Samah Abu-Assab

Integration of Preference Analysis Methods into Quality Function Deployment

A Focus on Elderly People

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Samah Abu-Assab
Cottbus, Germany

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To the greatest persons I have ever known, to my parents

Foreword

Quality Function Deployment (QFD) is a popular product planning tool which has been developed to assure that the voice of the customer is not only heard by market researchers but all the way throughout the product development process. Up to now, many QFD approaches have been presented in the literature, all of them have in common that along a chain of tables and graphs collected customer requirements are consistently transformed into engineering descriptions of new products.

Recently, instead of customer and expert workshops, the usage of more advanced market research methods has been proposed for collecting customer requirements: Preference measurement methods like conjoint analysis were used to estimate the importance of assumed customer requirements more reliably and – additionally – for relating them validly to engineering descriptions (see for early references, e.g., Baier 1998 or Pullman et al. 2002). Applications of these new methodological combinations have shown a consistent superiority over the traditional QFD approach. They generate concepts for promising new products more reliably and validly, since the underlying preference structure of the customers is estimated and modelled more adequately. Sample applications have been, e.g., the development of electronic devices or sports equipment for young people or people from 20 up to 40 years of age.

However, if the customers – and consequently the respondents in the market research part of the approach – are elderly people, the demanding task of a conjoint analysis data collection step seems to be too sophisticated for the target group. Here, more simple but nevertheless valid and reliable preference measurement methods are needed. Candidates could be modifications of the self-explicated preference measurement approach that recently gained considerable attention from the marketing researchers.

The author of this book, Ms. Samah Abu-Assab has developed such new preference measurement approaches and combined them with QFD. She applied them in many market research surveys to markets for elderly people (e.g. cell phones or smart homes for elderly people) and analyzed all through whether the new approaches are superior to the already known combinations of QFD and conjoint analysis. The results look promising: the new approaches seem to be adequate for the target group.

Ms. Abu-Assab did an excellent job in developing and testing the new approaches. The book summarizes this complex research over four years in Germany. The dissertation was accepted by the Faculty of Mechanical, Electrical, and Industrial Engineering at the

Brandenburg University of Technology (BTU) Cottbus in June 2011. We hope that the book will find a favourable reception by a large, interested audience.

Prof. Dr. Daniel Baier

Acknowledgement

I wrote the presented work during my scholarship in Germany as an internal doctorand at the department of Marketing and Innovation Management at the Brandenburg University of Technology Cottbus. At the beginning, I was told that writing a dissertation is a long journey that will turn my life upside down and change many of my perspectives. It took me a while before I realized that it was true and at the end of this journey, it did. Succeeding in this journey would not have been possible without the support of many good people.

I thank the German Academic Exchange Service DAAD for their financial support during my graduate time by a 4-year scholarship and for their partial financial support in printing this book.

I would like to acknowledge the support of my supervisor Prof. Dr. Daniel Baier throughout my work. I would also like to thank the members of my graduate committee Prof. Dr. Ralf Woll for accepting to be my second supervisor and Prof. Dr. Magdalena Mißler-Behr for accepting to take the head of the committee and for her support. Many thanks also go to Dr. Alexandra Rese for accepting to take the documentation job.

Furthermore, I heartily thank all those who supported me throughout this work. I namely thank my colleagues Dr. Florenta Costache, Mr. Sergey Polyetayev, Ms. Eleni Vasileiadou, and Dr. Said Esber for their support during the whole journey. Many thanks also go to the student-support that helped me in my projects. My special thanks go to Sarah Döring, Mirko Kühne, Diego Altamirano, Wahyu Utomo, Philipp Tursch, Hanane Sabil, Daniel Richter, and Ksenia Mitasova.

In my private circle, I thank all my family and friends for their unconditional support and their understanding for my commitment to achieve this goal. In Germany, my very special thanks go to Sabine Otto for her continuous encouragement, motivation, and her trust. In Jerusalem, my deepest appreciation and thanks go to my parents, Inas, Safa', Nabil, and Nadine for the unstoppable support and encouragement in all times and in achieving my goals.

