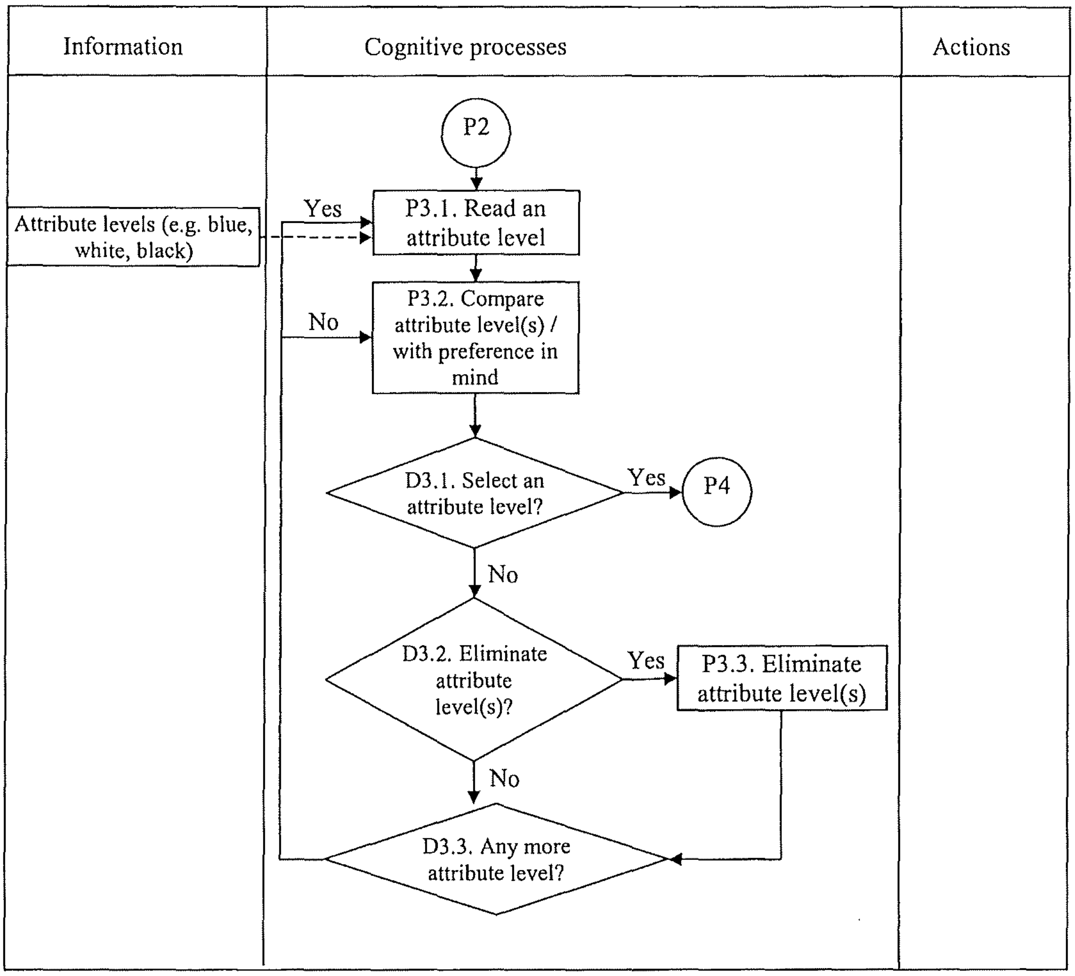

Figure 6.9 Within attribute comparison

6.4.1.2 Consumer Decision-Making Strategy in Product Selection

As seen in figure 2.2 in the literature review, participants will select an appropriate decision-making strategies given the task in front of them, and will also change their decision-making strategy as the decision-making process is progressing. In the current study, it is found that the participants used both multi-stages compensatory and non-compensatory decision-making strategies to evaluate product alternatives in product selection process. Similar findings have been obtained from other studies [7], [28].

When performing product selection, participants eliminated unwanted choice and performed compensatory comparison between alternatives when the number of alternatives could be handled by consumers. The median and inter quartile ranges display the uses of non-compensatory and compensatory decision-making rules are tabulated in tables 6.3 and 6.5. Percentages of different strategies used are tabulated in tables 6.4 and 6.6.

Table 6.3 Median and inter quartile ranges of non-compensatory and compensatory rules occurrences in product selection for T-shirt experiment

16 products		256 products	
Occurrences of non-compensatory strategies	Occurrences of compensatory strategies	Occurrences of non-compensatory strategies	Occurrences of compensatory strategies
(1, 2, 2)	(1, 1, 1)	(2, 2, 3)	(1, 1, 1)

Table 6.4 Percentage of product selection strategies in T-shirt experiment

Percentage of pure compensatory strategies	Percentage of pure non-compensatory strategies	Percentage of multi-stages strategies
0%	4.17%	95.83%

Table 6.5 Median and inter quartile ranges of non-compensatory and compensatory rules occurrences in product selection for mobile phone cover experiment

Occurrences of non-compensatory strategies	Occurrences of compensatory strategies
(4, 5.5, 9)	(2, 3.5, 7)

Table 6.6 Percentage of product selection strategies in mobile phone cover experiment

Percentage of pure compensatory strategies	Percentage of pure non-compensatory strategies	Percentage of multi-stages strategies
0%	0%	100%

The process of participants employing non-compensatory and compensatory decision-making strategies is described in figures 6.10 and 6.11. Figure 6.10 describes the process of participants evaluate initial choices and employ non-compensatory decision-making rules, while figure 6.11 describes how participants choose which attribute to be evaluated.

Here the elimination process was conducted using Lexicographic rule. Participants selected alternatives having the most attractive attribute level in the most important attribute. After initial evaluation on the most important attribute, if there were more than one alternative remained, the process continued with the next best attribute. This strategy was also performed by evaluating attributes by the sequence of how they were displayed.

When adopting a compensatory rule, participants evaluated alternative-by-alternative and performed valuation at the end of each alternative. After evaluating all product alternatives under consideration, participants then compared the values of alternatives and selected product alternative with the highest value. Another method to perform the compensatory rule was to compare attribute levels across alternatives, and chose an alternative that had a larger number of better attribute level compared to other alternatives. The compensatory rules are described in figures 6.12 and 6.13. Figure 6.12 describes the compensatory rule in which participants evaluate alternatives across attributes, while figure 6.13 describes the compensatory rule in which participants perform overall evaluation of each alternative and select alternative having the highest perceived value.

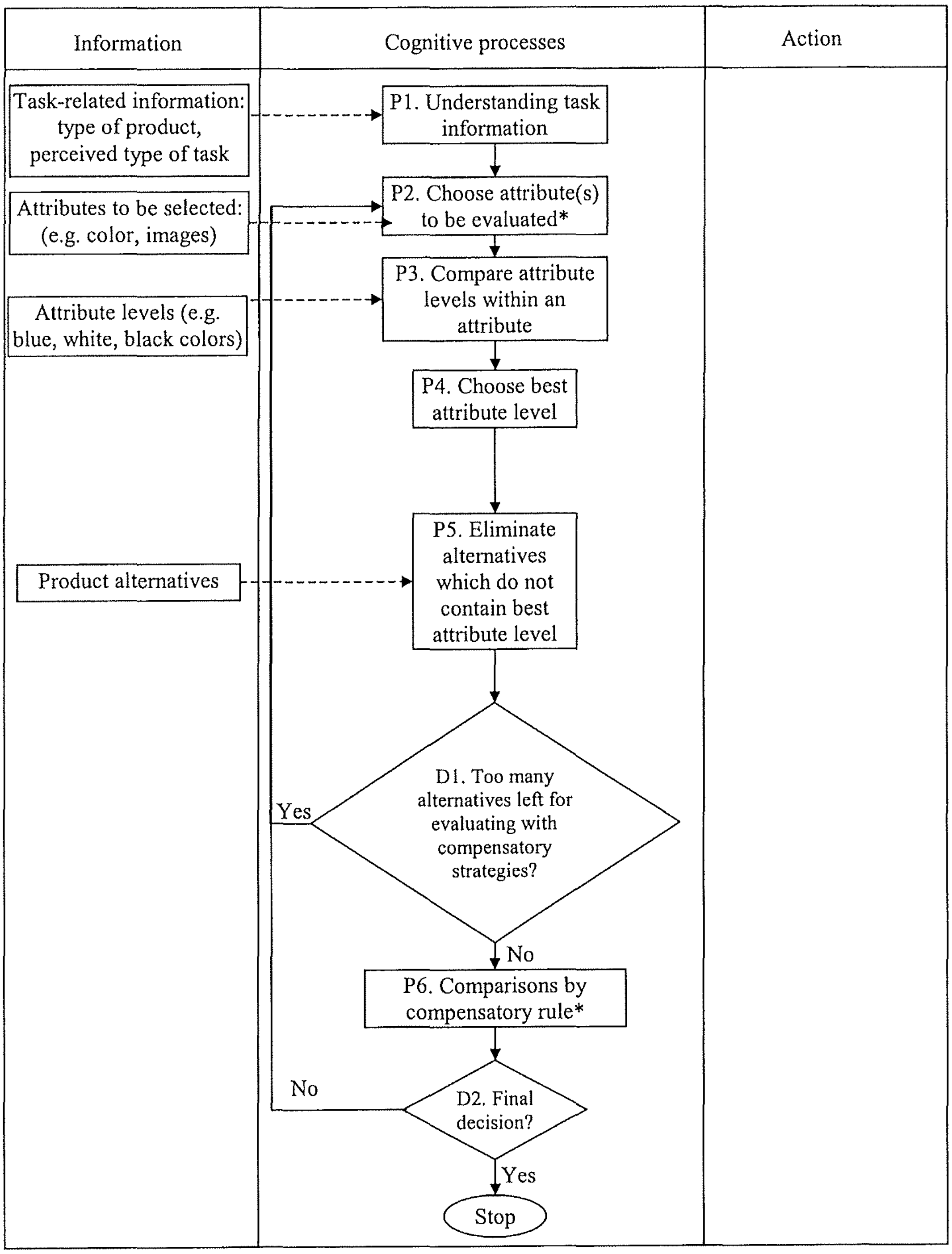

Figure 6.10 CTA of decision-making strategy in product selection

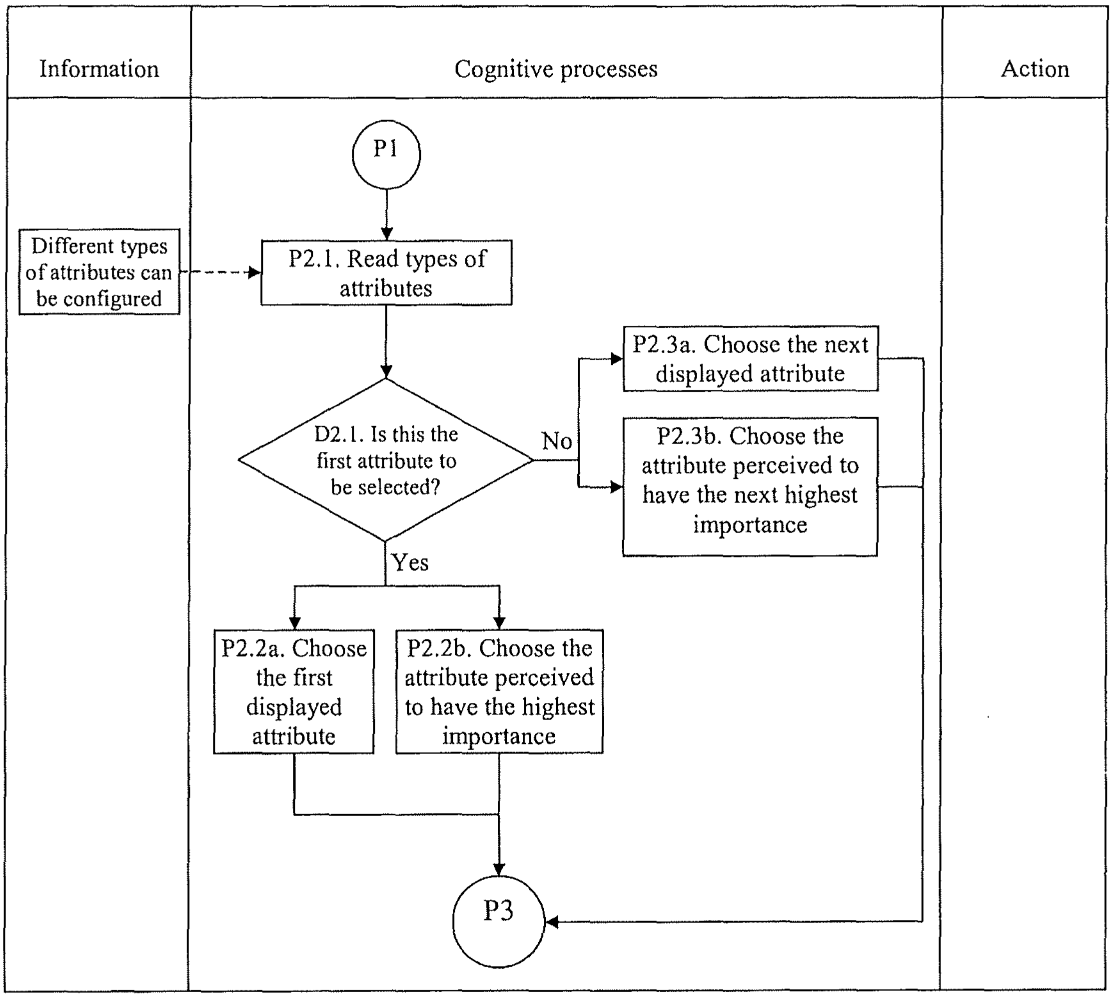

Figure 6.11 Choosing attribute to be selected

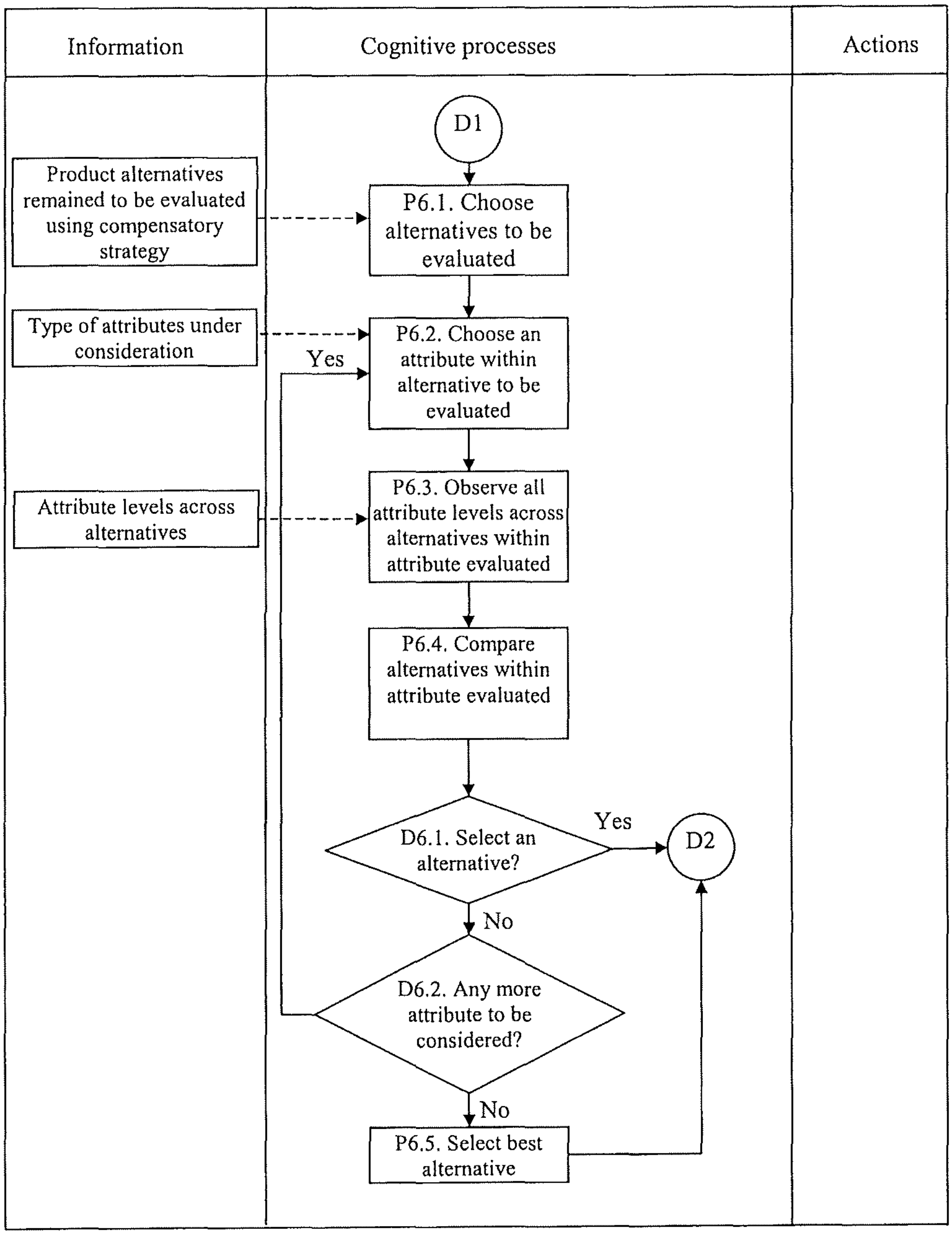

Figure 6.12 Compensatory rule 1

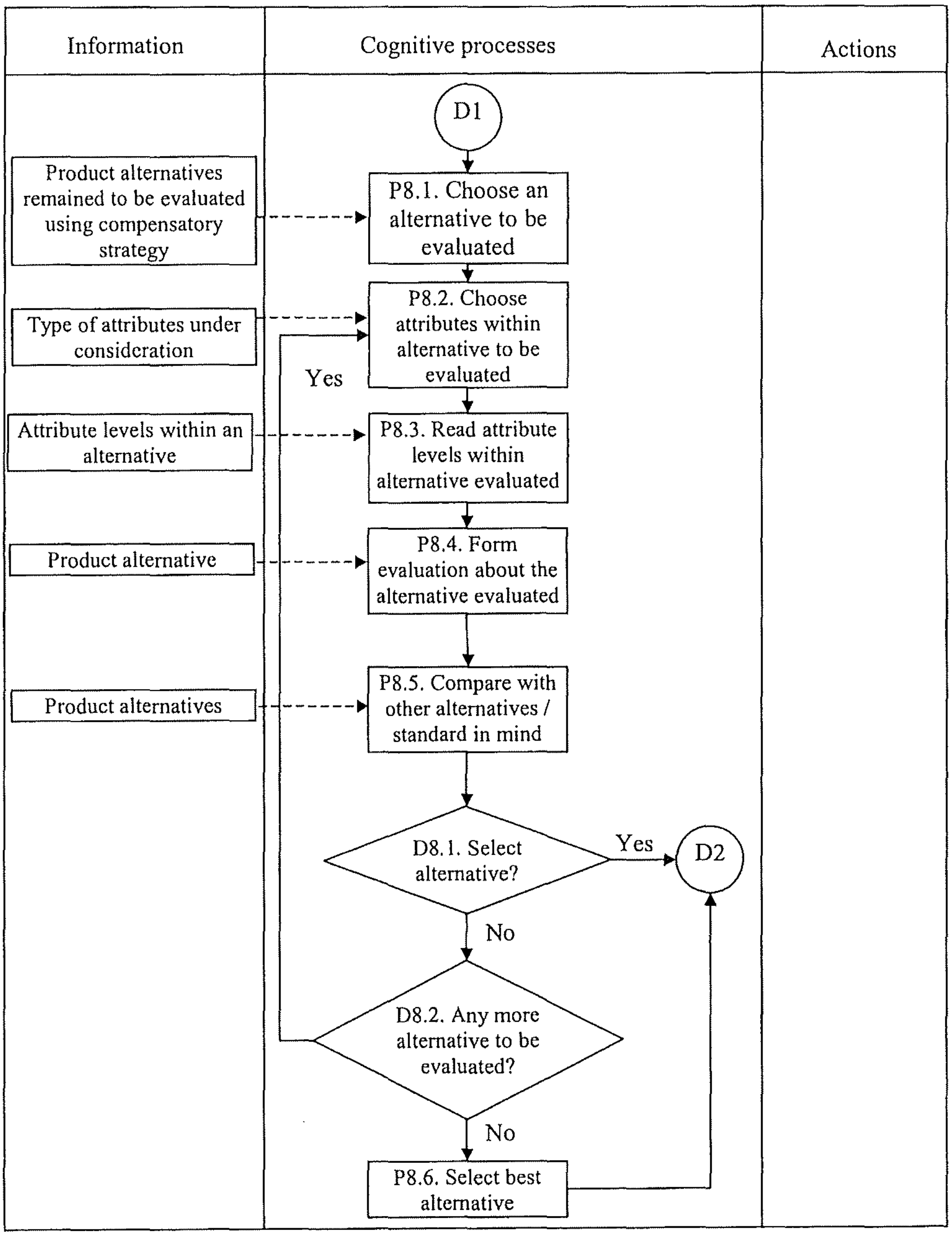

Figure 6.13 Compensatory rule 2

Decision-making strategies in product selection, as described in figures 6.10 to 6.13, show adaptiveness of consumer decision-making. Task complexity has been recognized as one of the most important determinant to the contingency of consumer decision-making [3], [5], [7]. Task complexity here refers to the number of product alternatives and attributes offered, which in essence related to the number of information need to be reviewed and evaluated by consumers.

The usage of multi-stages decision-making strategies is recognized as a method to optimize between effort and accuracy. Consumers will first screen a large set of available products and identify only a set of the most promising products, in order to save efforts in reviewing too many information. Subsequently, consumers evaluate the most promising products in depth, and perform comparisons across products on important attributes in order to maximize the accuracy within the consideration set [6], [19].

6.4.2 Consumer information processing and learning

In processing by attribute, participants first compared various attribute levels in an attribute, and then moved to the next attribute. In processing by alternative, participants examined one product alternative at a time and gathered information on several attributes before moving to the second product alternative.

In product configuration, in which choice is represented by attribute, participants use processing by attribute more often than processing by alternative ($W(95)$, $Z=-6.046$, $p<0.0001$). In product selection, however, in which choice is represented by alternative, participants use processing by alternative more often than processing by attribute ($W(95)$, $Z=-8.509$, $p<0.0001$).

Table 6.7 presents the median values of percentage of information processing strategies used by participants, either processing by attribute or processing by alternative, obtained from verbal protocol data in the experiment of selecting and configuring T-shirt.

Table 6.7 Median and inter quartile ranges of percentage of information processing strategy used by participants

	Processing by attribute	Processing by alternative
Product Configuration	(71.43, 84.62, 91.43)	(8.57, 15.38, 28.57)
Product Selection	(3.68, 5.88, 9.2)	(90.12, 94.12, 96.32)

(d, e, f) indicates (25^{th} quartile, median, 75^{th} quartile)

The experiment in which participants were asked to evaluate T-shirts also measure different consumer learning processes. In this experiment, an indication about different levels of learning is examined from verbal protocol data. All participants' verbal statements in evaluating products are coded into three different types of learning statements.

The first type of statement indicates learning within attribute preference in order to compare attribute levels within an attribute, and choosing the best attribute level (e.g. 'choose white body color from all available colors', 'like blue body color better than other colors'). The second type of statement indicates learning across attribute preference to compare different attributes and select the more important attribute (e.g. 'start to evaluate sleeve color first'). The third type of statement indicates tradeoffs (e.g. 'like the white body color but don't like the brown sleeve color in this product alternative')

Each statement is then converted into percentage by dividing the number of statements made corresponding to certain kinds of learning by the total number of statements made. Table 6.8 summarizes median and inter quartile range values of statements indicating different types of learning.

Table 6.8 Median and inter quartile ranges values of different type of learning in configuration and selection method

	% statements indicating learning within attribute preference	% statements indicating attribute importance	% statements indicating tradeoffs made
Configuration	(40, 57, 87)	(0, 29, 40)	(0, 10, 21)
Selection	(33, 41, 46)	(11, 20, 33)	(33, 40, 43)

(a, b, c) indicates (25^{th} percentile, median, and 75^{th} percentile)

Table 6.8 shows that compared to product selection, in product configuration participants are able to learn within-attribute and across attribute preferences, and make less trade-offs. Non-parametric statistics indicate significant differences between product configuration and product selection in terms of within-attribute preference learning ($W(95)$, $Z=-8.630$, $p<0.0001$), across attribute preference learning ($W(95)$, $Z=-3.127$, $p<0.01$), and trade-off statements ($W(95)$, $Z=-11.485$, $p<0.0001$).

6.5 Discussion

Findings related to decision-making strategies provide support to hypothesis 6a. In product selection, participants perform multi-stages non-compensatory followed by compensatory decision-making strategies, while in product configuration, participants perform matching among attribute levels that is more similar to elimination rules.

In the context of consumer information processing, it has been shown that the consumer tends to process information in ways that are consistent with choice representation, either processing by attribute or by alternative, even though they could process information any way they chose [30]. Findings related to information processing strategy support hypothesis 6b. In product configuration, participants are keen on attribute-based processing.

Different information processing strategies have different impacts on how consumers learn about their own preferences. Huffman and Kahn stated that by configuring their own products, consumers were able to learn about their own preferences within each attribute [12]. By comparing and choosing an attribute level from an attribute (e.g. choosing blue from a range of available colors), consumers were able to learn which attribute level they liked the best. By learning their within-attribute preference, consumers selectively attended to attribute levels and product that they liked [37]. Learning within-attribute preference also helped to reduce perceived choice complexity and increase satisfaction [12].

In product selection, by eliminating and comparing alternatives, consumers were required to learn not only within-attribute preferences, but also across-attribute preferences. Consumers needed to choose preferred attribute levels as well as to determine the importance of each attribute relative to each other, and also to make trade-offs among attribute levels within each alternative.

Consistent with experiment measurement presented in chapter 4, the perceived tradeoffs measured using a 7-scale Likert (with 7 being highest perceived tradeoff) indicates that participants perceived higher tradeoffs when using product selection rather than when using product configuration ($W(95)$ $Z=-4.934$, $p < 0.0001$). Median and inter quartile ranges of perceived tradeoffs in product configuration and selection are (2, 3, 4) and (3, 4, 5).

The experimental results in the current study also confirm that participants perceive lower choice complexity in product configuration rather than product selection ($W(95)$ $Z=-7.695$, $p < 0.0001$). Measurement of perceived choice complexity using a 7-scale Likert (with 7 being highest perceived choice complexity) indicate that median and inter-quartile ranges of perceived choice complexity in product configuration and product selection are (1.67, 2.33, 3) and (3.5, 4, 5) respectively.

In this study, it is also found that both satisfaction with process and decision using product configuration were significantly higher than using product selection. Non-parametric tests confirm significant differences between product configuration and product selection in terms of satisfaction with decision (W(95) Z=-6.93, $p < 0.0001$) and satisfaction with process (W(95) Z=-8.31, $p < 0.0001$). Using a 7-scale Likert (with 7 being highest level of satisfaction), results indicated that median and inter-quartile ranges of satisfaction with process using product configuration and product selection are (5, 5.5, 6) and (3, 3.5, 4). Median and inter-quartile ranges of satisfaction with decision using product configuration and product selection methods are (5, 5.5, 6) and (3.5, 4, 5) respectively. Furthermore, correlation tests show that choice complexity significantly correlates with satisfaction with decision (correlation coefficient = -0.434, $p < 0.001$) and with process (correlation coefficient = -0.623, $p < 0.001$).

Besides the learning process in product configuration, consumers can also obtain psychological benefits from the process of designing their own product, or known as do-it-yourself design [72], [103]. In the do-it-yourself product design process, consumers are actively participating in the product design process. This type of design allows consumers to express their individuality to reveal personal taste and values [103]. It is become logical when the consumers are able to like the product better after investing time and effort to design their own product, especially when the product are designed in such ways to meet each individual taste and values.

Configuration process also induces something like "pride of authorship" [72]. A daily example given in the study is that many people would prefer to hang 5000-

pieces of a self-assembled jigsaw puzzle which looks less attractive rather than a simple picture or poster.

In product configuration, consumers are able to design their own product and gain control over the design process in terms of number of iterations, instant feedback from the configurator interface that enable trial and error process, and the time invested in the process. Consumers are likely to experience a feeling of self-efficacy, a belief that they are capable of producing a desired effect. This feeling is likely to produce a higher appreciation towards the self-designed products compared to products designed by somebody else [104].

The setting of this experiment does not allow a thorough investigation of participants' cognitive process behind their learning. When participants make their statements about learning within attribute preferences, there are two possibilities arise. The first is that participants are actually discovering their preferences via a learning process, and the second is that participants are actually articulating their known preferences. It is hypothesized that the first possibility becomes more and more likely as the task complexity increases and as the level of consumers' knowledge towards the product decreases. It can be deducted that in functional products and in situations where the number of product alternatives is high, learning within-attribute preferences is easy to do. And as shown, it in turns provides greater satisfaction with the process and decision.

The discovery of preferences is closely linked with the concept of innovativeness and creativity [105]. Consumer innovativeness here refers to the degree in which an individual is relatively earlier in adopting new products rather than other members of his social system. Every consumer, to some extent, has propensities to adopt new ideas, products, and services. Creativity refers to productive thinking in consumption-related problem solving. In the area of design, it is believed that design ability is possessed by everyone [106]. The innovation and creativity can drive the discovery of product preferences, especially as it is facilitated via the product configuration. Product configuration enables consumers to discover something that they thought they don't like before. And in terms of process itself, the process of discovery in product configuration also lead to different decision-making strategies with strategies used in product selection.

6.6 Summary

This chapter presents experimental works studying consumer decision-making strategy when performing product configuration and product selection. Further analyses indicate that there are close relationships between consumer decision-making strategies and decision quality. Participants mainly use processing by attribute in product configuration. This type of information processing facilitates learning of participants' within attribute and reducing trade-offs among attribute levels. As a result, participants experience less perceived choice complexity, are more satisfied with the final decision and more satisfied with the process.

The next chapter presents modeling of decision-making time in product configuration and product selection processes.

CHAPTER 7

DECISION-MAKING TIME IN PRODUCT SELECTION AND PRODUCT CONFIGURATION

7.1 Introduction

Decision-making time has been studied for decades [5], [7], [59]. Studies about decision-making time (time for consumers to acquire and process information prior reaching a purchase decision) continue to have importance not only for researchers, but also for marketers and policy makers wishing to influence consumer decision-making environments [107], [108]. As an example, knowledge related to the amount of time consumers are willing to spend in making decisions can help product providers to decide the number of choices offered to consumers, different types of information, etc. Currently in industry, it is also become a challenge for product providers to help consumers find what they want in the shortest possible time [109].

Decision-making time indicated that consumers applied different decision-making strategies in order to cope with different task complexities [7]. Decision-making time can be influenced by various factors, such as task complexity, attribute complexity, similarity of alternatives, and information display format [7], [30].

The results of current study indicate a significant difference between time spent in product configuration and product selection. The study also shows that participants employed different decision-making strategies in the two processes mentioned above. The purpose of this chapter is to apply knowledge related to decision-making strategies in order to provide prediction of decision-making time both for product configuration and product selection. This model focuses on decision-making time prediction as functions of number of attributes and attributes levels as well as different decision-making strategies employed. Some assumptions are listed as follows:

- The model deals with comparable products from the same product category. In this case, the products of investigation are T-shirts with four attributes.
- There are noticeable differences among product alternatives and attributes.
- Consumers do not know exactly what they want, so they need to perform decision-making strategies to evaluate available choices

In order to achieve the purpose mentioned above, first a conceptualization for modeling decision-making time is proposed. The model is then tested against experimental results in order to test its validity.

Product providers present different types and amounts of information to consumers in order to facilitate product configuration and product selection processes. The total number of choices, which is provided by the product provider for consumers to decide on at least one product alternative, will be referred as the ***number of decision units***. The term choice here refers to the attribute level or alternative. Formulation of the number of decision units here also makes certain assumptions. Firstly, it enables participants to explore all possible attribute levels before they decide on at least one product alternative. Secondly, it is assumed that participants are willing to spend effort in searching for the information, and do not search information in a random manner.

Let:

m = number of attributes

n_i = number of levels in each attribute i, where i = 1, 2, ..., m

In product configuration with choice representation by attribute, in order to come up with one product alternative, consumers only need to choose different attributes and attribute levels, and combine them into a product alternative. Thus, the total number of decision units would be equal to total number of attribute levels offered.

$$\textit{Number of decision units (in terms of attribute level)} = \sum_{i=1}^{m} n_i \qquad \text{(Eq.1)}$$

In this study, for simplicity, all n values are set to be equal ($n_1 = n_2 = \ldots = n_i = \ldots = n_m = n$). The equation becomes:

$$\textit{Number of decision unit (in terms of attribute level)} = n*m \qquad \text{(Eq.2)}$$

In product selection and choice representation by alternative, consumers need to compare product alternatives, and decide on a product alternative. Therefore, the total number of decision units would be equal to the total number of alternatives provided. Let n_i be the number of levels in attribute i, where i = 1, 2, ..., m; then:

$$Number\ of\ decision\ unit\ (in\ terms\ of\ product\ alternative) = \prod_{i=1}^{m} n_i \qquad \text{(Eq.3)}$$

With all n values are set to be equal:

$$Number\ of\ decision\ unit\ (in\ terms\ of\ product\ alternative) = n^m \qquad \text{(Eq.4)}$$

With a different number of decision units presented to consumers, the questions raised are how consumers evaluate those decision units in order to make decisions, and what is the associated decision-making time.

7.2 Underlying Theories in Model Building

The following part explains some basics theories and previous findings that will be used in the construction of the model.

7.2.1 Information Theory

Information is transmitted from an information source, perceived and processed by a person for whom the information is intended. Information itself can be regarded as uncertainty reduction. In order to understand how a person perceives and processes information, the information can be quantified based on its characteristics. Shannon formulated the information entropy, so as to measure how many bits of information are needed in order to reduce information uncertainty [110]. One bit is the amount of information necessary to reduce uncertainty by half. In order to reduce uncertainty, a person can divide the solution space into half and then ask himself whether the solution lies on the first half of the solution space. The person then continues to further divide the correct solution sub-space into half and ask himself whether the solution lies on the first half of the solution sub-space until he find the correct answer. This process is an uncertainty reduction by each time dividing the problem space into half.

When all choices are equally likely, the amount of information given is:

$$H = \log_2 n \qquad \text{(Eq.5)}$$

n = number of choice

This research draws an analogy between uncertainty reduction and the decision-making process. Decision-making can be viewed as a process of reducing the number of choices in order to reach one decision. In the decision-making process, consumers perform comparisons to retain the best options. The decision-making process is regarded as a series of binary decisions. Given n number of equal-likely choices, the total number of comparisons performed is $\log_2 n$.

In 1952, Hick investigated choice reaction time by measuring reaction time needed to differentiate stimuli and provide response to the stimuli [111]. The experiment used human subjects to identify one out of several light bulbs that has been turned on and to react by pressing the corresponding button for the light bulb. In the study, it was found that choice reaction time was a linear function of Shannon's measures of information, H. This was because stimuli were assumed to be identified in a series of binary decisions, and each decision took the same amount of time [111].

Choice reaction time was formulated as:

$$RT \propto a + b \log_2 n \qquad \text{(Eq.6)}$$

RT= choice reaction time

b = time to process 1 bit of information

a = time to process other than choice decision

Information theory and choice reaction time provides an indication that decision-making time can be obtained as a function of the number of stimuli and uncertainty reduction paradigm. However, researchers still question how to bring the notions of information theory and choice reaction time closer to estimate decision-making time in the field of consumer decision-making. The following section reviews work related to Elementary Information Processes (EIPs) that breaks down consumer decision-making process into elementary cognitive analyses.

7.2.2 Elementary Information Processes

Several researchers proposed a way to compare decision-making processes in terms of effort metric [59], [112], [113]. The idea was to decompose a decision-making process into well-defined and calculable smaller cognitive activities. This way of modeling assumed that consumers followed certain rules or heuristics in solving decision problems. Even though in reality consumers are very dynamic and their decision-making processes are contingent on different situational factors, decomposing the decision-making process into smaller cognitive activities and the underlying reasons helps to provide an approximation of how much mental effort is spent in the decision-making process.

Various researchers proposed to decompose the decision-making process using a set of mental activities related to information processing called Elementary Information Processes (EIPs) [59], [114], [115]. Every decision-making process could be composed from a specific collection and sequence of EIPs. In their research, it was found that different EIPs followed standard times. Different EIPs and their corresponding times are tabulated in table 7.1.

Table 7.1 EIP times based on Bettman et al., 1990

EIPs	Activity	Time (seconds)
READ	Read an attribute level into short term memory	1.19
ADD	Add two attribute level values	0.84
MULTIPLY	Weight one value with another	2.23
COMPARE	Compare two attribute levels or two information values	0.09
ELIMINATE	Remove attribute level (s) from consideration	1.8
SUBSTRACT	Calculate size of difference between two attribute levels	0.32
MOVE	Go to next attribute level	-
CHOOSE	Announce preferred alternative and stop process	-

Time to read a piece of information combined encoding of information with motor activity of moving mouse, ranging from 0.2 – 0.8 seconds [116], and eye fixation, estimated to require a minimum of 0.2 seconds [95]. In previous research, a piece of information here refers to a level within an attribute level that can be described using a single word, 1 or 2 digit numbers, but does not refer to long sentences or paragraph description regarding the information [3], [4], [59]. In our case, the information is either color, thumbnail picture that can be regarded as symbols. When reading color or symbol information, people will not evaluate that information in detail. Here it is assumed that the time to read those types of information is equivalent to time to read single word or numbers. Time to perform comparison was very short, and estimated to have collinearity with elimination, since the comparison of two or more choices was normally followed by elimination of choices.

7.2.3 Methodology of the Modeling

Consumer decision-making process is a process of comparing different attribute levels and alternatives. The comparison process can be viewed as binary decisions of eliminating choices to come to one final decision. However, the decision-making process involves more complex perception rather than just recognizing simple stimuli, as originally presented in Hick's experiment [111]. In decision-making process, other than differentiating simple stimuli, consumers also judge favorability of each attribute level, and use those levels as a basis of comparison and decision. To this extent, the notion of information theory is used as an approximation about how people compare available information before reaching a decision. By combining binary decision and Elementary Information Processes, mental effort and time to make decision can be estimated using mental effort and decision-making time of EIPs involved.

Decision-makings in product configuration and product selection involve a set of Elementary Information Processes (EIPs). In both situations, participants need to read information, either on attribute level or product alternative, compare attribute levels, and eliminate unwanted choices. As shown in chapter 6, participants employ different decision-making strategies in product configuration and product selection. In fact, each decision-making strategy consists of a set of EIPs. What differ a strategy from another strategy are the amount of each EIPs involved and the sequence of those EIPs. And the fact that there are differences in the number of EIP, difference in decision-making strategy infers different decision-making time.

Looking at this notion, the model is established by calculating different number of EIPs required in product configuration and product selection, then calculating decision-making time in both scenarios.

By understanding differences between product configuration and product selection processes, it provides knowledge for the product provider to help consumers find what they want in the shortest possible time and with less effort spent. The next section analyzes EIPs in product configuration and product selection and formulates mental effort and decision-making time accordingly.

7.3 Modeling Decision-Making Time in Product Configuration

The modeling of decision-making time in product configuration will be conducted by specifying decision-making strategies in product configuration, and the corresponding amount of mental effort in terms of number of EIPs required in performing those strategies. The strategies take account of participants reading attribute levels in each attribute as well as considering interaction among attributes. Participants may consider interaction among two, three, of four attributes together when evaluating the available choice. The decision-making time is calculated by summing up the time for each EIP. Predictions of decision-making time is then generated, and compared to decision-making time from experiments specified in chapter 4 of this thesis. An additional experiment is conducted in order to provide a validation for the proposed model.

7.3.1 Mental Effort required in Product Configuration

Chapter 6 of this study provides evidence of two different strategies employed by participants in product configuration process. The first one is that participants choose an attribute level then choose the second attribute level to match the first one, choose the third attribute level to match the chosen attribute levels, and so on. There is no iteration in between. The second strategy involves iteration in between. Participants go back and forth among attributes (e.g start from first attribute, second attribute, go back to first attribute, second, third, etc.).

In essence, decision-making strategies in product configuration can be further decomposed into two main activities. The first one is to choose the best attribute level within an attribute (e.g. best color, best shape). The second one is to match an attribute level with a previously chosen attribute level (e.g. match sleeve colors with previously chosen body color of a T-shirt).

As stated previously:

m = total number of attributes

n = total number of attribute levels in each attribute level

Evaluating an attribute to choose best attribute level

In order to evaluate and choose one of n attribute levels (e.g. choose a color from the list of blue, grey, crème, and white colors), the mental effort required is to read attribute level information, to compare attribute levels, and to eliminate unwanted attribute levels. The total amount of mental effort is formulated as follow:

- Total number of 'READ' $\propto$ n (Eq.7)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.8)
- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.9)

Interaction among attributes

When a participant decides on an attribute level in an attribute (e.g choose blue body color), the next attribute can be chosen to match the chosen attribute level (e.g.

choose sleeve color to best match blue body color). In other word, the participant considers interactions among different attributes. An example of matching between two attributes is shown in figure 7.1.

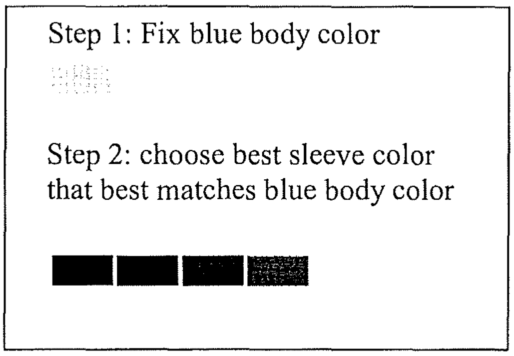

Figure 7.1 Interaction between two attributes

Mental efforts required in matching two attributes are:

- Total number of 'READ' $\propto 2*n$ (Eq.10)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.11)
- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.12)

Similar with conditions mentioned above, when the participant fixes m-1 attributes and considers interactions among m attributes, the formula become:

- Total number of 'READ' $\propto m*n$ (Eq.13)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.14)
- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.15)

Combining total mental efforts spent:

- Total number of 'READ' $\propto y_1 * n + y_2 * 2n + \ldots + y_m * m*n$

  Total number of 'READ' $\propto n\,(y_1 + 2\,y_2 + \ldots + m\,y_m)$ (Eq.16)

  y_i = number of times participants perform evaluation on i attribute(s), means that:

  y_1 = number of times participants perform evaluation on 1 attribute

  y_2 = number of times participants perform evaluation on 2 attributes (fix one attribute level and match the second attribute to the first attribute)

  y_m = number of times participants perform evaluation on m attributes (fix m-1 attribute levels and match the m^{th} attribute to the rest of chosen attributes)

- Total number of 'COMPARE' $\propto \sum_{i=1}^{m} y_i\,(\log_2(n))$ (Eq.17)

- Total number of 'ELIMINATE' $\propto \sum_{i=1}^{m} y_i\,(\log_2(n))$ (Eq.18)

7.3.2 Decision-making time required in Product Configuration

Previous research in Elementary Information Processes by Bettman *et al* (1990) provided estimation of EIP time of 'READ', 'COMPARE', and 'ELIMINATE' to be 1.19, 0.09, and 1.8 seconds respectively.