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List of Abbreviations

2NDRY	Secondary
Abs.	Absolute
ACA	Adaptive Conjoint Analysis
AHP	Analytical Hierarchy Process
AHP	Analytical Hierarchy Process
ASE	Adaptive Self-Explication
CA	Conjoint Analysis
CAPI	Computer-Assisted Personal Interviewing
CASE-MAP	Computer-Assisted Self-Explication of Multi-Attributed Preferences
CBC	Choice-Based Conjoint
CBI	Conjoint-Based Inference
CCA	Customized Conjoint Analysis
CCC	Customized Computer Conjoint Analysis
CC-SE	Conjunctive-Compensatory Self-Explicated
CJQCA	Central Japan Quality Control Association
cm	Centimetre
CR	Customer Requirement
CVA	Conjoint Value Analysis
Dec	December
DF	Design Feature
e.g.	Exempli gratia (Latin: for example)
eBook	Electronic Book
EC	Engineering Characteristics
et al.	Et alii (Latin for: and others)

FMEA	Failure Modes & Effects Analysis
FP	Full Profile
FPM	Fast Polyhedral Method
GOAL/QPC	Growth Opportunity Alliance of Lawrence, Massachusetts/Quality Productivity Centre
GQFD	Green Quality Function Deployment
HB	Hierarchy Bayes
HII	Hierarchical Information Integration
HoQ	House of Quality
i.e.	id est (Latin for: that is)
IAUM	Incentive-Aligned Upgrading Method
IFA	German: International Fair of Broadcasting Services
JSA	Japanese Standards Association
JSQC	Japanese Society for Quality Control
KPO	Key Process Operations
LCD	Liquid Crystal Display
mAh	Milliampere per hour
Max	Maximum
Min	Minimum
mm	Millimetre
MMS	Multimedia Messaging Service
mo.	Month
n	Number of respondents
NPD	New Product Development
n.s.	not significant
OLS	Ordinary Least Squares
p.	page

PC	Part Characteristics
PCPM	Paired Comparison Preference Measurement
PDCA	Plan, Do, Check, and Act cycle
pp.	pages
QFD	Quality Function Deployment
R&D	Research and Development
rel.	relative
SAS	Statistical Analysis System
SE	Self-explicated
SER	Self-Explicated Ratings
SMS	Short Message Service
SPSS	Statistical Package for the Social Sciences
SSI Web	Sawtooth Software Incorporated Web
TCA	Traditional Conjoint Analysis
TQC	Total Quality Control
TQM	Total Quality Management
TV	Television
Uhus	Under Hundred
VDM	Virtual Design Method
VOC	Voice of Customer

1 Introduction

1.1 The Starting Point

We are living in a technological era where many of the products are complex and have a large number of characteristics.[1] For companies, it represents a big challenge to conceive the consumer requirements concerning the characteristics especially of technological products at a time when adapting to the customers' needs and wishes constitutes a main success factor for the survival of the company on the market. After all, the marketing process begins, continues, and ends through the decisions of consumers.

The segment of elderly consumers is quickly increasing proportionally all over the world. In Germany, the average life expectancy is now over 80 years, and by 2060 around 34% of the population will be over 65 (Federal Statistical Office 2009, p. 5). As behaviour changes and physical condition start to deteriorate through the ageing process, elderly people develop new needs, wants, and wishes that should be met. Thus, the urge to adapt new products and services for elderly peoples' needs is important in order to gain them as customers for companies.

Against this background, the challenge is doubled for companies. On one hand, there is the complexity of technological products, and on the other, the necessity to understand the needs of consumers, especially those of the elderly. As a result, companies have to quickly adapt to continuous changes and developments and respectively force themselves to be more efficient in their processes to survive today's technological and marketing challenges. Market research is one of the tools that the companies use to understand their customers' needs and to develop new or to improve existing products. Thus the adaptation of market research methods to the many substantial changes in technologies, applications, and in demographics is inevitable.

The present work contributes to customer-oriented market research by suggesting a new approach based on the combination of the quality function deployment and a preference analysis method, namely the self-explicated method, adapted to the needs of elderly people, whose demands and requirements form the basic construct in the process of product improvement and/or development.

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1 For example, an LCD TV, a digital camera, and a notebook are technological complex products with large number of features and characteristics.

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1.2 Introduction to the Integration of Preference Analysis Methods into QFD

Preference analysis[2] consists of three alternative approaches:[3] the compositional (e.g. self-explicated methods), decompositional (e.g. conjoint analysis), and hybrid approaches (e.g. adaptive conjoint analysis) (Green and Srinivasan 1990, p. 9; Hensel-Börner 2000, p. 4; see Figure 1).

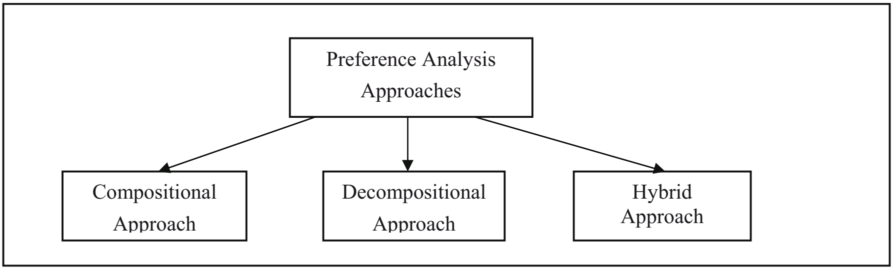

Figure 1: Preference analysis and its alternative approaches (Own representation adapted from Green and Srinivasan 1990, p. 9; Hensel-Börner 2000, p. 5)

One of the most well-known methods of the preference analysis is the conjoint analysis (Baier and Zirn 1995, p. 19) and it is one of the popular multivariate analyses in marketing (Hair et al. 2010; p. 266). The purpose of the methodology is to predict individual preferences of consumers (see Agarwal and Green 1991, p. 141) based on the premise that a product is made of a bundle of attributes and levels (Brockhoff 1999, p. 13).

An alternative to the conjoint analysis approach is the self-explicated approach. The self-explicated approach is widely used to cope with problems with a large number of attributes[4] for its simplicity and easiness (Green and Srinivasan 1990, p. 9; Srinivasan and Park 1997, p. 286). It gathers the preferences of customers in a direct way in which respondents are asked separately on each attribute and level (see Jain et al. 1979, p. 248). The traditional self-explicated method includes two stages: the desirability of attribute levels within each attribute and the relative attribute importance across attributes (Netzer and Srinivasan 2011, p. 141; Srinivasan and Wyner 1989; Srinivasan 1988). There are many variants of the self-explicated method, those that explicitly recognise

[2] It is also known as preference (structure) measurement (Green and Srinivasan 1990, p. 9).

[3] The two terms approach and method are used synonymously here.

[4] For a definition of attributes refer to Section 3.2.1.

the conjunctive phase (see Huber 1974; Leigh et al. 1984; Wright and Kriewall 1980; Srinivasan 1988) and those with a clear defined attribute importance concept (Srinivasan 1988; Green et al. 1988; Dorsch and Teas 1992). Other improved self-explicated methods, such as the adaptive self-explicated method (Srinivasan and Park 1997) or the web-based adaptive self-explicated procedure (Netzer and Srinivasan 2011), have been introduced.

Recently, many researchers have combined preference analysis methods, in particular the conjoint analysis, with other methods to overcome some of the limitations of the integrated method and vice versa, taking advantage of the fact that the preference analysis approaches are quantitative, customer-oriented, and suitable for present-day technologically complex products. A case in point is Quality Function Deployment (QFD). It is one of the widely used methods in the development and improvement of products. This qualitative, customer-oriented method's main purpose is to transfer the Voice of Customer (VOC) from the marketing department to the production department in a company. Because QFD has many deficiencies (see Section 4.4), researchers have combined it with other methods and tools.