By substituting time estimation of EIPs, the time to make decision can be predicted.

Decision-making time $\propto T_{READ} + T_{COMPARE} + T_{ELIMINATE}$ (Eq.19)

Decision-making time $\propto$

$$1.19 * n\,(y_1 + 2y_2 + \ldots + m\,y_m) + 0.09 * \sum_{i=1}^{m} y_i\,(\log_2(n)) + 1.8 * \sum_{i=1}^{m} y_i\,(\log_2(n))$$

(Eq.20)

In the experiment of current study, participants were asked to configure a product while performing verbal protocol to verbally explain their thinking process. From verbal protocol and click track data, different ways of evaluating attribute levels and their corresponding interactions can be identified. Values of parameters y_i, can be found, indicating how many times participants performed evaluation on one attribute (y_1), two attributes (perform matching between 2 attributes) (y_2), etc. By recognizing different values of yi for different participants, inter-individual variability is acknowledged.

An example is illustrated below. A participant uses the first strategy in which she evaluates each attribute once, and matches the next attribute with the previously chosen attribute. The total time would be:

$$= 1.19 * n\,(y_1 + 2y_2 + \ldots + m\,y_m) + 0.09 * (\sum_{i=1}^{m} y_i(\log_2 n)) + 1.8 * (\sum_{i=1}^{m} y_i(\log_2 n))$$

$= 1.19 * 2\,(1 + 2 + 3 + 4) + 0.09 * 4*(\log_2 2) + 1.8 * 4*(\log_2 2)$

$= 31.36$ seconds

Since different participants compare and evaluate choices differently, individual variability can be represented using a distribution, and then compared with the time obtained from the experiment. In this case, the distribution used is normal distribution.

7.3.3 Matching with Experimental Result on Product Configuration

In order to match between decision-making time from the prediction and the experiment, the time for performing verbal protocol is separated and then the rest of the time will be regarded as decision-making time. The verbal protocol time slows down the decision-making process, since participants need to verbalize their thinking process. Video recording data shows that participants performed verbal protocol either independently or concurrent with actions of moving and clicking the mouse. Times for performing verbal protocol that happen independently are eliminated. It is assumed that those times only indicate participants provide justification of their thinking process or their actions, but not adding values to decision-making. Direct measurement using stopwatch was conducted in order to measure the length of each verbal protocol time.

The decision-making time for all participants is represented as a distribution before being compared with the time predicted using formulas above. Independent t-tests were performed and all tests ($t(47)$, $p > 0.1$) indicated that there are no differences between distributions obtained from prediction and experimental work. The comparisons are shown in table 7.2.

Table 7.2 Matching between predicted time and time obtained from T-shirt experimental results in product configuration

Conditions		Distribution obtained from prediction (time in seconds)	Distribution obtained from experiment (time in seconds)
16 products	1st strategy	NORM(34.7, 2.54)	NORM(37.9, 11.8)
	2nd strategy	NORM(55.5, 17.1)	NORM(64.8, 22.6)
256 products	1st strategy	NORM(56.3, 9.97)	NORM(67.9, 21.6)
	2nd strategy	NORM(104, 30.8)	NORM(114, 29.7)

Figure 7.2 illustrates the plot of decision-making time in product configuration with the conditions of 16 and 256 products as well as conditions in which participants employ the first or the second type of decision-making strategies. Decision-making time from prediction and experiment from each condition mentioned above are plotted and compared against each other.

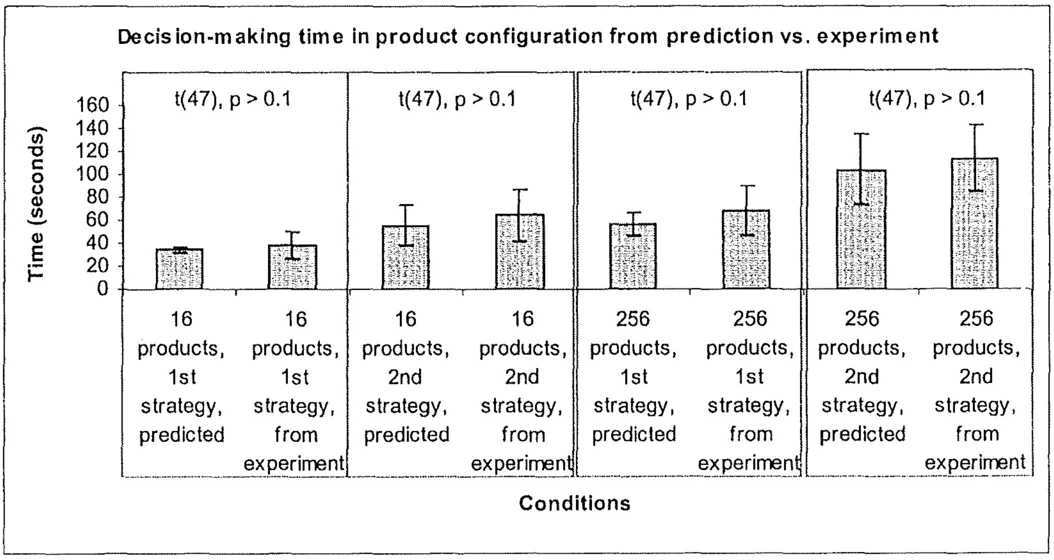

Figure 7.2 Decision-making time in product configuration

7.3.4 Model Validation in Product Configuration

The proposed model is further validated using an additional experiment investigating decision-making time in product configuration. The additional set of experiments presents higher numbers of products offered to the participants. There are six attributes with each attribute consists of six attribute levels, means that there are 46,656 possible products. Participants were asked to perform decision-making in product configuration, and decision-making time for each participant is recorded.

The idea of model validation is to use the model proposed above to calculate the range of decision-making time required for participants to perform product configuration on 6 attributes with 6 attribute levels each. This set of decision-making time is then compared to the set of decision-making time obtained from the experiment. If there is no significant difference between decision-making time from the model and from the experiment, it means that the model is successful.

Eight participants were asked to configure their own personal name card by choosing six different attributes: name card template, background color, image, and colors of three groups of text. A sample snapshot from the experimental experiment can be seen in figure 7.3. Experiment instruction for the name card can be found in appendix E and the experiment interface can be accessed via the following URL: http://143.89.20.102:8080/experiment1/

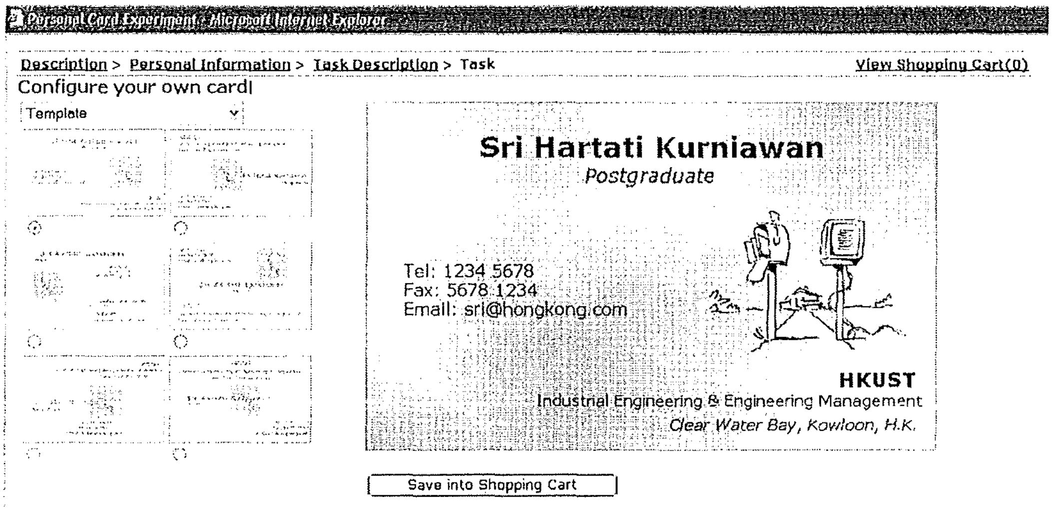

Figure 7.3 Experimental interface for configuring personal name card

The first step is to use equation 20 specified above to approximate the decision-making time in product configuration

Decision-making time in product configuration =

$$1.19 * n\,(y_1 + 2y_2 + \ldots + m\,y_m) + 0.09 * \sum_{i=1}^{m} y_i\,(\log_2(n)) + 1.8 * \sum_{i=1}^{m} y_i\,(\log_2(n))$$

In this case, the values of n and m can be substituted. Parameter n represents number of attribute levels, and parameter m represents number of attributes. Both n and m are equal to 6.

As mentioned previously, the values of y_i are for predicting decision-making time is obtained from experimental results. It serves as an initial estimation of how many times participants evaluate an attribute independently (y_1), evaluate 2 or more attribute together ($y_2, \ldots, y_m$). Therefore, the values of y_i need to be tested against another experiment in which values of y_i are not known.

The values of parameters y_i from the previous experiment are fitted into an equation in order to describe the values of y_i as function of i (y_i denotes how many attributes considered at a time). Data from the previous experiment with four attributes showed that values of yi followed the following equation:

$$y_i = 0.758 + 0.823\ i - 0.259\ i^2 + 0.0177\ i^3 \qquad \text{(Eq.21)}$$

This equation, when plotted, shows a positively skewed bell curved distribution with a longer tail in the right side of the curve. This indicates that participants mostly considered one attribute independently and two attributes together. As the number of attributes increases, participants evaluate 3 or more attributes together less frequently.

Based on the equation mentioned above, first y_i values are generated in order to provide prediction of decision-making time. Results from prediction are compared with decision-making time obtained from experiment. Independent t-test statistics show no difference between decision-making time obtained from experiment and theoretical prediction ($t(47)$, $p > 0.1$) with both following normal distributions. The parameters of distribution from experiment and theoretical prediction are NORM (154, 40.2) and NORM (151, 47.5) consecutively. Figure 7.4 illustrates the plot of decision-making time model validation in product configuration.

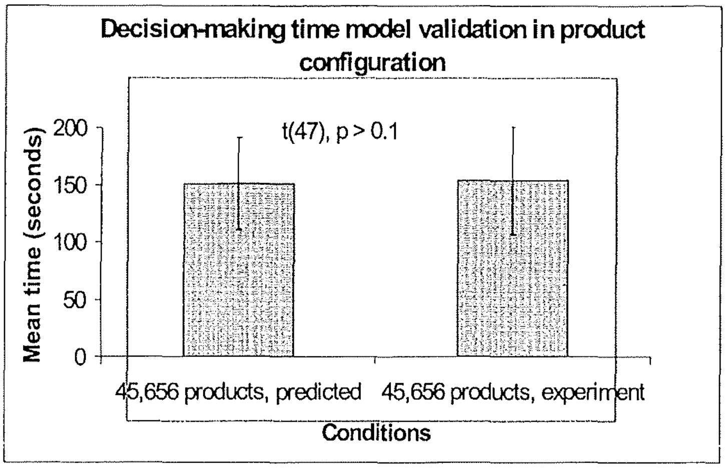

Figure 7.4 Decision-making time model validation in product configuration

Figures 7.2 and 7.4 provide an observation about the relationship between decision-making time and number of product offered. It can be seen that in product configuration, decision-making time does not have a linear relationship with the number of product alternative offered.

However it can be seen that decision-making time has a linear relationship with the number of decision unit. The experiment from current study offers 16 and 256 product alternatives. There are four different attributes. In the condition of 16 products, each attribute consists of two attribute levels, while in the condition of 256 products, each attribute consists of four attribute levels. According to equation 2, the number of choices for the conditions of 16 and 256 products are 8 and 16. From table 7.2, it can be seen that the decision-making time for the condition of 256 products is approximately two times longer as compared with the condition of 16 products. When extended using a set of experiments offering 6 attributes and 6 attribute levels, the decision-making time show a linear trend as the function of number of choices. This is illustrated by figure 7.5.

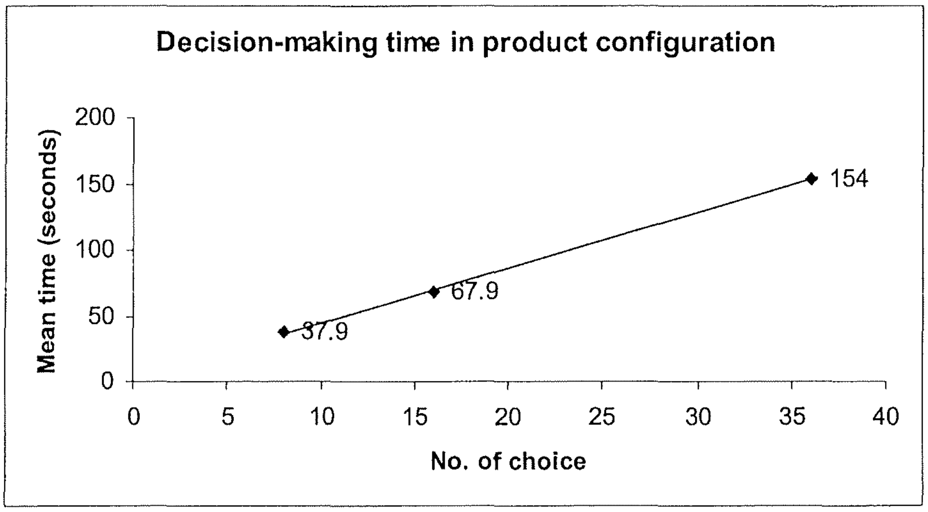

Figure 7.5 Trend of decision-making time in product configuration

7.4 Modeling Decision-making time in Product Selection

Similar as the modeling conducted for product configuration, the modeling of decision-making time in product selection will be conducted by specifying decision-making strategies in product selection, and the corresponding amount of mental effort in terms of number of EIPs required in performing those strategies. The decision-making time is calculated by summing up the time for each EIP. Predictions of decision-making time is then generated, and compared to decision-making time from experiments specified in chapter 4 of this thesis. An additional experiment is conducted in order to provide a validation for the proposed model.

In product selection, formulation of decision-making time is different from product configuration because of two reasons. The first one is that the notion of product alternatives carries a different size of information, as compared to attribute level in product configuration. As a comparison, figure 7.6 below shows one decision unit in product configuration (in terms of attribute level) versus one decision unit in product selection (in terms of product alternative). Research in consumer decision-making assumes that the amount of information carried in product alternative is m times greater than information carried in attribute level, with m being the number of attributes.

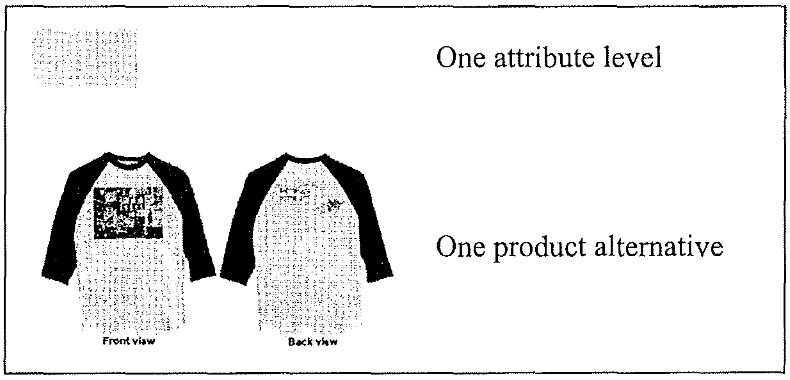

Figure 7.6 Comparison between an attribute level and a product alternative

The second reason is that in product selection, all possible products can be displayed on a single web site. The display manner facilitates consumers to browse through all product alternatives before engaging in decision-making process of comparing, and selecting one best alternative. While in product configuration, in order to see all possible products, consumers have to construct them by choosing and combining attribute levels from different attributes.

7.4.1 Mental Effort required in Product Selection

Findings from the experiment of current study suggested that when performing decision-making in product selection, participants perform at least three different activities. The first one is to browse available choices and to learn which ones available for them to choose. The second one is to eliminate unwanted choices, normally using non-compensatory strategy. The third one is to carefully examine the best alternative among remaining alternatives, normally using compensatory strategy, when the number of remaining alternatives becomes manageable.

Browsing activity

Browsing can be defined as an exploratory, information seeking strategy that depends upon serendipity. It is especially appropriate for ill-defined problems and for exploring new task domains [117]. In the context of consumer decision-making, consumers perform browsing because they are not familiar with which ones available for them to choose. Therefore they would like to know the range of attributes and corresponding attribute levels they can choose from. In performing browsing, it seems that consumers look at a large amount of information, however, they may not remember it all, and observe it in a random manner. Measurements of browsing time were conducted using stopwatch. Since browsing time varied from participant to participant, it is excluded from our decision-making time calculation.

Using non-compensatory decision-making rule

Non-compensatory decision-making rule is in essence a comparison of alternatives in an attribute and elimination of unwanted alternatives possessing undesirable attribute levels. If there are too many alternatives remaining consumers continue to compare the rest of alternatives in another attribute and keep eliminating alternatives until the number of alternatives is manageable enough to be compared extensively.

A simple non-compensatory decision-making rule that is commonly used is Lexicographic [23]. Using a Lexicographic rule, a consumer compares different alternatives starting from the most important attribute, chooses the most attractive attribute level and eliminates all alternatives that do not posses the most attractive attribute level. If more than one alternative remains, the consumer will proceed to the second most important, and compare the rest of alternatives in a similar manner. The sequence of comparison can also be based on sequence of display.

As an example, a consumer starts with body color, chooses the most attractive color, such as blue , then eliminates all T-shirts having body colors other than blue. If more than one alternative remains, the consumer evaluates remaining alternatives by examining sleeve colors, chooses the most attractive sleeve color, such as black, and eliminates all alternatives having sleeve color other than black.

With each attribute having n levels, to perform a Lexicographic rule on an attribute requires a mental effort of 'READ', 'COMPARE' and 'ELIMINATE'.

- Total number of 'READ' $\propto n$ (Eq.22)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.23)
- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.24)

So, total mental effort spent in Lexicographic rule involving p attributes:

Total mental effort of 'READ' $\propto p*n$ (Eq.25)

Total mental effort of 'COMPARE' $\propto p * \log_2 n$ (Eq.26)

Total mental effort of 'ELIMINATE' $\propto p* \log_2 n$ (Eq.27)

Using compensatory decision-making rule

Compensatory decision-making rule is in essence comparison of alternatives by evaluating each alternative as a whole, and compensating bad features of an alternative using good features of it. Participants normally form an overall impression of each product alternative then compare them to each other.

To perform compensatory strategy on x number of product alternatives, the mental effort required are as follows:

- Total number of 'READ' $\propto x*m$ (Eq.28)
- Total number of 'ADD' $\propto x\ (m-1)$ (Eq.29)
- Total number of 'COMPARE' $\propto \log_2 x$ (Eq.30)
- Total number of 'ELIMINATE' $\propto \log_2 x$ (Eq.31)

7.4.2 Decision-making time required in Product Selection

Time to perform product selection can be specified as:

Decision-making time $\propto z_1 * T_{NON\text{-}COMPENSATORY} + z_2 * T_{COMPENSATORY}$ (Eq.32)

z_1 = number of times participants perform non-compensatory strategy

z_2 = number of times participants perform compensatory strategy

While $T_{NON\text{-}COMPENSATORY} \propto T_{READ} + T_{COMPARE} + T_{ELIMINATE}$

$T_{NON\text{-}COMPENSATORY} \propto 1.19\ (p*n) + 0.09\ (p * (\log_2 n)) + 1.8\ ((p* \log_2 n))$ (Eq.33)

And $T_{COMPENSATORY} \propto T_{READ} + T_{ADD} + T_{COMPARE} + T_{ELIMINATE}$

$T_{COMPENSATORY} \propto 1.19\ (x*m) + 0.84\ (x\ (m-1)) + 0.09\ (\log_2 x) + 1.8\ (\log_2 x)$ (Eq.34)

7.4.3 Matching with Experimental Result on Product Selection

From the verbal protocol and observation data, different ways of evaluating attribute levels and alternatives can be identified. From experimental data, values of parameters z_i can be found, indicating how many times participants perform non-compensatory strategy (z_1), compensatory strategy on 2 attributes (z_2), and compensatory strategy on 4 attributes (z_3).

For example, for number of products = 16, if a participant performs non-compensatory on three attributes and compensatory on two alternatives, then the total time needed is:

$$
\begin{aligned}
T_{NON\text{-}COMPENSATORY} &= 1.19\ (p*n) + 0.09\ (p * (\log_2 n)) + 1.8\ (p*(\log_2 n)) \\
&= 1.19\ (3*n) + 0.09\ (3 * (\log_2 n)) + 1.8\ (3* (\log_2 n)) \\
&= 1.19\ (3*2) + 0.09\ (3 * 1) + 1.8\ (3* 1) \\
&= 1.19\ (3*2) + 0.09\ (3 * 1) + 1.8\ (3* 1) \\
&= 12.81 \text{ seconds}
\end{aligned}
$$

$$
\begin{aligned}
T_{COMPENSATORY} &= T_{READ} + T_{ADD} + T_{COMPARE} + T_{ELIMINATE} \\
&= 1.19\ (x*m) + 0.84\ (x\ (m-1)) + 0.09\ (\log_2 x) + 1.8\ (\log_2 x) \\
&= 1.19\ (2*m) + 0.84\ (2\ (m-1)) + 0.09\ (\log_2 2) + 1.8\ (\log_2 2) \\
&= 1.19\ (2*4) + 0.84\ (2 *3) + 0.09 + 1.8 \\
&= 1.19\ (2*4) + 0.84\ (2*3) + 0.09 + 1.8 \\
&= 16.45 \text{ seconds}
\end{aligned}
$$

Time to make decision = 29.26 seconds

Similarly, by recognizing individual differences, the predicted time can be represented using certain distribution functions. The data is observed to follow normal distribution.