Mazur (2000, p. 1) declared that competitiveness in this millennium may possibly belong to those who integrate more than one discipline into a system, rather than to those who work with one tool. With this statement Mazur (2000) emphasised that quality function deployment should be considered as a "great room" in which other methods can become integrated. Gustafsson (1996, p. 1) also maintained that one of the key areas in the development of new products is cross-functional collaboration. Gustafsson (1996) suggested the combination of conjoint analysis and QFD in the product development and roughly indicated the use of self-explicated method and QFD.

In summary, both methods the preference analysis methods and QFD are customer-oriented, focusing on hearing the VOC to increase customer satisfaction and are used in the development of new products. Their integration helps to overcome some deficiencies of the methods and thus to empower them.

1.3 Integration of Preference Analysis Methods into QFD for Elderly People

In marketing literature and to the author's best knowledge, elderly people are not emphasised or directly considered in preference analysis methods and in quality function deployment as a separate target group. This work fills this gap by focussing mainly on tailoring the combination of preference analysis methods and QFD to elderly people for new and improved product development.

The proportion of elderly people in the population is increasing in the world, especially in the industrial countries and in Europe. However, today's elderly people are totally different from the elderly of last generations in many ways. For example, on the economic level, today's elderly people create an interesting target group for companies. The economic power of the elderly is increasing and will continue to rise with the increase in their percentage in the population and their consumption power with their longevity. Elderly people of today have better health conditions than previous generations (Lehr 2002, p. 89). However, the ageing process cannot be stopped and accordingly in time certain physical and cognitive limitations appear or happen to the elderly person each in a different degree and way. Because of these natural physical and cognitive limitations stemming from ageing in general, elderly consumers differ from young consumers in certain demands and in their intensities. These ageing limitations are considered in market research methods used in this work, namely the integration of preference analysis into QFD in two ways. The main way is by integrating self-explicated method into QFD and the second way was by adapting the conjoint analysis integrated into QFD in order to make the method easier and less burdensome to elderly people.

The main two issues taken into consideration in tailoring the research methods in the present work are (1) to make the interviews easier and simpler for the elderly taking them and (2) to make it require less cognitive effort from elderly respondents so that the results are acceptable. In doing so, the self-explicated method was selected to be integrated into QFD for elderly people analogously to its use in complex technological products where a large number of attributes are used.

Conjoint analysis and self-explicated approaches prove to be suitable to measure preferences of consumers. The hybrid conjoint analysis, the adaptive conjoint analysis, and the self-explicated methods are suggested to be used for large numbers of attributes (Green and Srinivasan 1990, p. 9). Park et al. (2008, p. 562) indicate that products from the information age are complex which imposes a big challenge for marketers trying to understand customer preferences. They added that conjoint analysis is not suited for such a complex task mainly because of the huge cognitive effort exerted on respondents when conducting a conjoint interview (for detailed reasons refer to Park et al. 2008, p. 562); whereas, Bradlow (2005, p. 320), in his “wish list”, indicated the importance of further research on conjoint analysis when large number of attributes are used. For this case, Bradlow (2005, pp. 320-321) suggested (1) the use of partial-profiles where each profile used is based on an experimentally designed subset of attributes (for details about partial-profile see, e.g., Green and Krieger 1990; Bradlow et al. 2004), or (2) the use of the self-explicated conjoint method in which attributes and levels are directly collected from respondents (for details about the self-explicated conjoint method see, e.g., Green and Krieger 1987). However, the self-explicated approach is easier to implement than conjoint analysis (Srinivasan and Park 1997, p. 286; Park et al. 2008, p. 563), and imposes less of a cognitive burden on respondents, something which increases quickly along with the number of attributes and attribute levels increase (Park et al. 2008, p. 563). As a result, the self-explicated approach is selected to be used in the integration into QFD for elderly people on the example of technological products. Additionally in the present work, the combination of conjoint analysis and QFD is also investigated on the same examples.