In order to match the predicted time with experimental results, time for performing verbal protocol and time to perform browsing are separated. Then the rest of the time is matched with the time predicted using formulas above. Independent t-tests indicated no significant difference in distributions obtained from prediction and experimental work ($t(47, p > 0.1)$). The comparisons are shown in table 7.3.

Table 7.3 Matching between predicted time and time obtained from T-shirt experimental results in product selection

Conditions	Distribution obtained from prediction	Distribution obtained from experiment
16 products	NORM(50.1, 14.7)	NORM(55, 18.4)
256 products	NORM(74.6, 20.2)	NORM(82.5, 30.5)

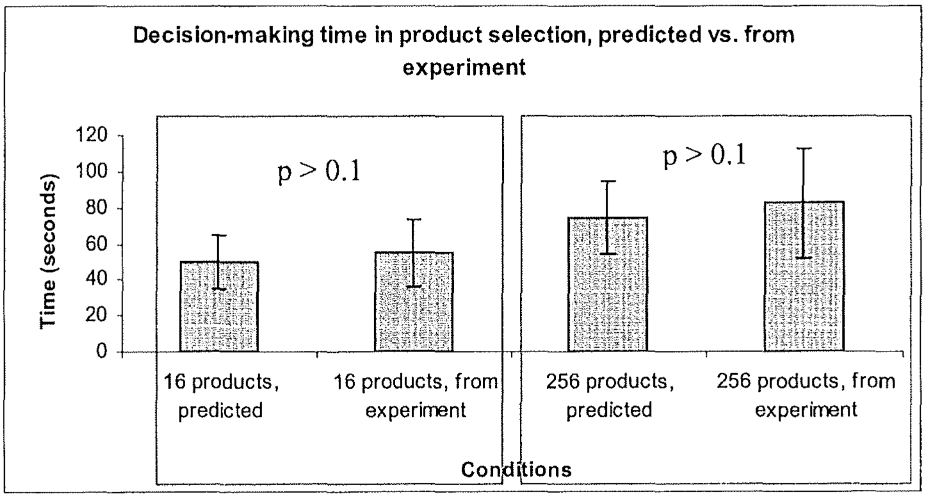

Figure 7.7 Decision-making time in product selection

7.4.4 Model Validation in Product Selection

The proposed model is further validated using an experiment investigating decision-making time in product selection. Similar with the validation process in product configuration, the idea is to use the model to calculate decision-making time, and then compare decision-making time from the model with decision-making time from the additional set of experiments. This experiment is the same experiment used for product configuration model validation. This experiment also presents different number of product offered.

Eight participants were asked to select their own personal name card by choosing one out of 46,656 (6^6) name cards. These name cards consist of all possible combinations of six different attributes: name card template, background color, image, and colors of three groups of text with each attribute consists of six attribute levels. A snapshot of interface in selecting name card can be seen in figure 7.8. Experiment instruction for the name card can be found in appendix E and the experiment interface can be accessed via the following URL: http://143.89.20.102:8080/experiment1/

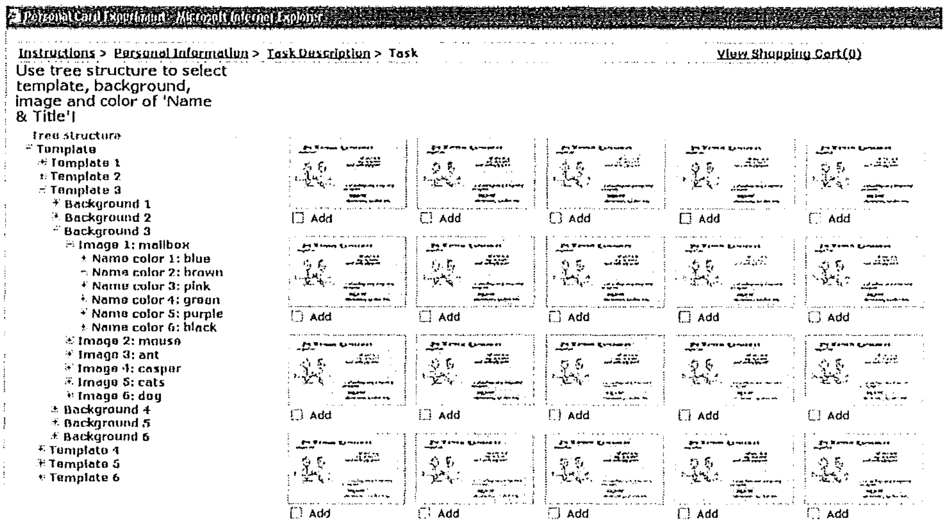

Figure 7.8 Experimental interface for selecting a personal name card

The first step is to use equations from the model to predict the decision-making time.

Decision-making time $\propto z_1 * T_{NON\text{-}COMPENSATORY} + z_2 * T_{COMPENSATORY}$ (Eq.32)

$T_{NON\text{-}COMPENSATORY} \propto 1.19\ (p*n) + 0.09\ (p * (\log_2 n)) + 1.8\ ((p* \log_2 n))$ (Eq.33)

$T_{COMPENSATORY} \propto 1.19\ (x*m) + 0.84\ (x\ (m-1)) + 0.09\ (\log_2 x) + 1.8\ (\log_2 x)$ (Eq.34)

As mentioned previously, the values of z_i are for predicting decision-making time is obtained from experimental results. It serves as an initial estimation of how many times participants use compensatory and non-compensatory strategies Therefore, the values of z_i need to be tested against another experiment in which those values are not known.

The second step is to find the values of parameters z_i from the previous experiment, and to fit them in the equations to calculate decision-making time. Zi values indicate how many times participants performed non-compensatory and compensatory strategies. These values are used to provide prediction of decision-making time. Then the parameters p, x, and m are substituted. Figure 7.8 shows that there are 6 attributes, means that m is equal to 6. The parameter p represents number of attributes in which participants use non-compensatory Lexicographic rule. From previous findings, p is equal to m-1. The parameter x represents the number of product alternative evaluated using compensatory strategy. Previous findings also indicated that x is either equal to 2 or 4.

Next, predictions of decision-making time are compared with decision-making time from experiment. Independent t-tests showed no difference between decision-making time obtained from experiment and theoretical prediction ($t(47)$, $p > 0.1$) with both following normal distributions. The parameters of distribution from experiment and theoretical prediction are NORM (233, 63.6) and NORM (209, 20.6) consecutively. Decision-making time model validation in product selection is plotted in figure 7.9.

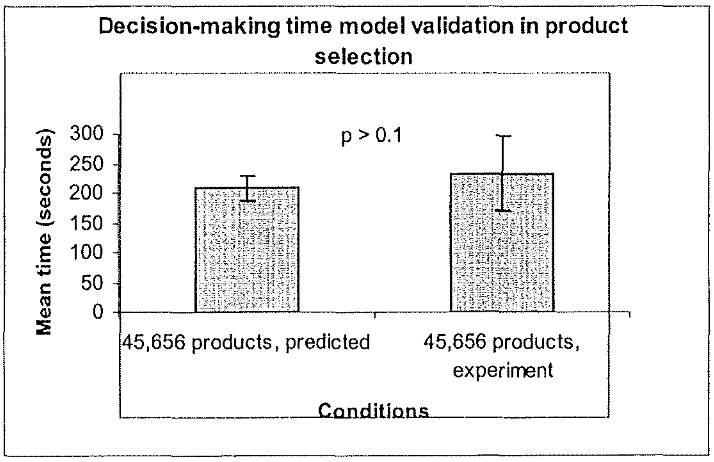

Figure 7.9 Decision-making time model validation in product selection

From figures 7.7 and 7.9 it is showed that decision-making time does not have a linear relationship with the number of product offered. Previous research shows that as the number of product increases, the time needed to make a decision will also increase until participants reach a threshold in which they decide to stop taking and processing information. After the threshold point, increasing the number of product will not increase decision-making time. It is simply because participants will stop taking and processing information [28]. Using this additional set of experiments, it is showed that the decision-making time as a function of number of choices follows a phenomenon mentioned above. The trend is showed in figure 7.10.

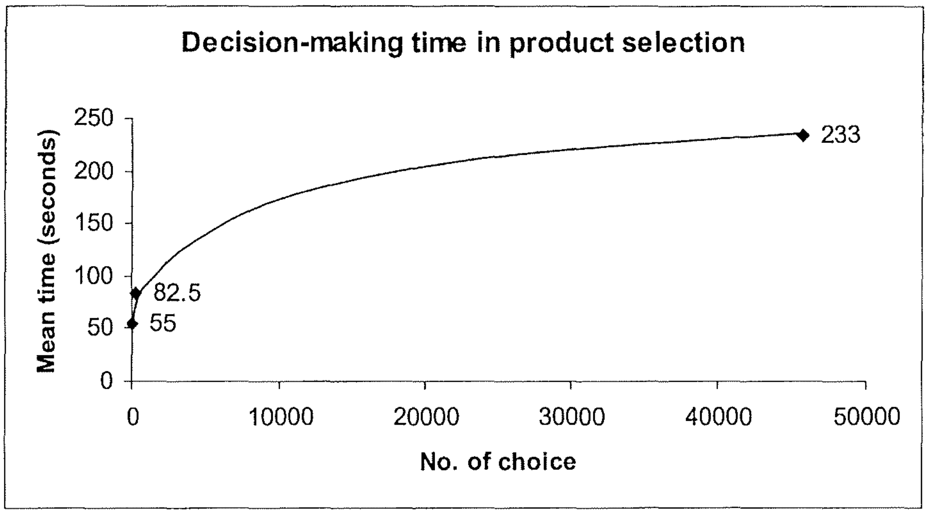

Figure 7.10 Trend of decision-making time in product selection

7.5 Summary

Based on predictions and validation above, it can be concluded that time to make a decision can be predicted by understanding how participants compare information in terms of attribute level and product alternatives in product configuration and product selection. Analyses of decision-making processes are performed using a set of measurable and calculable mental operations such as reading, comparing, and eliminating information. The way consumers compare choices can be approximated from Information Theory, in which consumers attempt to reduce uncertainty by performing binary comparisons among choices available.

This study finds that product configuration provides greater satisfaction with process and decision rather than product selection. Further examination shows that shopping method and choice representation contribute to the satisfaction mentioned above. Later study demonstrates that participants use different decision-making strategies in product configuration and product selection. The idea that different decision-making strategies require different amount of mental efforts seems obvious. In performing product configuration, participants use a strategy similar to pure Lexicographic, in which they choose alternatives that posses best attribute levels in each attribute, ignoring much of the potentially less attractive alternatives. In product selection process, participants use multi-strategy non-compensatory and compensatory strategies. Compensatory strategy requires participants to process all relevant decision information. Thus, there appear to be clear differences between product configuration and product selection in the amount of information evaluated and decision-making time. The strategy used in different tasks is in turns become a main course of decision-making time reduction. Participants save time because they only need to review less amount of information by evaluating attributes and attribute levels independent of product alternatives in product configuration compared to product selection.

CHAPTER 8

CONCLUSIONS AND FUTURE WORK

8.1 Summary of findings

8.1.1 Experimental findings related to decision quality

Product configuration provides greater satisfaction with decision and process, and also helps participants to find a product closer to their expectation prior to buying, with fewer products evaluated, when compared with product selection.

Both choice representation by attribute and shopping method by configuration contribute to the favorability of product configuration over product selection. Participants experience greater satisfaction with process and evaluate fewer numbers of products when evaluating choices represented by attribute rather than by alternative. Shopping method by configuration provides greater satisfaction with decision and process, guides participants to find a product according to their expectation prior to buying with fewer products evaluated, than does shopping method by selection.

8.1.2 Experimental findings related to decision-making strategy

Product configuration in which choice is represented by attribute enables participants to choose attributes and attribute levels independently. Accordingly, participants adjust their decision-making strategies in choosing attributes and attribute levels without the need to evaluate a great number of product alternatives. Participants do not need to make trade-offs and compensate attribute levels they like with other attribute levels they dislike. Most participants evaluate each attribute once, select the best attribute level, and use those selected attribute levels as anchors to select other attribute levels. The rest go back and forth among attributes until they find a product they like best.

Using product configuration, participants will need more imagination and creativity in order to come up with a combination of attributes. Participants can perform trial and error by performing back and forth strategies mentioned above. In product configuration, combination of chosen attributes is displayed in a visualizator. Only one product is displayed at a time. With this condition, participants need to memorize previously configured products if they want to compare with the current product displayed in the visualizator.

On the other hand, product selection presents a large number of product alternatives to participants. This condition brings two implications. First, participants need to browse around to understand the range of offering. Secondly, due to the large amount of information involved, participants need to screen out unwanted product alternatives in order to reduce their mental workload in evaluating product alternatives. When the number of product alternatives is manageable, participants compare several product alternatives in a more detailed manner and perform compensatory decision-making rules.

8.1.3 Findings related to modeling of decision-making time

This thesis proposes a model of decision-making time using the notion of Information Theory and Elementary Information Processes. The tenet of this model is that consumer decision-making can be modeled as a series of binary decisions in reducing the number of choices in order to reduce the task complexity. Each step of reducing the number of choices follows a series of Elementary Information Processes (EIPs) such as 'READ', 'COMPARE', and 'ELIMINATE', with each EIP following a standard time found in previous research [59]. Although there are various ways to compare product alternatives or attributes, the time to compare those options can be approximated by the time to perform uncertainty reduction.

The model successfully predicts decision-making time as a function of number of attributes and number of attribute levels offered by the product provider. By injecting the knowledge of decision-making strategies found in this study, consumer decision-making time in product selection and product configuration can be predicted. Furthermore, the model is tested against an additional experiment, and shows that the model can predict decision-making time with a greater number of products offered.

It is demonstrated that decision-making time in product configuration follows a linear relationship with the number of choices (i.e. the number of attributes and attribute levels offered). Product configuration enables presentation of a minimum amount of information and allows participants to process and evaluate all choices. Meanwhile in product selection, due to the great amount of information presented, participants decide to stop taking and processing information after they reach a certain threshold. Therefore, after the threshold, increasing the number of product alternatives will not increase the decision-making time.

8.2 Conclusions and Implications of the study

Today, product providers attempt to stay competitive by proliferating the number of SKU's offered. This brings benefits by increasing the possibility of consumers finding the product they like, and will capture a larger market share. At the same time, the proliferation also brings drawbacks for consumers who are confused with too many product alternatives presented to them, simply because they have limited cognitive capacity and are unable to process a potentially vast amount of information related to product alternatives offered. Therefore, a new shopping method allowing consumers to explore as many product alternatives as they want, using a minimum amount of information will be advantageous.

Results from this thesis demonstrate that product configuration provides advantages over product selection by offering greater satisfaction with decision and process, greater enjoyment, less perceived process and choice complexity, and guiding consumers to find their desired product with less effort. These advantages, besides being attributed to the shopping method that allows consumers to have a freedom in designing their own products, are also attributed to the choice representation by attribute that minimizes the amount of information needed to be evaluated by consumers.

Product configuration brings benefit for both product provider and consumers. When product providers represent choice by attribute, they are able to organize information with the least amount of information needed. They are also able to represent and communicate their capability to inform consumers on what are the possibilities for them to choose. Consumers are able to make an informed choice, learn about their preferences, and express their choices to the product providers. Configuration shopping induces consumers' enthusiasm, involvement and enjoyment of being able to 'design' their own products via a two-way interaction between consumers and product providers.

In product configuration, consumers focus on evaluating attributes and their levels in order to find a best match among attribute levels. This type of strategy facilitates consumers' learning about their within attribute preferences and avoid consumers making trade-offs. Significant correlations between decision-making strategies and decision quality have been found. The use of decision-making strategies in product configuration is in turn inducing greater satisfaction and lower perceived choice complexity.

In summary, this thesis provides answers to research questions posted previously. Measurements of decision quality in product configuration are conducted, in comparison with decision quality in product selection. Moreover, various factors influencing the decision quality are also explored. This thesis also examines decision-making strategies in product configuration and seeks the relationship between these strategies with decision quality. A model predicting decision-making time is provided.

Findings from experiments offer a perspective on a new way of offering product alternatives to consumers via product configuration, and how the new way will affect consumers' satisfaction with decision and process, and help consumers find their desired product with less effort spent. This perspective is especially useful for marketers and product providers when they want to design how their products or services are offered to their consumers.

While some benefits of product configuration is made obvious by direct measurements of consumers' satisfaction and perception, there is a potential for huge advantages offered by product configuration. The current trend of reversed economy has brought consumers to the center stage of product design, production, and marketing activities. Consumers' knowledge and easy access to huge number of products and their related information have created different consumers' attitude towards shopping. Today, consumers would like to quote and vote for their preferences and even place their own ideas by designing their own unique individual products. As a consequence, product providers are no longer designing products, manufacturing them, and offering them to consumers. The whole process has been reversed. Consumers design the product, buy it, and send the order to be manufactured.

This process is in turn bringing positive implications for both product providers and consumers. Product providers can avoid making wrong products that no consumers want thus avoiding scraps and price markdown. Instead the productions are initiated on demand. Besides getting the products the way they want it, consumers also experience enjoyment, a sense of involvement and pride of authorship in designing their own product.

The notion of design-by-end-consumers, accompanied with the advantages for product provider and consumers that have not been possible before, can now be facilitated by product configuration.

8.3 Contributions of this Thesis

This thesis provides contributions both to academia and potential industry applications. In academia, it provides contributions in several ways:

- It pioneers research in comparing product configuration and product selection in terms of decision quality, decision-making strategy, and decision-making time, with statistically verified results.
- It provides a model to predict the range of decision-making times in product configuration and product selection processes as functions of number of attributes and number of attribute levels. This model breaks decision-making strategies into more fundamental Elementary Information Processes (EIPs) and uses standard times of those EIPs to predict decision-making time.

This thesis also yields potential applications in industry:

- This research provides evidence of advantages of product configuration over product selection in terms of consumer decision-making process and decision quality.
- Findings related to this study can help product providers as a guideline for redesigning their Web stores. Using results of this study, it is suggested that the product provider should present the choice offered to consumers by attribute in order to reduce perceived choice complexity, and reduce the number of choices which need to be evaluated by consumers to achieve satisfaction with the process. Product providers also should use configuration shopping method in order to provide greater enjoyment and sense of involvement, which in the end will lead to consumers' satisfaction with process and decision.
- Results from this study shows consumers' preference of product configuration over product selection, given the same type of product offered to them. With the findings above, it is desirable to design products to be modular and configurable. Products that possess characteristics to facilitate mix and match among attribute levels are desirable in order to facilitate product configuration, which will lead to better decision quality.
- Prediction regarding decision-making time helps product provider to estimate the range of decision-making time as a function of number of

attributes and attribute levels without the need of conducting experiments.

8.4 Limitations of this Thesis

Three important boundary conditions with respect to this thesis should be made explicit. First, this study focuses on aesthetic attributes without price consideration rather than on functional attributes of a product. Results and conclusions of this study should not be extended to the latter. Each attribute in functional products is highly correlated with price; for example, the higher the memory capacity of a personal computer, the higher is the price. In the case of functional attributes, decision on each attribute is made based on the willingness to pay, but less on interactions among attributes. In the case of aesthetic attributes, consumers put more focus on interactions among attributes according to personal taste and preferences. This difference may influence consumer decision-making. In reality, price has a big influence in decision-making. Therefore, it is desirable to also include the price influence as a future study.

Secondly, if the decision-making process requires consumers' technical understanding of the product, the results and conclusions of this thesis may not apply. This is because the variation of the levels of knowledge among different consumers can potentially overwhelm the effect of varying shopping method and choice representation in product configuration and product selection processes.

Thirdly, the findings of this thesis do not pertain to decision-making with the help of interactive decision aids, intelligent filtering software, or the presence of a sales person. These types of decision aids and sales agents may alter one's decision-making process by eliminating the browsing or initial evaluation process by directly screening out undesired products or attributes. The effects of software recommendation and persuasion from sales agents towards consumer decision-making should be investigated for future research.

8.5 Recommended areas for future research

What lies ahead of this study appears to be interesting fields to be explored. While the present thesis provides insights into the effect of product configuration towards decision quality and decision-making strategy, further research is desirable.
This study can be further extended in several directions. Given the well-established field of consumer decision-making, it is interesting to investigate various factors that have been shown to have an effect on the conventional consumer decision-making studies. Some of the factors are task complexity and personal / individual factors.

Task complexity refers to the number of product alternatives and number of attributes offered to consumers. In product configuration, consumers make decisions on attributes and attribute levels; therefore it is desirable to study effects of varying number of attributes and attribute levels on decision quality and decision-making strategies in product configuration. Given that humans have a limited cognitive capacity, it would be interesting to find out whether consumers will focus more on attribute or attribute levels.

To date, the effect of personal and individual factors on product configuration is unknown. It remains a question whether product configuration is able to provide greater satisfaction and enjoyment for a specific group of consumers having a special personality trait compared to other traits. This study will bring a large contribution to the study of consumer decision-making in product configuration. This study can be performed by employing known questionnaires to categorize people based on different personality traits, for example analytic versus holistic, and then investigate their attitudes toward product configuration.

This thesis finds that participants are able to capture the benefits of product configuration over product selection. Participants find configuring products to be enjoyable and not difficult, whereas they show a trend towards mass-confusion using product selection. Effects of different levels of knowledge have not been investigated in product configuration. As consumers grow more experienced with product configuration, it is hypothesized that the difference between product configuration and product selection will become bigger and bigger.

Von Hippel argues that as consumers get more experience and knowledgeable about a product design, they would prefer to design the product by themselves rather than take other people's design [118]. Similarly, in this case, as consumers get more experienced with product configuration, the findings of this study may be accentuated.

It is also desirable to extend this study to investigate consumer decision-making with different types of products, especially products having functional related attributes like personal computers and consumer electronic products, in order to further confirm whether findings of this study also apply to different types of products. In essence, this is an extension of decision-making in which the final decision not only involves one product or one service, but many of them. It is hypothesized that there are other variables that may influence consumer decision-making in a bundle of products and service, such as evaluation of each product, interaction among products, conflicts among products, etc. This thesis provides an initial proposition that bundling of products or services can be better offered using configuration rather than selection method.

Some other factors which appear to contribute to the success of Web-stores in general are also worth consideration. Web design and usability have received growing attention because they contribute to the success of E-commerce. Web design and usability may interact with shopping method and choice representation in increasing or decreasing decision quality.

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APPENDIX A

ANALYSES ON THE DECISION QUALITY AND CONSUMER PERCEPTION

A. 1. Plots

The following figures present various items of decision quality and consumer perception as functions of number of products offered, shopping method, choice representation, and gender.

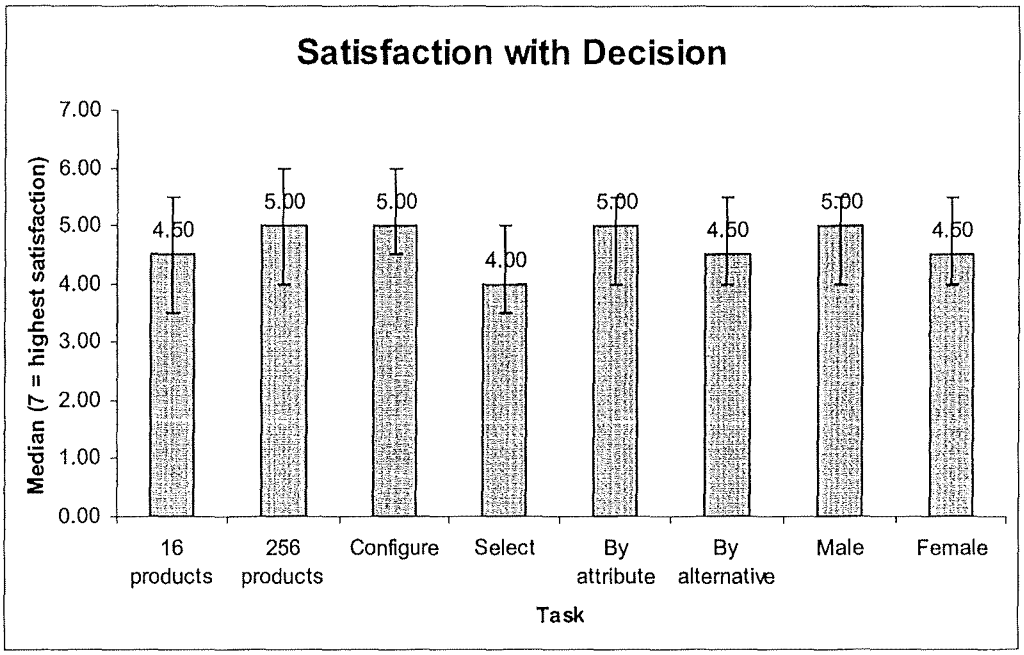


Figure A.1 Satisfaction with decision made

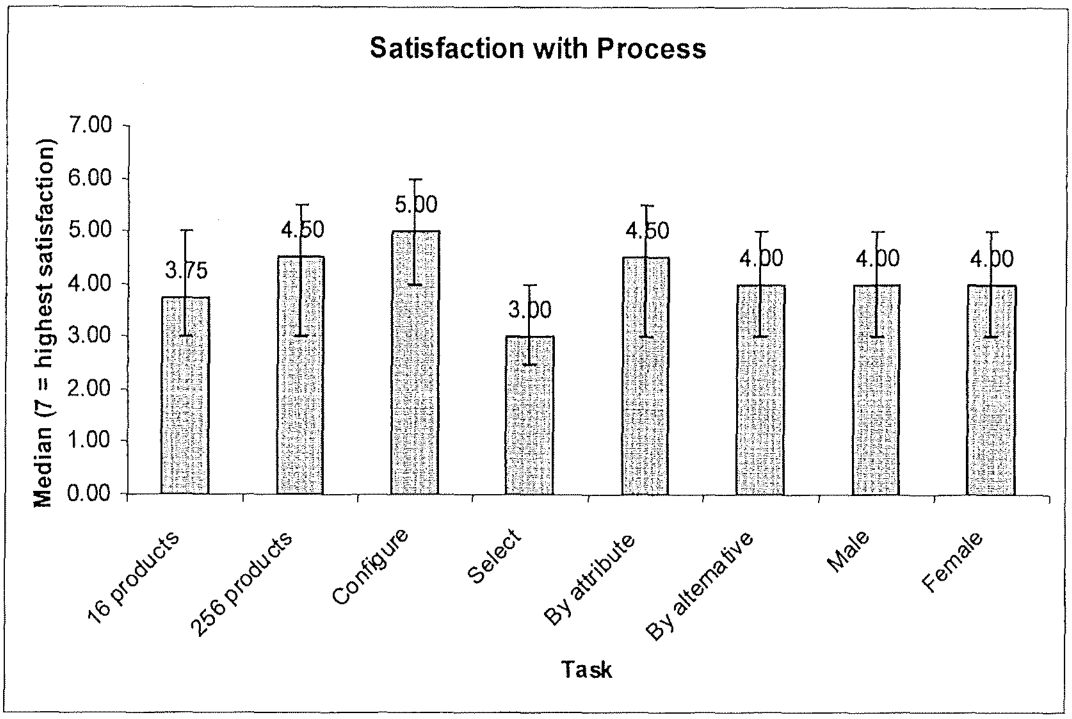


Figure A.2 Satisfaction with process

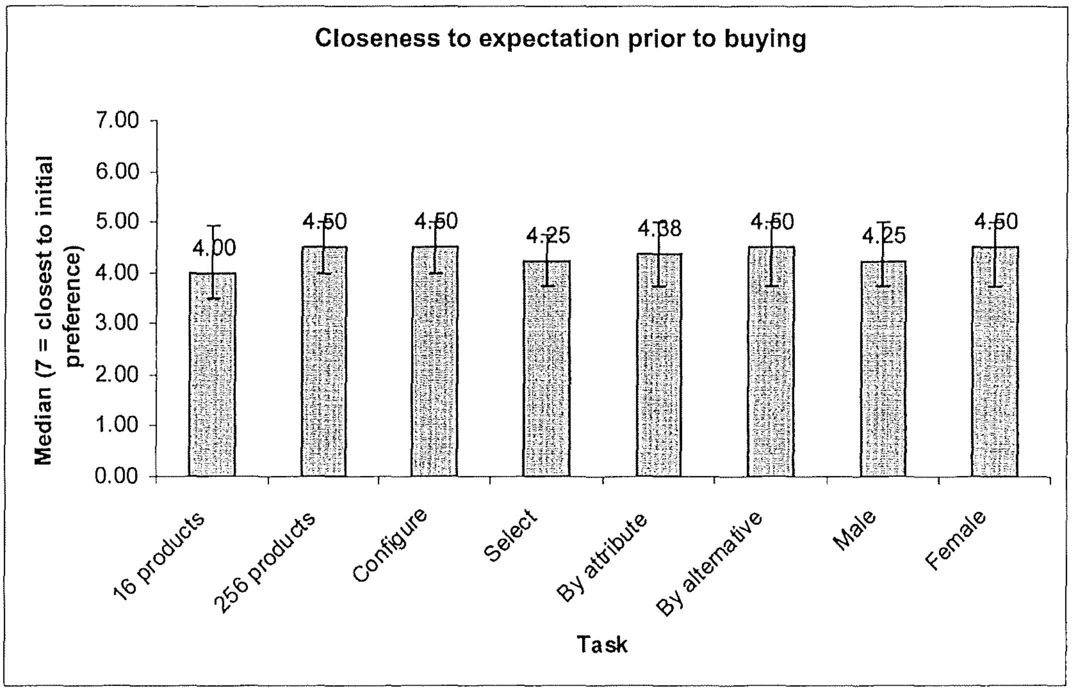


Figure A.3 Closeness to expectation prior to buying

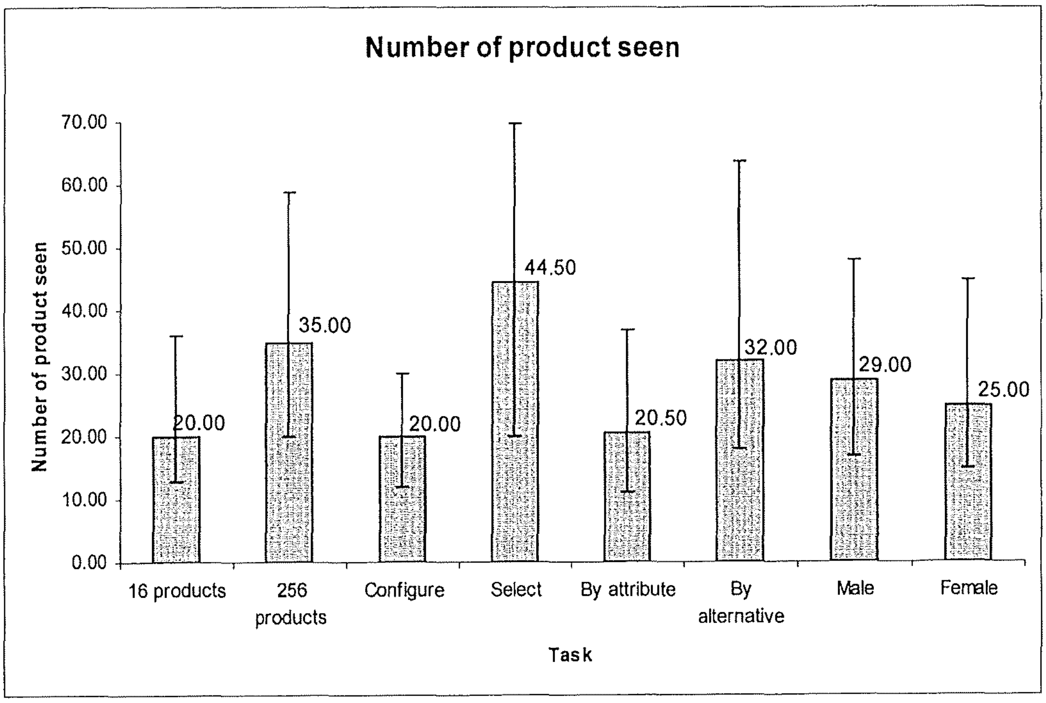


Figure A.4 Number of products seen

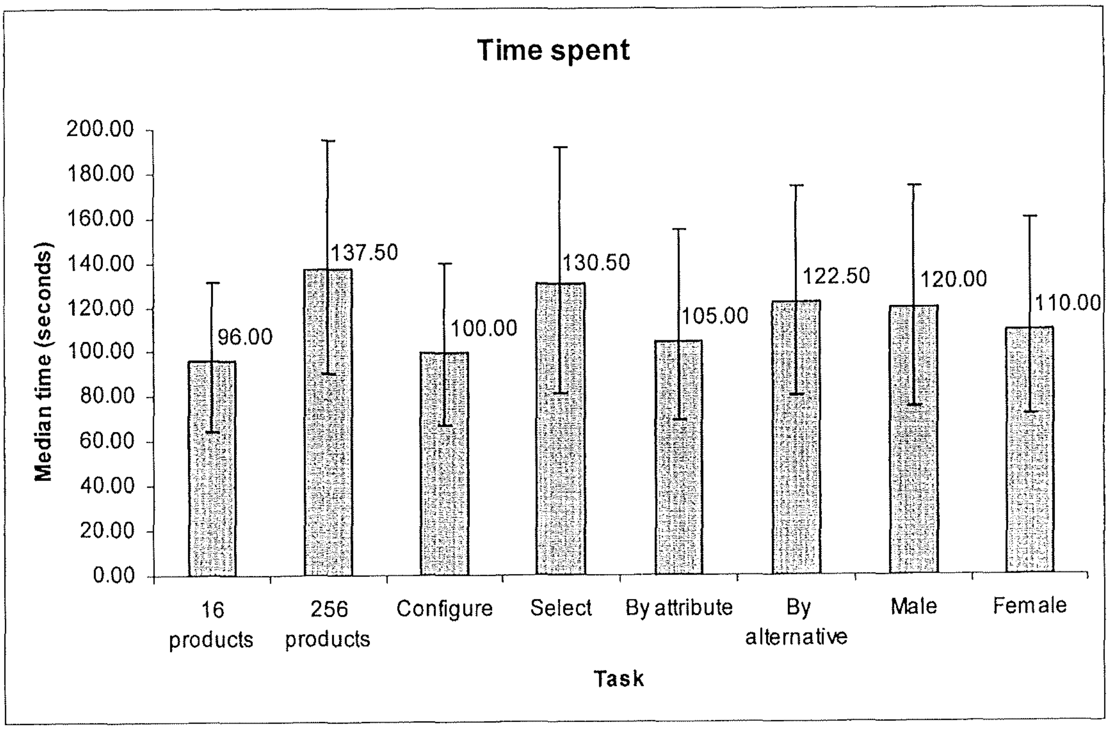


Figure A.5 Time spent

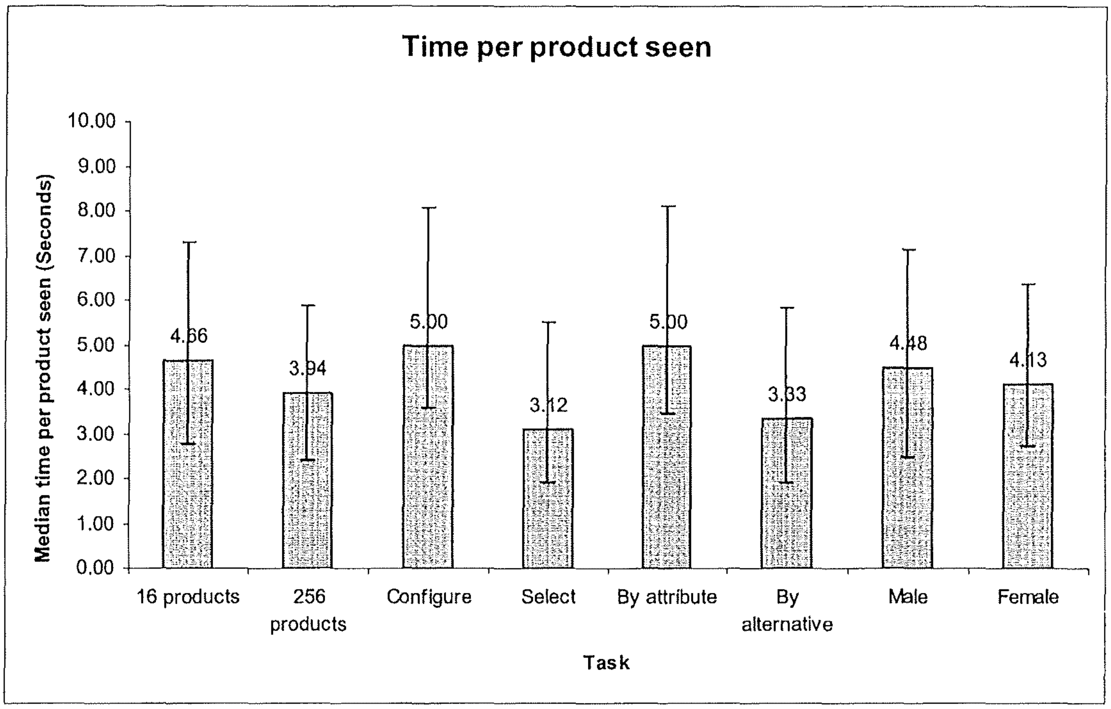


Figure A.6 Time spent per product seen

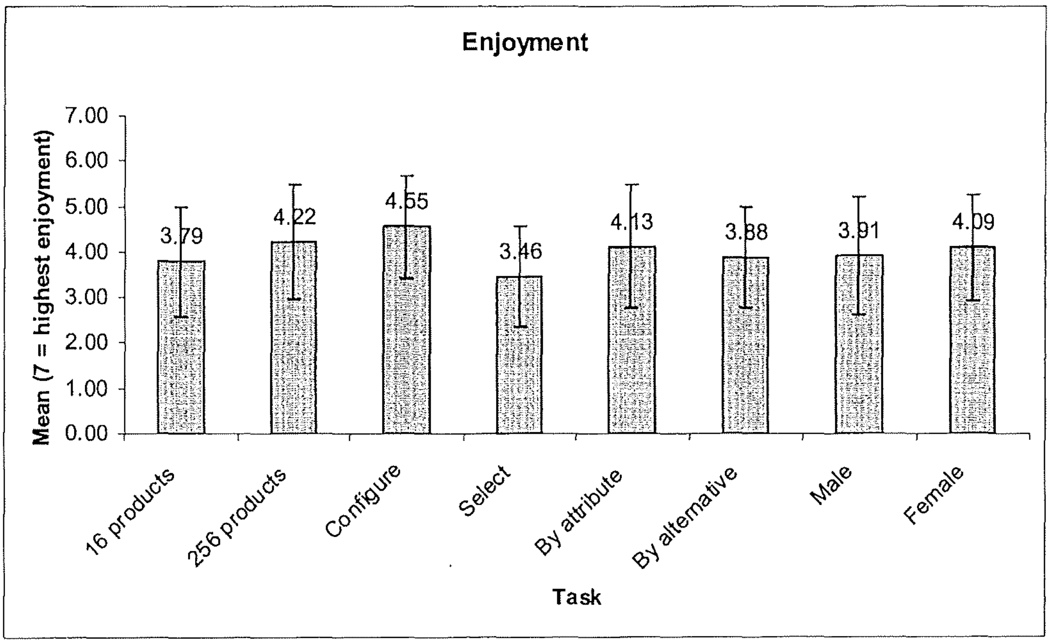


Figure A.7 Enjoyment plot

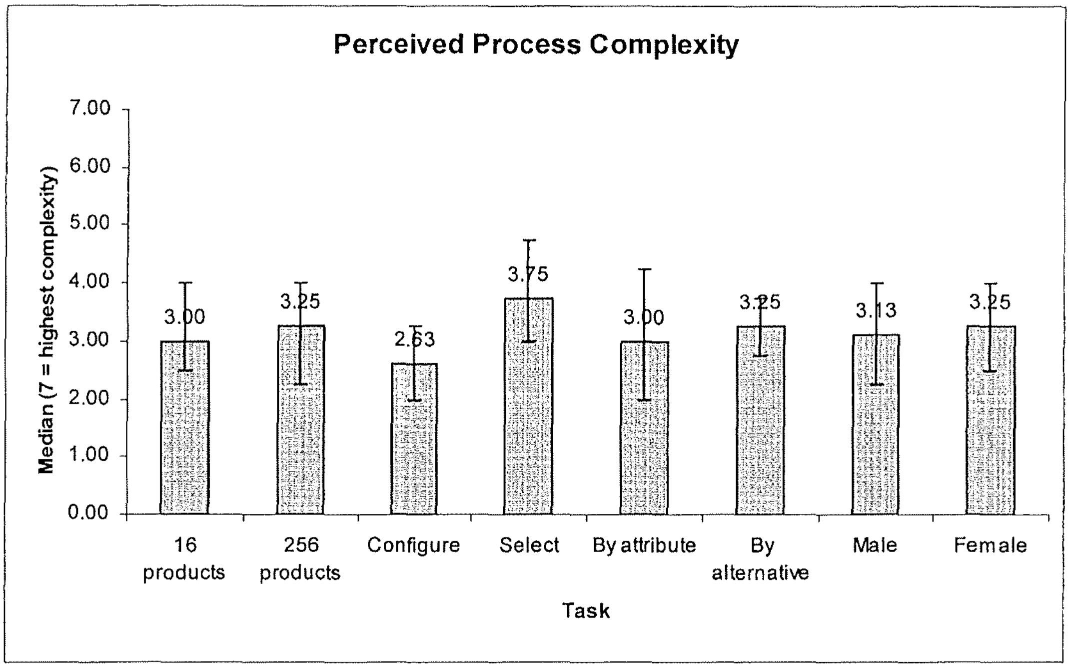


Figure A.8 Perceived process complexity plot

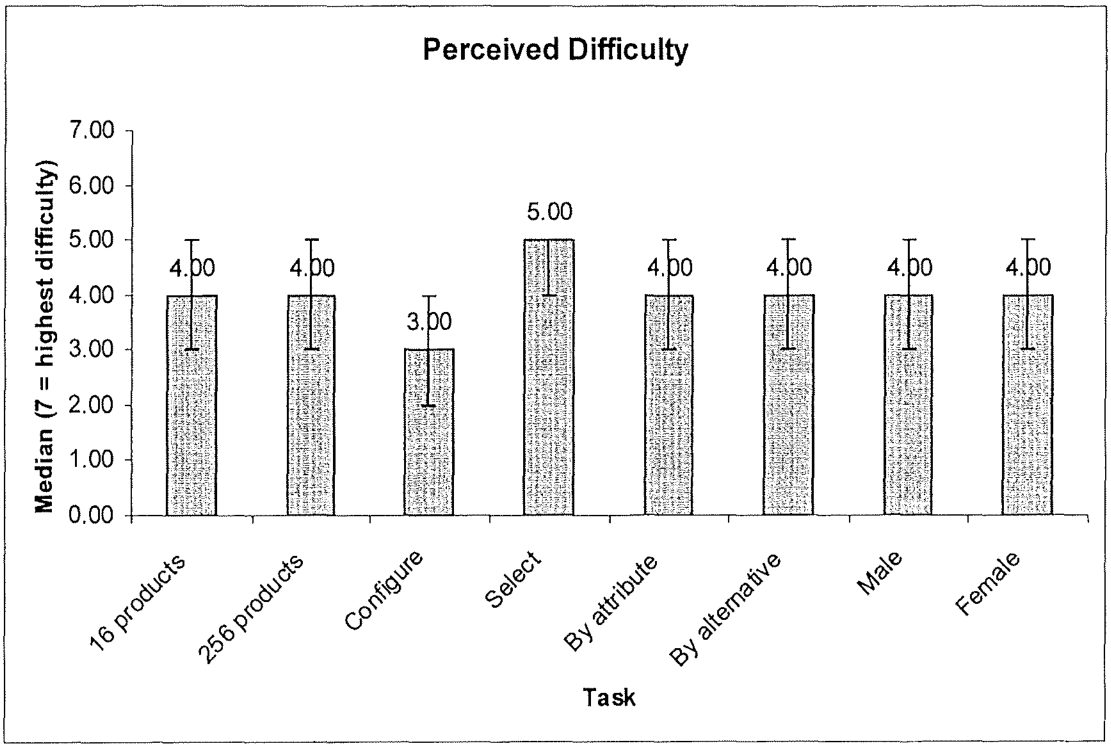


Figure A.9 Perceived difficulty plot

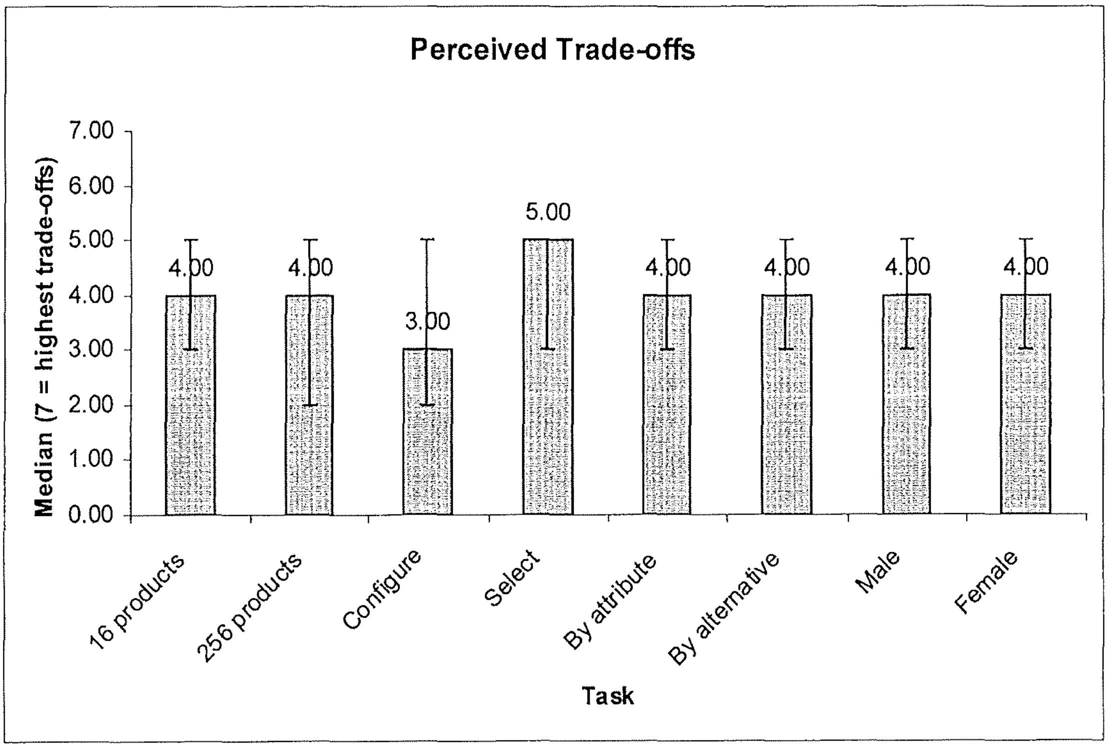


Figure A.10 Perceived trade-offs plot

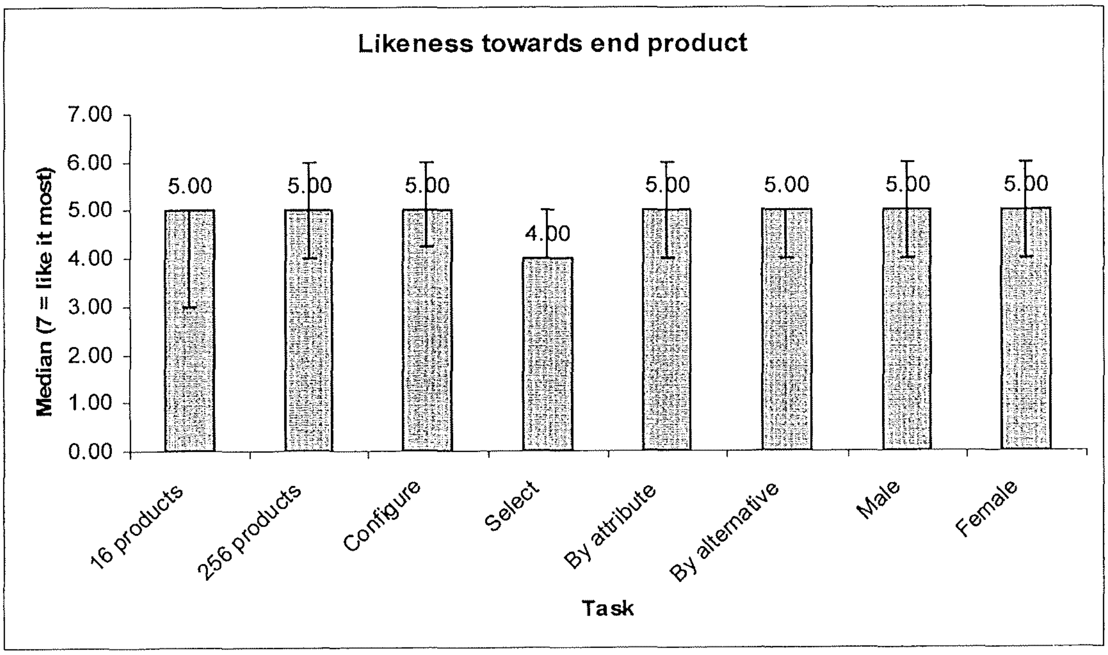


Figure A.11 Perceived favorability towards end product plot

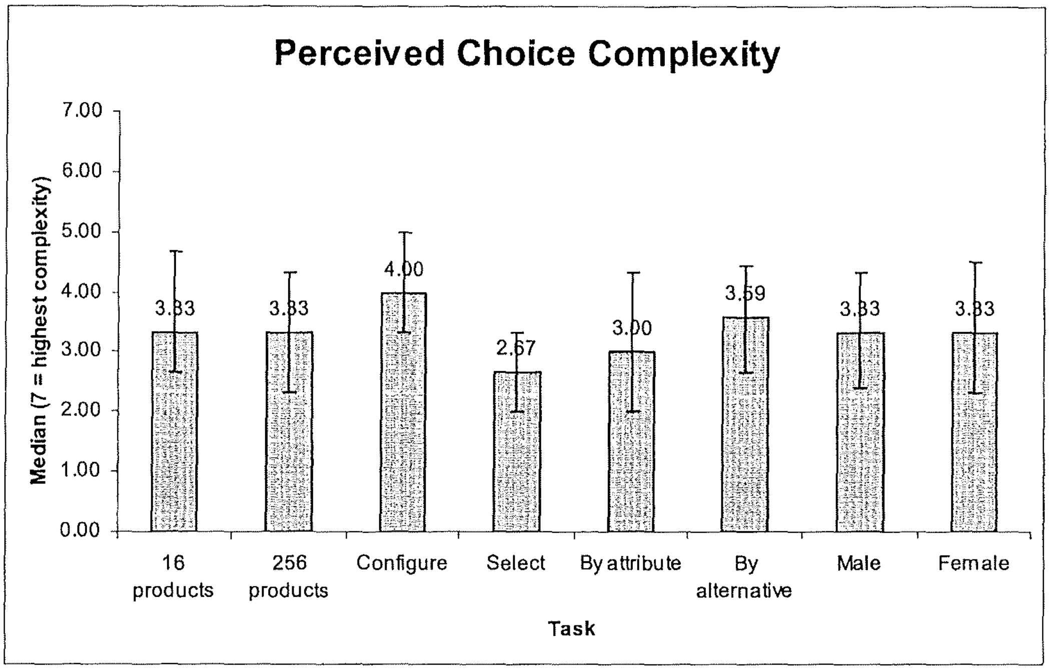


Figure A.12 Perceived choice complexity plot

A. 2. Statistical tests

This appendix presents results of various statistical tests which will be tabulated in the following tables.

Table A.1 Cronbach Alpha values testing items of questionnaires

Items tested	Alpha value
Satisfaction with decision	0.7757
Satisfaction with process	0.9225
Closeness between final product and expectation prior to buying	0.6921
Perceived enjoyment	0.9133
Perceived choice complexity	0.8688
Perceived process complexity	0.8378
Perceived difficulty	0.8290

Table A.2 Normality test

Factors investigated	p-values
Satisfaction with decision	< 0.0001
Satisfaction with process	< 0.0001
Closeness with expectation prior to buying	<0.001
Perceived enjoyment	0.076
Perceived favorability towards end product	< 0.0001
Perceived choice complexity	<0.01
Perceived process complexity	<0.001
Perceived difficulty	< 0.0001
Perceived trade-offs	< 0.0001
Total time spent	< 0.0001
Number of products seen	< 0.0001
Average time spent per product	< 0.0001

A.2.1 Main effects towards decision quality and consumer perception

The normality test above shows that almost all of the data do not follow a normal distribution. Therefore, non-parametric tests were conducted in order to investigate the main effects of the factors. Non-parametric tests are distribution free, means that they do not assume the data to follow certain distributions. The non-parametric test chosen is Wilcoxon signed rank test. It is equivalent to t-tests for related samples.

Table A.3 Effects of number of products towards decision quality and consumer perception

Factors investigated	Number of product offered
Satisfaction with decision	W(191), Z=-5.822, p< 0.0001
Satisfaction with process	W(191), Z=-5.511, p< 0.0001
Closeness between expectation and final product	W(191), Z=-6.494, p< 0.0001
Perceived enjoyment	W(191), Z=-5.601, p< 0.0001
Perceived favorability of end product	W(191), Z=-5.442, p< 0.0001
Perceived choice complexity	W(191), Z=-1.986, p=0.047
Perceived process complexity	W(191), Z=-0.944, p=0.345
Perceived trade-offs	W(191), Z=-4.292, p< 0.0001
Perceived difficulty	W(191), Z=-0.851, p=0.395
Total time spent	W(191), Z=-7.315, p< 0.0001
Number of product seen	W(191), Z=-8.448, p< 0.0001
Average time spent per product	W(191), Z=-2.364, p=0.018

Table A.4 Effects of shopping method towards decision quality and consumer perception

Factors investigated	Shopping method
Satisfaction with decision	W(191), Z=-9.026, p< 0.0001
Satisfaction with process	W(191), Z=-9.936, p< 0.0001
Closeness between expectation and final product	W(191), Z=-5.093, p< 0.0001
Perceived enjoyment	W(191), Z=-8.106, p< 0.0001
Perceived favorability of end product	W(191), Z=-7.38, p< 0.0001
Perceived choice complexity	W(191), Z=-9.351, p< 0.0001
Perceived process complexity	W(191), Z=-8.969, p< 0.0001
Perceived trade-offs	W(191), Z=-6.026, p< 0.0001
Perceived difficulty	W(191), Z=-8.463, p< 0.0001
Total time spent	W(191), Z=-6.329, p< 0.0001
Number of product seen	W(191), Z=-9.321, p< 0.0001
Average time spent per product	W(191), Z=-5.772, p< 0.0001

Table A.5 Effects of choice representation towards decision quality and consumer perception

Factors investigated	Choice Representation
Satisfaction with decision	W(191), Z=-1.82, p=0.069
Satisfaction with process	W(191), Z=-2.421, p=0.015
Closeness between expectation and final product	W(191), Z=-1.392, p=0.164
Perceived enjoyment	W(191), Z=-2.615, p=0.009
Perceived favorability of end product	W(191), Z=-2.018, p=0.044
Perceived choice complexity	W(191), Z=-2.697, p=0.007
Perceived process complexity	W(191), Z=-1.672, p=0.095
Perceived trade-offs	W(191), Z=-1.034, p=0.301
Perceived difficulty	W(191), Z=-1.515, p=0.13
Total time spent	W(191), Z=-3.074, p=0.002
Number of product seen	W(191), Z=-7.667, p< 0.0001
Average time spent per product	W(191), Z=-5.09, p< 0.0001

Table A.6 Effects of gender towards decision quality and consumer perception

Factors investigated	Gender
Satisfaction with decision	W(191), Z=-1.204, p=0.228
Satisfaction with process	W(191), Z=-0.254, p=0.799
Closeness between expectation and final product	W(191), Z=-1.55, p=0.121
Perceived enjoyment	W(191), Z=-1.628, p=0.104
Perceived favorability of end product	W(191), Z=-0.674, p=0.5
Perceived choice complexity	W(191), Z=-0.329, p=0.742
Perceived process complexity	W(191), Z=-0.176, p=0.86
Perceived trade-offs	W(191), Z=-0.9, p=0.368
Perceived difficulty	W(191), Z=-0.545, p=0.586
Total time spent	W(191), Z=-0.986, p=0.324
Number of product seen	W(191), Z=-0.848, p=0.396
Average time spent per product	W(191), Z=-0.661, p=0.509

A.2.2 Raw data related to decision quality and consumer perception

Besides the statistical tests, the raw data are also presented and tabulated in the following tables.

Table A.7 Inter quartile ranges of satisfaction with decision

Inter quartile ranges of satisfaction with decision (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(4.50, 5.00, 5.88)	(5.00, 5.50, 6.00)	(4.00, 4.75, 5.50)	(4.50, 5.50, 6.00)
	By selection	(3.00, 4.00, 5.00)	(3.50, 4.50, 5.00)	(3.63, 4.50, 5.00)	(3.13, 4.00, 5.00)

Table A.8 Inter quartile ranges of satisfaction with process

Inter quartile ranges of satisfaction with process (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(4.50, 5.00, 5.50)	(5.00, 6.00, 6.00)	(3.00, 4.00, 4.50)	(4.13, 5.00, 5.88)
	By selection	(2.00, 3.00, 3.50)	(2.50, 3.00, 3.88)	(3.00, 3.50, 4.00)	(3.00, 3.50, 4.00)

Table A.9 Inter quartile ranges of closeness between expectation and final product

Inter quartile ranges of closeness between expectation and final product (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(3.75, 4.25, 5.00)	(4.50, 5.00, 5.25)	(3.75, 4.00, 4.75)	(4.31, 4.63, 5.00)
	By selection	(3.50, 3.75, 4.50)	(4.00, 4.25, 5.00)	(4.00, 4.50, 4.75)	(3.50, 4.00, 4.75)

Table A.10 Inter quartile ranges of perceived enjoyment

Inter quartile ranges of perceived enjoyment (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(4.00, 4.63, 5.25)	(5.00, 5.38, 6.00)	(3.00, 3.75, 4.50)	(3.75, 4.63, 5.25)
	By selection	(2.25, 3.25, 3.75)	(2.50, 3.25, 4.00)	(2.75, 3.75, 4.50)	(3.00, 3.50, 4.44)

Table A. 11 Inter quartile ranges of perceived favorability towards end product

Inter quartile ranges of perceived favorability of the final product (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(5.00, 5.00, 6.00)	(5.00, 6.00, 6.00)	(3.00, 4.00, 5.00)	(5.00, 5.00, 6.00)
	By selection	(3.00, 4.00, 5.00)	(3.25, 4.00, 5.00)	(4.00, 4.00, 5.00)	(3.00, 4.00, 5.00)

Table A. 12 Inter quartile ranges of perceived choice complexity

Inter quartile ranges of perceived choice complexity (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(1.67, 2.33, 3.00)	(1.67, 2.00, 2.67)	(2.42, 3.33, 4.00)	(2.67, 3.00, 4.00)
	By selection	(3.33, 4.38, 5.25)	(3.67, 4.33, 5.59)	(3.33, 4.42, 5.00)	(3.00, 3.67, 4.33)

Table A.13 Inter quartile ranges of perceived process complexity

Inter quartile ranges of perceived process complexity (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(1.81, 2.25, 3.00)	(1.50, 2.00, 2.44)	(2.50, 3.13, 3.75)	(2.50, 3.25, 3.50)
	By selection	(3.25, 4.38, 5.25)	(3.06, 4.00, 4.75)	(3.25, 3.50, 4.44)	(2.75, 3.38, 3.75)

Table A.14 Inter quartile ranges of perceived difficulty

Inter quartile ranges of perceived difficulty (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(2.00, 3.00, 4.00)	(3.00, 3.00, 4.75)	(4.00, 5.00, 6.00)	(3.25, 5.00, 5.00)
	By selection	(2.00, 3.00, 3.75)	(3.00, 4.00, 5.00)	(3.25, 4.00, 5.00)	(4.00, 5.00, 6.00)

Table A.15 Inter quartile ranges of perceived trade-offs

Inter quartile ranges of perceived trade-off (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(2.00, 2.00, 3.00)	(2.00, 3.00, 5.00)	(4.00, 5.00, 6.00)	(3.00, 4.00, 6.00)
	By selection	(2.00, 2.00, 3.00)	(3.00, 4.00, 5.00)	(3.00, 4.00, 5.00)	(3.00, 5.00, 6.00)

Table A.16 Inter quartile ranges of total time spent

Inter quartile ranges of total time spent (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(55.75, 70.00, 94.75)	(72.50, 110.00, 145.00)	(70.50, 101.50, 137.25)	(90.00, 123.00, 183.50)
	By selection	(71.25, 115.00, 150.75)	(95.00, 160.00, 224.50)	(115.75, 167.50, 223.75)	(74.00, 120.00, 165.00)

Table A.17 Inter quartile ranges of number of product seen

Inter quartile ranges of number of product seen (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(7.25, 14.00, 22.25)	(13.00, 26.50, 39.25)	(14.00, 17.00, 23.00)	(16.00, 25.00, 30.00)
	By selection	(13.00, 17.50, 32.75)	(18.00, 37.50, 56.25)	(56.00, 88.00, 141.75)	(32.50, 48.00, 70.00)

Table A.18 Inter quartile ranges of average time spent per product

Inter quartile ranges of average time spent per product (a, b, c) indicates (25th Quartile, Median, 75th Quartile)		Choice representation			
		By attribute		By alternative	
		16 products	256 products	16 products	256 products
Shopping method	By configuration	(3.83, 5.48, 9.13)	(3.23, 4.14, 7.19)	(3.78, 5.22, 7.53)	(3.76, 4.86, 7.63)
	By selection	(3.85, 5.39, 8.06)	(3.40, 4.81, 6.12)	(1.18, 1.89, 2.73)	(1.40, 2.16, 2.84)

APPENDIX B

SAMPLE QUESTIONNAIRE

CLOSENESS BETWEEN YOUR FINAL T-SHIRT AND YOUR INITIAL PREFERENCE

	Worse than I expected		Exactly as I expected			Better than I expected	
The body color of the T-shirt I decided on	1	2	3	4	5	6	7
The sleeve color of the T-shirt I decided on	1	2	3	4	5	6	7
The front picture of the T-shirt I decided on	1	2	3	4	5	6	7
The back picture of the T-shirt I decided on	1	2	3	4	5	6	7

SATISFACTION WITH DECISION MADE

	Strongly disagree						Strongly agree
I am pretty satisfied with the final T-shirt I decided on	1	2	3	4	5	6	7
I am pretty certain that I made the best decision about the final T-shirt	1	2	3	4	5	6	7

SATISFACTION WITH SHOPPING PROCESS

	Strongly disagree						Strongly agree
This shopping process using this method was as good as I expected	1	2	3	4	5	6	7
This shopping process using this method was satisfying to me	1	2	3	4	5	6	7

PERCEPTION ON THE CHOICE COMPLEXITY

	Strongly disagree						Strongly agree
With regard to choice, I think there was too much confusion	1	2	3	4	5	6	7
With regard to choice, I think there was too much complexity	1	2	3	4	5	6	7
I have difficulties to find the T-shirt I like best	1	2	3	4	5	6	7

PERCEPTION ON THE PROCESS COMPLEXITY

	Strongly disagree						Strongly agree
This whole process is too complicated	1	2	3	4	5	6	7
I understood the functionality of the Website	1	2	3	4	5	6	7
I understand how process works	1	2	3	4	5	6	7
I think help function is needed	1	2	3	4	5	6	7

PERCEPTION ON ENJOYMENT

	Strongly disagree						Strongly agree
This shopping process using this method was an enjoyable process	1	2	3	4	5	6	7
I continued the shopping process, not because I had to, but because I wanted to	1	2	3	4	5	6	7
I enjoyed this shopping process for its own sake, not just for the T-shirt I may have decided	1	2	3	4	5	6	7
During the shopping process I felt the excitement of the hunt	1	2	3	4	5	6	7

PERCEPTION ON DIFFICULTY / TRADE-OFFS

	Strongly disagree						Strongly agree
Finding the T-shirt I like the most using the shopping method is difficult	1	2	3	4	5	6	7
Using this shopping method, I need to sacrifice the attributes I like for the attributes I don't like	1	2	3	4	5	6	7
I spend a lot of effort to find the T-shirt I like the most	1	2	3	4	5	6	7
I find it difficult to find best combinations of attribute that form the best T-shirt	1	2	3	4	5	6	7

FAVORABILITY TOWARDS THE END PRODUCT

	Don't like it at all						Like it very much
My level of likeness towards the final T-shirt I decided on is:	1	2	3	4	5	6	7

APPENDIX C1

EXPERIMENT INSTRUCTION ON CHOOSING T-SHIRT

This appendix presents the experiment instruction provided to the participants. Each participant has to read the experimental instruction and then given a chance to ask questions. If there is no question asked, the participants then proceed to sign the subject consent form and then start the experiment.

Welcome to the Experiment

Objective: To conduct a study of customer decision-making process when faced with alternatives

Scenario: You are going to go abroad for a study exchange program. You decided to buy a shirt with pictures describing Hong Kong, so that you can show it to your new friends and introduce the city where you come from.

You will be faced with different methods of shopping. At the end of each shopping trip, you are only asked to find ONE T-shirt that you like most.

Method:

The experimenter will present you with information about the different T-shirt / T-shirt components. Your task is to seek information you need in finding which T-shirt you want to choose while performing verbal protocol (you need to verbally speak out what is in your mind). You can start to seek information from any point and stop to make decision anytime when you think you have enough information to make decision. **[NB: Please be VERY SERIOUS in your choice, as your behavior directly affects the result of the experiment]**

You will be given several tasks. Please regard the tasks as **independent** tasks, mean that the previous tasks **WILL NOT** influence your behavior or decision in other tasks. During the experiment, if you really cannot find any T-shirt you like, you can say to the experimenter and you are free to abort at any time you want. Of course, this will mean that you fail to choose the T-shirt of your choice. At the end, the experimenter will ask you to rate how satisfied you are with your choice and how close your choice with your original thoughts.

PLEASE REMEMBER:

Since this experiment attempts to simulate a real situation, please treat yourself as a REAL person that is considering finding a T-shirt. At the end of the experiment, each person can get **TWO SETS OF DO-IT-YOURSELF T-SHIRT KIT** you have decided on.

- Thank you for your help -

APPENDIX C2

EXPERIMENTER GUIDELINE IN T-SHIRT EXPERIMENT

Step 1: Greet participants, ask participants to read the introduction to experiment and give them a chance to ask questions, if any.

Step 2: Ask participants to fill the consent form

Step 3: Assign participants to the tasks, for each task:

> Step 3.1. Let participants read the task description, give them a chance to ask questions, if any
>
> Step 3.2. Let participants start the task, experimenter start the video recording
>
> Step 3.3. During the task, remind participants if they forget to perform verbal protocol
>
> Step 3.4. Upon hearing participants make statements that they reach their final decision, stop the video recording
>
> Step 3.5. Ask participants to fill questionnaires related to decision quality
>
> Step 3.6. Give a minute break before start the next task

Step 4: Upon finishing all tasks, ask participant to choose the most liked method and ask them to explain why

Step 5: Give participants a choice to choose either two T-shirts or HK $60 cash rewards

Step 6: Dismiss the participant and ask them to collect their rewards 2 weeks after the experiment

Step 7: Participants come back two weeks after to collect their preferred rewards

APPENDIX C3

A DISCUSSION REGARDING PARTICIPANTS' REWARD IN THE T-SHIRT EXPERIMENT

In the experiment investigating decision quality, the experimenter posts a notice in the school's Electronic Notice board to invite participants to take part in the experiment. Participants are offered two T-shirts as their reward for participating in the experiment.

Upon arrival to the experimental location, participants need to read experiment instruction, stating that at the end of the experiment, they will receive two T-shirts as their reward. Participants then start the experiment to perform their decision-making process and fill subjective questionnaires to measure their decision quality.

After finishing the experiment, participants were given a second chance to reconsider between two T-shirts or HK$60 cash rewards. Total 69% of the total participants change their mind and choose HK$ 60 cash rewards. In order to get better understanding, an analysis is conducted in order to compare the two groups of participants, the group of participants who choose cash and the one who choose T-shirts.

Results from non-parametric test indicate that there are no significant differences between the two groups in every items of decision quality, perception of choice and perception of process (p values > 0.1). It is because that during their decision-making processes, all participants assume that they will get T-shirts as their reward. The decision quality is not influenced by the decision to choose either T-shirts or cash rewards.

In this experiment, participants were offered two T-shirts as their reward. Results showed that most participants choose three or more different T-shirts from different tasks assigned to them (one participant consistently choose the same T-shirt, and one participant choose two different T-shirts over the eight different tasks). The difference of T-shirts may imply two possibilities. The first one is that the participants treat each task independently, and what have been chosen in the previous task does not influence the current task. The second one is the participants is seeking for variety for the sake of the T-shirt reward. No verbal data indicate participants seek for variety was found. Therefore, the second possibility is ruled out.

APPENDIX D1

EXPERIMENT INSTRUCTION ON CHOOSING MOBILE PHONE COVER

This appendix presents the experiment instruction provided to the participants. Each participant has to read the experimental instruction and then given a chance to ask questions. If there is no question asked, the participants then proceed to sign the subject consent form and then start the experiment.

Welcome to the Experiment

Objective: To conduct a study of customer decision-making process when faced with alternatives

Scenario: You are going to choose a mobile phone cover for yourself. You will be faced with different methods of shopping. At the end of each shopping trip, you are only asked to find ONE mobile phone cover that you like most.

Method:

The experimenter will present you with information about the different mobile phone cover / mobile phone cover components. Your task is to seek information you need in finding which mobile phone cover you want to choose. You can start to seek information from any point and stop to make decision anytime when you think you have enough information to make decision. [**NB: Please be VERY SERIOUS in your choice, as your behavior directly affects the result of the experiment**]

You will be given two tasks. Please regard the tasks as **independent** tasks, mean that the previous tasks **WILL NOT** influence your behavior or decision in other tasks. During the experiment, if you really cannot find any mobile phone cover you like, you can say to the experimenter and you are free to abort at any time you want. Of course, this will mean that you fail to choose the mobile phone cover of your choice. The experimenter will scan your eye movement using a special device. This device is harmless and will bring no side effects to your health.

PLEASE REMEMBER:

Since this experiment attempts to simulate a real situation, please treat yourself as a REAL person that is considering finding a mobile phone cover.

- Thank you for your help -

APPENDIX D2

EXPERIMENTER GUIDELINE IN MOBILE PHONE COVER EXPERIMENT

Step 1: Greet participants, ask participants to read the introduction to experiment and give them a chance to ask questions, if any.

Step 2: Ask participants to fill the consent form

Step 3: Detect participants' dominant eyes. Ask participants to open both eyes and point their finger to a distant object. Ask them to close the right eyes and ask if their fingers still pointing at the same object. If their answers are yes, it means that the right eyes are the dominant eyes. Same case for left eyes.

Step 4: Ask participants to perform calibration with the eye-tracking device.

Step 5: Assign participants to the tasks, for each task:

> Step 5.1. Let participants read the task description, give them a chance to ask questions, if any
>
> Step 5.2. Let participants start the task, experimenter start the eye-movement recording
>
> Step 5.3. Upon hearing participants make statements that they reach their final decision, stop the eye-movement recording
>
> Step 3.6. Give a minute break before start the next task

Step 6: Dismiss the participant, present them with HK$50 reward.

APPENDIX D3

DATA ANALYSIS OF DECISION-MAKING STRATEGIES

The objective of providing this appendix is to explain the decision-making strategies extraction method from the raw data, which are verbal protocol and eye movement data. Classification of decision-making strategies from verbal protocol or process tracing method has been known to involve subjectivity and judgment of the data interpreters. It is desirable to provide a step-by-step method in order to reduce the subjectivity caused by ambiguous data. By providing this method, given the same set of raw data, other researchers are able to repeat the analyses and obtain similar results.

As stated in chapter 6 in the main body, the nature of this study is an exploratory study, in order to provide initial understanding about decision-making strategies in product configuration, as compared to strategies in product selection. Therefore the interest here is to explore the strategies and classify them into an initial classification in the product configuration. For product selection, this thesis will only attempt to classify the strategies into known classification, based on compensatory or non-compensatory rules.

D3.1 Procedure

The general step of data analysis of verbal protocol and eye-gaze data follow several steps described in the following flowchart:

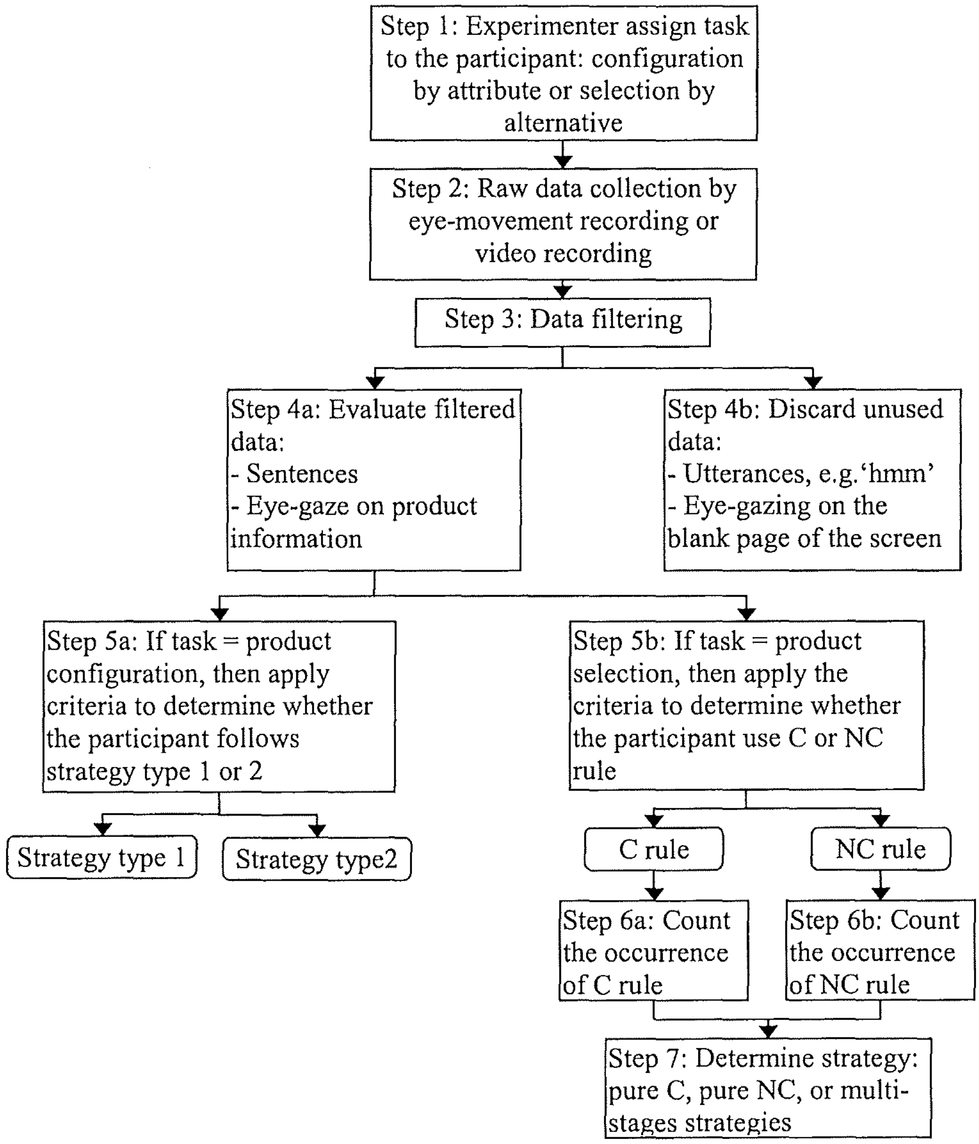


Figure D3.1 Data analysis flowchart

Step 1: The participant are assigned a task, either it is configuration by attribute or selection by alternative

Step 2: Raw data collection either by video recording (T-shirt experiment) or eye-movement recording (mobile phone cover experiment)

Step 3: Data filtering to obtain useful data

Step 4a: Evaluate filtered data: sentences from verbal protocol or eye-gaze data

Step 4b: Discard unused data such as utterances, gazing at blank part of the screen

Step 5a: If task evaluated is product configuration, then apply the following criteria:

If at least one attribute is evaluated more than once, then categorize as strategy type II,

Else categorize as strategy type I

Step 5b: If task evaluated is product selection, then apply the following criteria:

If the participant exhibits comparisons of several product alternatives using a particular attribute and followed by elimination of product alternatives that do not possess the selected attribute levels, then he is classified as using a non-compensatory rule.

If the participant reveals comparisons of several product alternatives based on several attributes, followed by an overall worth assessment of each product alternatives, then he is classified as using a compensatory rule.

Step 6a and 6b: calculation of compensatory (C) and non-compensatory (NC) rules

Step 7: Determining the strategy used

If the number of C rule = 0, then the participant uses a pure NC strategy

If the number of NC rule = 0, then the participant uses a pure C strategy

Else, participant uses a multi-stages strategy

As described in the flowchart above, not all data can be used. For verbal protocol data, some statements collected do not reflect any meaning, such as the statements like 'well..', 'ok..', mentioned independently of any evaluation of an attribute or a product. Utterances also considered as invalid data. It is very hard to predict what would be the meaning of the utterances such as 'err..', 'hmm..', or 'oh'. In the eye-movement data, participants sometimes looked at the blank space of the screen. The eye-movement recording software recorded the eye position every 110 milliseconds (about 9 times per seconds). It is found that participants gazed at blank spaces when they move their attention between two objects (i.e. two products or two attribute levels). The data that do not contribute to the decision-making process description are eliminated. The rest are regarded as valid data to be extracted in order to capture consumer decision-making strategies.

The percentage and standard deviation of percentages of filtered data over the total available data for different conditions are summarized in the following table. From the table, it can be seen that the verbal protocol provides more valid data, since participants verbal description are always related to the decision-making process description. In the eye-movement recording, the data show what participants are looking at particular times, including product-related information, and other information not related to products. In this case, the noise data is much higher compared to verbal protocol data.

Table D3.1 Summary of filtered data

Conditions		Filtered data
Verbal protocol data on T-shirt experiment	Selection, 16 products	(90.38%, 9.11%*)
	Selection, 256 products	(89.77%, 8.49%)
	Configuration, 16 products	(91.03%, 6.91%)
	Configuration, 256 products	(93.51%, 6.17%)
Eye movement data on mobile phone cover data	Selection, 128 products	(66.23%, 12.35%)
	Configuration, 128 products	(61.68%, 12.18%)

*: (a,b) denotes mean and standard deviation

Table D3.2 Filtered data for each participants in verbal protocol data for t-shirt experiment

Participant no	Product selection, 256 products	Product selection, 16 products	Product configuration, 16 products	Product configuration, 256 products
1	84.62%	91.67%	100.00%	100.00%
2	81.82%	100.00%	100.00%	100.00%
3	91.67%	88.89%	100.00%	100.00%
4	57.14%	60.00%	88.89%	91.67%
5	100.00%	93.33%	93.33%	88.89%
6	100.00%	100.00%	100.00%	100.00%
7	100.00%	92.31%	94.44%	80.00%
8	87.50%	82.35%	92.86%	93.33%
9	90.00%	84.62%	93.33%	83.33%
10	92.86%	92.31%	86.67%	93.33%
11	88.24%	100.00%	100.00%	100.00%
12	66.67%	69.23%	63.64%	100.00%
13	80.00%	92.31%	92.86%	92.86%
14	83.33%	85.71%	76.92%	100.00%
15	93.33%	100.00%	88.24%	100.00%
16	88.89%	91.67%	78.57%	100.00%
17	78.57%	100.00%	80.00%	88.89%
18	90.00%	91.67%	88.89%	91.67%
19	92.86%	92.86%	93.33%	92.31%

20	87.50%	85.00%	91.67%	88.89%
21	100.00%	100.00%	93.33%	71.43%
22	100.00%	63.64%	100.00%	100.00%
23	90.00%	95.00%	90.00%	93.33%
24	88.24%	93.33%	83.33%	100.00%
25	91.30%	86.67%	88.89%	87.50%
26	93.75%	93.33%	92.31%	100.00%
27	89.47%	75.00%	84.62%	85.71%
28	92.86%	92.86%	93.75%	92.86%
29	86.36%	84.62%	92.31%	100.00%
30	94.12%	90.00%	100.00%	100.00%
31	90.48%	93.33%	93.33%	93.33%
32	95.24%	92.31%	84.62%	94.74%
33	90.48%	90.00%	86.67%	100.00%
34	91.67%	92.86%	90.00%	90.91%
35	93.33%	100.00%	92.31%	92.31%
36	92.86%	92.86%	94.12%	85.71%
37	100.00%	91.67%	100.00%	93.75%
38	73.33%	84.62%	88.46%	93.75%
39	94.12%	93.33%	93.10%	90.91%
40	94.12%	78.95%	90.48%	94.44%
41	90.48%	91.67%	93.75%	94.74%
42	94.44%	100.00%	92.86%	90.00%
43	100.00%	90.91%	86.67%	86.67%
44	88.89%	100.00%	95.00%	95.65%
45	78.57%	90.00%	100.00%	100.00%
46	94.44%	88.89%	91.67%	96.55%
47	92.86%	100.00%	91.67%	95.83%
48	87.50%	100.00%	91.67%	89.47%

Table D3.3 Filtered data for each participant in eye-gaze data for mobile phone cover experiment

Participant no.	Product configuration	Product selection
1	86.19%	65.31%
2	54.48%	71.33%
3	91.62%	59.22%
4	57.27%	50.18%
5	52.54%	71.11%

6	51.52%	42.61%
7	68.91%	67.33%
8	44.42%	57.31%
9	64.40%	57.06%
10	74.84%	79.94%
11	71.22%	71.77%
12	68.96%	82.11%
13	58.45%	64.34%
14	73.14%	48.90%
15	41.88%	73.27%
16	63.64%	53.46%
17	72.77%	54.31%
18	64.39%	71.29%
19	50.80%	66.30%
20	54.01%	46.57%
21	56.00%	68.96%
22	68.67%	52.74%
23	67.19%	63.42%
24	81.50%	36.05%
25	59.94%	77.06%
26	55.49%	84.36%
27	69.90%	69.85%
28	62.71%	58.86%
29	66.25%	63.35%
30	70.14%	88.59%
31	57.58%	78.85%
32	47.59%	68.75%
33	57.74%	89.75%
34	38.29%	69.86%
35	47.13%	80.69%
36	46.29%	78.23%
37	70.41%	63.35%
38	52.90%	66.98%
39	48.43%	74.76%
40	77.52%	60.89%

D3.2 Sample cases

The verbal protocol data are collected in the experiment in which participants were asked to select or configure a T-shirt for themselves. The eye-gaze data are collected in the experiment in which participants were asked to select or configure a mobile phone cover for themselves.

Some cases will be presented below in order to provide examples of the data analysis. The data presented below are filtered data.

D3.2.1 Product configuration

D3.2.1.1 Verbal protocol data

The verbal protocol data are collected through the experiment and recorded in videotapes. Consistent with Payne's methodology the protocols are broken into short phrases in order to avoid ambiguous analysis of what the participant do at particular times [3].

Examples of verbal protocol data are presented as follow:

S1: I am starting now

S2: Body colors, sleeve colors, front pictures, back pictures (i.e.mentioning type of attributes)

S3: Only two possibilities for each

S4: Start from the top to bottom

S5: Body color first

S6: Blue and light brown

S7: Like blue better

S8: Then sleeve color

S9: Blue is definitely better (than brown color)

S10: But combination of blue and blue seems too boring

S11: Back to body color

S12: Change to brown

S13: Look better now

S14: Front picture

S15: Don't like the boat

S16: Old fashion

S17: Two symbols

S18: Like the second one better

S19: More plain

S20: I decide to choose this T-shirt

The script above shows the participant uses the second type strategy. He evaluates first, second, go back to first, third and then fourth attribute subsequently.

Note that the words in brackets (in statements S2 and S9 are added by the researchers in order to provide better illustrations of the statements. Sometimes it is found that participants mentioned incomplete sentences although their intentions are clear. As an example, in statements S9, in which there are only two colors compared, the participant mentioned that "blue is definitely better". The words in brackets are added in order to provide better illustration of the verbal protocol from the participant).

D3.2.1.2 Eye-gaze data

The eye-tracking software will record participants' eye-gaze data. The data are in the forms of screen coordinates. An additional program will translate those coordinates into product part information. Original data will look like what is presented below:

Data
...
FCC1
FCC1
FCC1
FCC2
FCC2
undefined
undefined
...
FCC2
FCC4
FCC4
Undefined
Undefined
...
Front case
Front case
Front case
Front case
...

* FCC = Front cover color; BCC = Back cover color; KC = Keypad color; FKC: Function key color; Front case: front case displayed in the visualizator; Back case: back case displayed in the visualizator; Keypad: keypad displayed in the visualizator; Function key: function key displayed in the visualizator

(For explanation of different part of the phones, see the figure below. Note that the texts explaining the notations do not appear in real experiment, and just used here for illustration).

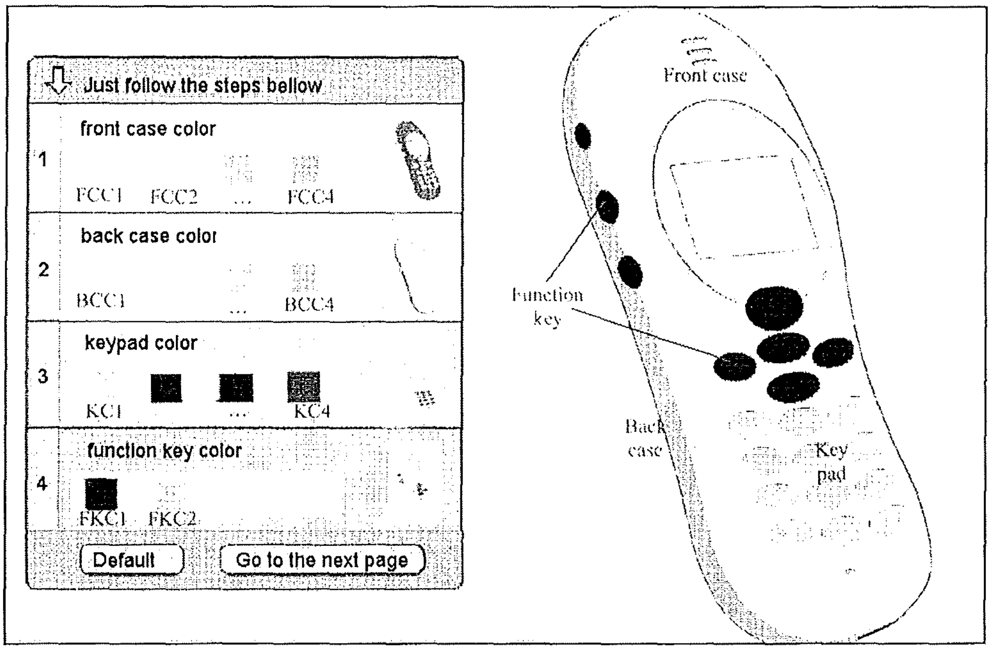


Figure D3.2 Explanations of terms for product configuration interface for mobile phone cover experiment

In order to extract decision-making data, the experimenter extracts useful data and presents different sequence of data as listed below.

D1: FCC1
D2: FCC2
D3: FCC4
D4: FCC3
D5: FCC4
D6: FCC1
D7: Front case
D8: BCC1
D9: BCC2
D10: BCC3
D11: BCC4
D12: BCC3
D13: Front case
D14: Back case
D15: Keypad
D16: KC1
D17: KC2
D18: KC3

D19: KC4
D20: KC2
D21: KC1
D22: Keypad
D23: Front case
D24: Keypad
D25: Front case
D26: Back case
D27: FKC2
D28: FKC1
D29: Front case
D30: Keypad
D31: Function key

From the eye gaze data, it can be seen that the participant evaluates front cover (showed in data D1-D6), back cover (D8-D12), keypad (D16-D21), then function key (D27-D28). Each attribute is evaluated once. It can be concluded that the participant is using strategy type 1.

Based on strategy classification in product configuration, every strategy can be clearly classified based on the rule specified above. If at least one attribute is evaluated more than once, then the strategy is categorized as strategy type II, else it is categorized as strategy type I.

D3.2.2 Product selection

D3.2.2.1 Verbal protocol data

Similarly, in product configuration, the protocols are broken into short phrases. Examples of verbal protocol data are presented in the following sections.

D3.2.2.1.1 Example of a typical case

The example of a typical case is presented as follows:

S1: There are options to use tree structure or see all products

S2: See all options

S3: Too many products

S4: I will use the tree structure

S5: Front pictures, several choices

S6: But I don't know what those pictures look like

S7: I will try to look at each picture

S8: I think the 'Victoria Peak' picture is the best

S9: Next is to choose sleeve color

S10: Blue, black, green, brown

S11: Green and brown are definitely out

S12: Blue is nicer than black

S13: Choose blue sleeve

S14: Now there are four shirts

S15: Different back pictures

S16: The one with only words 'Hong Kong' is nice

S17: Choose that one

S18: What is this next button?

S19: Oh, different body colors

S20: I think white is nice

S21: Choose white body color

S22: There are four T-shirts

S23: I have chosen the back picture

S24: But now seems my chosen back picture is not so match with the body color

S25: Too plain

S26: The last back picture is bigger

S27: It is better for the white body color

S28: It is better than the 'Hong Kong' with white body color

S29: Overall it is o.k.

S30: I will choose this

Subjective evaluations are performed in order to group those excerpts into different strategies. In verbal protocol data example above, it can be seen that the participant uses non-compensatory strategies in order to evaluate front picture (showed by statements S7-S8), sleeve color (showed by statements S9-S13), and back picture (showed by statements S14-S17) of the T-shirts. The participant uses compensatory strategy to evaluate the last two T-shirts (showed by statements S24-S30).

D3.2.2.1.2 Example of a more difficult case

To provide another example, some verbal protocol scripts provide more ambiguities and hence become more difficult to be evaluated.

S1: I will use the 'view all' options

S2: I see many T-shirts

S3: I will jump around

S4: Well,

S5: There are too many T-shirts

S6: I will just jump to T-shirts with 'the Peak' pictures

S7: Then look around again

S8: Black sleeve...

S9: Several body colors

S10: White, grey..

S11: Now see the logos

S12: Choose this one

S13: Compare to other logos, this one seems match with the front picture

S14: This is my final decision

The participant's final decision is T-shirt with white body color, blue sleeve color, peak picture, and back picture symbolizing the peak tower.

In this script, it is deducted that the participant used a non-compensatory rule to evaluate the front picture and decided to choose the peak picture (showed by statements S6). The participant also used a non-compensatory rule to evaluate body colors and decided to eliminate colors other than white and grey (showed by statement S10), and at the end chosen white color. However, how the participant chosen the sleeve color is less clear. The participant used a compensatory rule to determine the back picture that matches with the chosen front picture.

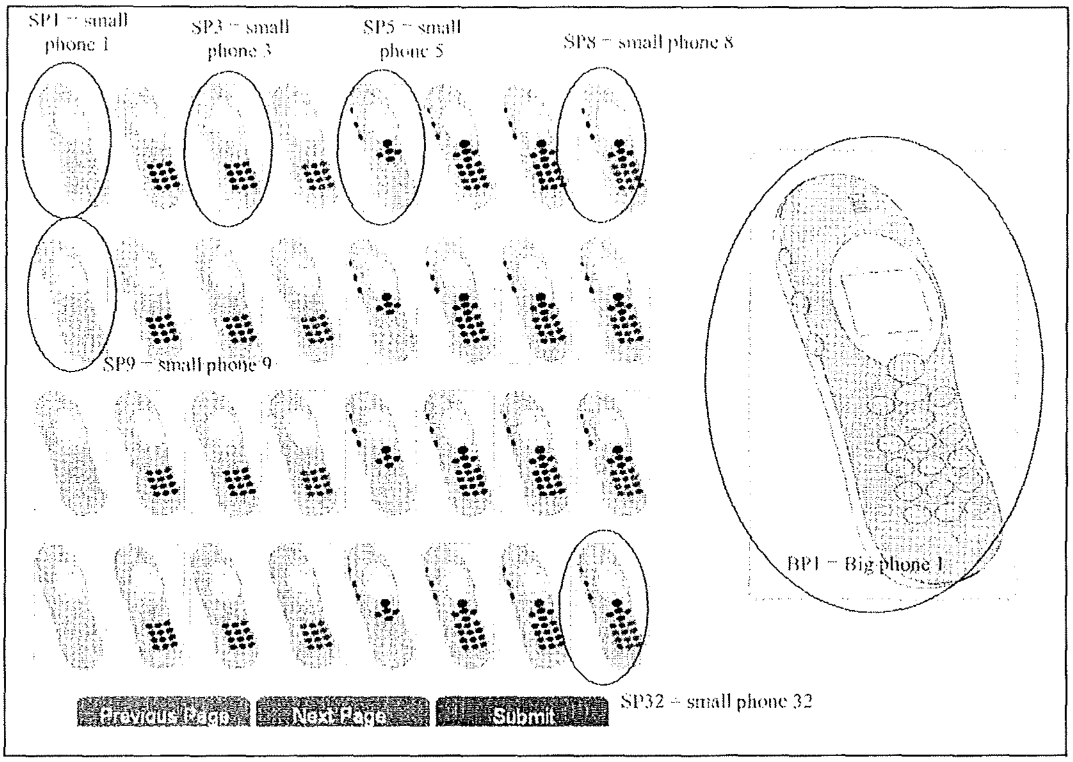
In this case, the ambiguity is with selection of the sleeve color. There is no indication of the participant used a compensatory rule in order to evaluate sleeve color together with other attributes. Based on the overall script, the participant also seems to evaluate the front picture, sleeve color, and body color independent of each others. It is deducted that the participant used a non-compensatory rule in order to evaluate the sleeve color.

D3.2.2.2 Eye-gaze data

Original data will look like what is presented below:

Data
...
undefined
undefined
SP9_Number_Key
SP9_Number_Key
SP9_Number_Key
SP2_Number_Key
SP2_Number_Key
undefined
undefined
SP2_Number_Key
SP2_Number_Key
SP1_Number_Key
undefined
undefined
SP5_Number_Key
SP5_Number_Key
SP5_Number_Key
SP5_Number_Key
...

*SPx_part denotes a certain part of small phone number x, example: SP5_Number_Key denotes number keypad for small phone number 5. The figures below provide illustrations of different parts.



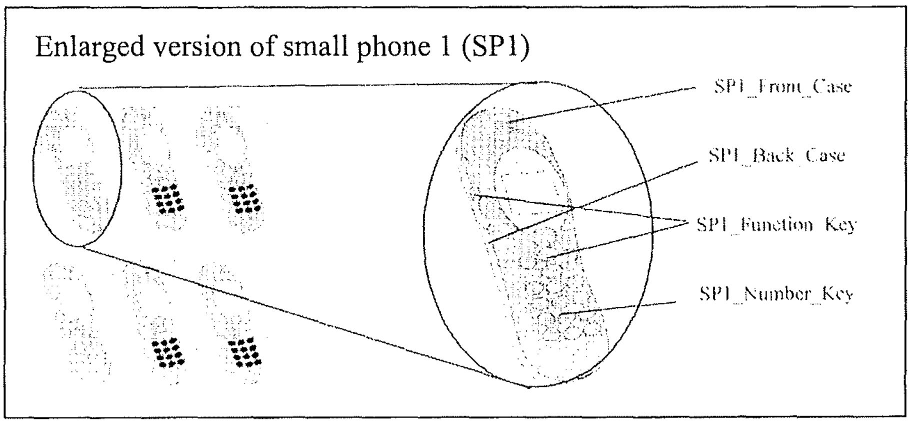


Figure D3.3 Explanations of terms for product configuration interface for mobile phone cover experiment

In order to extract decision-making data, the experimenter extracts useful data and presents different sequence of data as listed below.

D1: SP9_Number_Key
D2: SP2_Number_Key
D3: SP1_Number_Key
D4: SP2_Number_Key
D5: SP5_Number_Key
D6: SP6_Number_Key
D7: SP7_Number_Key
D8: SP8_Number_Key
D9: SP5_Number_Key
.
.
.

D21: SP10_Front_Case
D22: SP10_Number_Key
D23: SP10_Function_Key
D24: SP10_Front_Case
D25: SP10_Function_Key
D26: SP10_Number_Key
D27: SP10_Front_Case
D28: SP12_Number_Key
D29: SP12_Front_Case
.
.
.

Subjective evaluations are performed to classify the eye-gaze data into compensatory or non-compensatory rule. Similar with classification rule used in evaluating verbal protocol data, in eye-gazing data presented above, it can be seen that the participant evaluates number key using a non-compensatory rule (showed by data D1-D9). The participant uses a compensatory rule to compare the last two mobile phone covers (showed by data D21-D29).

D3.3 Outcomes of data analysis

The outcomes of the data analyses are presented in the following tables. Note that the tables have been presented in the main body of this thesis.

Table 6.1 Variation of product configuration strategies in T-shirt experiment

T-shirt 16 products			T-shirt 256 products		
The first strategy		Percentage of occurrence of the second strategy	The first strategy		Percentage of occurrence of the second strategy
Percentage of occurrence in which participants evaluate attributes based on the sequence of display	Percentage of occurrence in which participants evaluate attributes based on the perceived attribute importance		Percentage of occurrence in which participants evaluate attributes based on the sequence of display	Percentage of occurrence in which participants evaluate attributes based on the perceived attribute importance	
58.33%	12.50%	29.17%	52.08%	8.33%	39.58%

The inter quartile ranges for total number of repeated attribute evaluation for the second strategy in 16 products and 256 products are (6, 7.5, 9) and (5, 6, 9).

Table 6.2 Variation of product configuration strategies in mobile phone cover experiment

The first strategy		Percentage of occurrence of the second strategy
Percentage of occurrence in which participants evaluate attributes based on the sequence of display	Percentage of occurrence in which participants evaluate attributes based on the perceived attribute importance	
55.0%	7.5%	37.5%

The inter quartile ranges for total number of repeated attribute evaluation for the second strategy is (4.5, 7, 8).

In the case of product configuration, there is a very clear cut of different strategy, which is based on repetition on evaluation of attributes. If the participant evaluates at least one attribute more than once, then the strategy is classified as the second strategy, else it is classified as the first strategy.

Table 6.3 Median and inter quartile ranges of non-compensatory and compensatory strategies occurrences in product selection for T-shirt experiment

16 products		256 products	
Occurrences of non-compensatory strategies	Occurrences of compensatory strategies	Occurrences of non-compensatory strategies	Occurrences of compensatory strategies
(1, 2, 2)	(1, 1, 1)	(2, 2, 3)	(1, 1, 1)

Table 6.4 Percentage of product selection strategies in T-shirt experiment

Percentage of pure compensatory strategies	Percentage of pure non-compensatory strategies	Percentage of multi-stages strategies
0%	4.17%	95.83%

Table 6.5 Median and inter quartile ranges of non-compensatory and compensatory strategies occurrences in product selection for mobile phone cover experiment

Occurrences of non-compensatory strategies	Occurrences of compensatory strategies
(4, 5.5, 9)	(2, 3.5, 7)

Table 6.6 Percentage of product selection strategies in mobile phone cover experiment

Percentage of pure compensatory strategies	Percentage of pure non-compensatory strategies	Percentage of multi-stages strategies
0%	0%	100%

In product selection, the classification here is to classify the decision-making strategy into three broad categories: the use of several compensatory rules (called pure compensatory strategy), the use of several non-compensatory rules (called pure compensatory strategy), and the use of combined compensatory and non-compensatory rules (called multi-stages strategy). All data from participants can be categorized into one of the three strategies. The classification can be done relatively easier, since for each participant, there are clear indications on strategies used based on verbal protocol and eye-gaze data.

Consistent with the objective stated earlier, this thesis does not seek for comprehensive breakdown of decision-making rules in product selection, but will focus more on the general strategy, as basis of comparison with decision-making strategies in the product configuration.

As a summary, this appendix provides a review of data analysis conducted in order to extract decision-making strategies from verbal protocol and eye gaze data. A step-by-step guide is provided in order to minimize subjectivity of interpretation. The criteria of classification is also provided in order to increase the repeatability of the classification, means that other researchers are able to come up with same results if given the same set of data from this research.

APPENDIX E

SUBJECT INSTRUCTION FOR NAME CARD EXPERIMENT

Note: for current research, only parts of the name card experiment data were extracted. Originally it involves four tasks. For the purpose of time model validation, only data from two tasks (product configuration and product selection) are extracted.

Instructions for Name Card Experiment

Please read the following notes:

1. In this experiment, you are required to choose/design a personal card for yourself. The personal card that you have chosen will be printed for you with 100 copies by a printing company. Thus, please DO put effort to choose/design your best personal card and using real personal information is recommended.
2. This experiment consists of four tasks. Please treat these four tasks independently (e.g. what you do in task 2 should not base on what you did in task 1).
3. The detailed task description will be given before each task. You are required to read through the task description and watch the demonstration video before start the task.
4. You are required to fill in a short questionnaire after each task.
5. At the end of each task, you will see "Finish Task". When you see this message, please stop and experimenter will give you instructions.

I. Product configuration

(A) Read the task description:

1. You are required to design a card by combining six attributes, including Template, Background, Image and color of three groups of text.
2. If you like the card that you designed, then you can click on "Save in Shopping Cart".
3. You can modify the cards that you have designed and click on "Save as New Card in Shopping Cart" or "Overwrite Card in Shopping Cart". You can save as many cards as you want in the shopping cart.
4. When you click on "View Shopping Cart", which locates at the top right corner in the next page, you will view all the cards that you have saved.
5. You can make your final decision from all the cards that you have added in the shopping cart.

(B) Watch the demonstration:

1. Click here to watch the demonstration video (press "Ctrl+3" to view in full screen).
2. Close the demonstration video before press "Next" (Start the task).

II. Product Selection

(A) Read the task description:

1. Many cards will be displaced in tree structure for you to choose. You can navigate the tree and choose the cards with different combinations of Template, Background, Image and Color of your name.
2. If you find any card that you like, you can click on "Add", then the card will be added into your shopping cart. You can add as many cards as you want in the shopping cart.
3. When you click on "View Shopping Cart", which locates at the top right corner in the next page, you will view all the cards that you have clicked "Add".
4. You can make your final decision from all the cards that you have added in the shopping cart.

(B) Watch the demonstration:

1. Click here to watch the demonstration video (press "Ctrl+3" to view in full screen).
2. Close the demonstration video before press "Next" (Start the task).

APPENDIX F

SUBJECT CONSENT FORM

Consent Form for Participating the Experiments

1. Name ____________________________

2. Are you feeling uncomfortable in any way? Yes/No

3. Do you suffer from diabetics or epilepsy? Yes/No

4. Have you ever suffered from any serious disease such as heart disease?

   Yes/No

5. Are you under medical treatment or suffering disability which affects your daily life?

   Yes/No

If your answer is "Yes" to question (2), (3), (4), (5) please give details to the Experimenter.

DECLARATION

I consent to take part in the experiment. My replies to the above questions are correct to the best of my belief, and I understand that they will be treated as confidential by the experimenter.

I understand that I may at anytime withdraw from the experiment and that I am under no obligation to give reasons for withdrawing declared above.

I undertake to obey the regulations of the laboratory and instructions of the experimenter regarding safety only to my right to withdraw declared above.

The purpose and methods of the experiment have been explained to me and I have had the opportunity to ask questions.

Signature of Subject ____________________ Date __________________________

This experiment conforms to the requirement of the University Research Ethic Committee.

Signature of Experimenter _________________Date __________________________

(When completed this form should be filed in the Exposure Archive).

APPENDIX G

LIST OF EQUATIONS FOR DECISION-MAKING TIME FORMULATION

G.1 Formulation of decision-making time in product configuration

G.1.1 Mental Efforts in product configuration

Let:

m = total number of attributes

n = total number of attribute levels in each attribute level

Evaluating an attribute to choose best attribute level

- Total number of 'READ' $\propto n$ (Eq.7)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.8)
- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.9)

Evaluating interaction between two attributes

- Total number of 'READ' $\propto 2*n$ (Eq.10)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.11)

- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.12)

Evaluating interaction among m attributes

- Total number of 'READ' $\propto m*n$ (Eq.13)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.14)
- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.15)

Total mental effort in product configuration

- Total number of 'READ' $\propto y_1 * n + y_2 * 2n + \ldots + y_m * m*n$

  Total number of 'READ' $\propto n\,(y_1 + 2\,y_2 + \ldots + m\,y_m)$ (Eq.16)

  y_i = number of times participants perform evaluation on i attribute(s), means that:

  y_1 = number of times participants perform evaluation on 1 attribute

  y_2 = number of times participants perform evaluation on 2 attributes (fix one attribute level and match the second attribute to the first attribute)

  y_m = number of times participants perform evaluation on m attributes (fix m-1 attribute levels and match the mth attribute to the rest of chosen attributes)

- Total number of 'COMPARE' $\propto \sum_{i=1}^{m} y_i\,(\log_2(n))$ (Eq.17)

- Total number of 'ELIMINATE' $\propto \sum_{i=1}^{m} y_i\,(\log_2(n))$ (Eq.18)

G.1.2 Decision-making time in product configuration

Decision-making time $\propto T_{READ} + T_{COMPARE} + T_{ELIMINATE}$ (Eq.19)

Decision-making time $\propto$

$$1.19 * n\,(y_1 + 2y_2 + \ldots + m\,y_m) + 0.09 * \sum_{i=1}^{m} y_i\,(\log_2(n)) + 1.8 * \sum_{i=1}^{m} y_i\,(\log_2(n))$$

(Eq.20)

G.2 Formulation of decision-making time in product selection

G.2.1. Mental effort in product selection

<u>Using non-compensatory decision-making rule</u>

<u>Mental effort require for performing a lexicographic rule on an attribute:</u>

- Total number of 'READ' $\propto$ n (Eq.22)
- Total number of 'COMPARE' $\propto \log_2 n$ (Eq.23)
- Total number of 'ELIMINATE' $\propto \log_2 n$ (Eq.24)

<u>Total mental effort spent in Lexicographic rule involving p attributes:</u>

Total mental effort of 'READ' $\propto$ p*n (Eq.25)

Total mental effort of 'COMPARE' $\propto$ p * $\log_2$ n (Eq.26)

Total mental effort of 'ELIMINATE' $\propto$ p* $\log_2$ n (Eq.27)

Using compensatory decision-making rule on x product alternatives

- Total number of 'READ' $\propto$ x*m (Eq.28)
- Total number of 'ADD' $\propto$ x (m-1) (Eq.29)
- Total number of 'COMPARE' $\propto$ $\log_2$ x (Eq.30)
- Total number of 'ELIMINATE' $\propto$ $\log_2$ x (Eq.31)

G.2.2 Decision-making time in product selection

Decision-making time $\propto z_1 * T_{NON\text{-}COMPENSATORY} + z_2 * T_{COMPENSATORY}$ (Eq.32)

z_1 = number of times participants perform non-compensatory strategy

z_2 = number of times participants perform compensatory strategy

While $T_{NON\text{-}COMPENSATORY} \propto T_{READ} + T_{COMPARE} + T_{ELIMINATE}$

$T_{NON\text{-}COMPENSATORY} \propto 1.19\,(p*n) + 0.09\,(p * (\log_2 n)) + 1.8\,((p* \log_2 n))$ (Eq.33)

And $T_{COMPENSATORY} \propto T_{READ} + T_{ADD} + T_{COMPARE} + T_{ELIMINATE}$

$T_{COMPENSATORY} \propto 1.19\,(x*m) + 0.84\,(x\,(m-1)) + 0.09\,(\log_2 x) + 1.8\,(\log_2 x)$ (Eq.34)

APPENDIX H

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