For the purpose of testing both the conjoint analysis and self-explicated methods for the elderly people, the design of interviews should be tailored and adjusted for the elderly. The interviews should be made easier and simpler, shorten the interview's duration, and reduce the cognitive effort as much as possible using the available technologies. In the current work, some adjustments are suggested in constructing the interviews for elderly people. Face-to-face interviews are used with elderly people to collect their wants and needs and were also used in running the regular interviews whenever possible. A video was made to introduce the subject of the interview with all the attributes and attribute levels in order to make the interviews easier and more interesting for the elderly. Colours and font size were adjusted to the elderly to overcome possible viewing problems and information could be prompted over attributes and attribute levels to give more information or direction for the elderly across the entire interview.

In summary, two ways are suggests to tailor the methods used in this work for elderly people by (1) using self-explicated method and by (2) adjusting the design of the interviews to be more "friendly" and considerate to the elderly.

1.4 Goals and Structure of the Work

The main purpose of the present work is to propose a new approach based on the combination of the self-explicated and QFD methods for new or improved product development for elderly people. A further purpose is to test the new approach and to compare it to two similar approaches, namely Pullman's and Baier's approaches (for descriptions of both approaches see Section 5.1.1 and Section 5.2.1, respectively). Specifically, it will be investigated to which extent the suggested combination of the self-explicated and QFD methods is reasonable in comparison to the combination of conjoint analysis and QFD methods for elderly people. In doing so, two technological products are used for the implementation, namely “mobile phones” and “smart home” for elderly people. Both products are made of many attributes and attribute levels.

Based on these objectives, the general structure of the work is constructed as follows (see Figure 2): after the introduction, Chapter 2 handles the target group “elderly people”. The definition of ageing and various terms of “elderly people” are presented. In presenting the target group, the demographical development in Germany according to the actual 12th coordinated population projection is summarized and its implications as well as the socio-economical situation of elderly people which convey a good picture of the target group. At the end of the chapter, a review of the market research especially conducted on the elderly is handled in different areas to observe how elderly people are dealt with in the research.

In Chapter 3, the preference analysis methods are handled. First, the self-explicated approach is described followed by a description of its variants, in which the conjunctive-compensatory self-explicated method used in QFD in the new approach, is explained. Then the conjoint analysis method, as well as its variants, in which the adaptive conjoint analysis used in QFD, is explained. For the objective of the research, the advantages and disadvantages of the conjunctive-compensatory self-explicated and the adaptive conjoint analysis methods are presented, followed by a review of the comparison studies conducted between the self-explicated and the conjoint analysis methods in literature. At the end of the chapter, a description of the used assessment of results of the preference analysis methods, especially conjoint analysis, is given.

Quality Function Deployment is introduced in chapter 4. The basics of QFD as well as its approaches are handled first. Of particular importance is the discussion of advantages and disadvantages of QFD as well as the solutions suggested to overcome these problems. As a result, the combination of QFD and other methods is discussed and finally the special focus on the solution of integrating conjoint analysis into QFD to overcome some of its deficiencies is given. These three chapters build the basis of the empirical investigation.

Before starting with the empirical studies, a description of the three research approaches used in the investigation is given in Chapter 5. In this scope, Pullman’s, Baier’s, and the new approach are separately handled. Finally, the procedure of the empirical investigation is illustrated.

In Chapter 6, the empirical study on “mobile phones for elderly people” is conducted according to Pullman’s approach and Baier’s approach. The aim of this chapter is to test the two approaches with some adjustments in the interviews of elderly people. The result of each method is separately reported and at the end, a comparison of the results of the two methods is made.

The second empirical study on “smart homes for the elderly” is investigated in Chapter 7. In this empirical study, Pullman’s, Baier’s, and the new approach are conducted separately. A comparison of the results between the approaches is presented based on two issues, namely the direct comparison of results and the indirect influencing factors. Finally, the summary and corollaries are given. The aim of the second study is to test the new approach against the other two approaches for elderly people.

Finally, in Chapter 8, an overview of the work and a summary of results are presented with a critical discussion and outlook for future research. The aim is to recapitulate the most important results and recommendations for the target group of elderly people and in the outlook to indicate necessary further future research re-commendations.

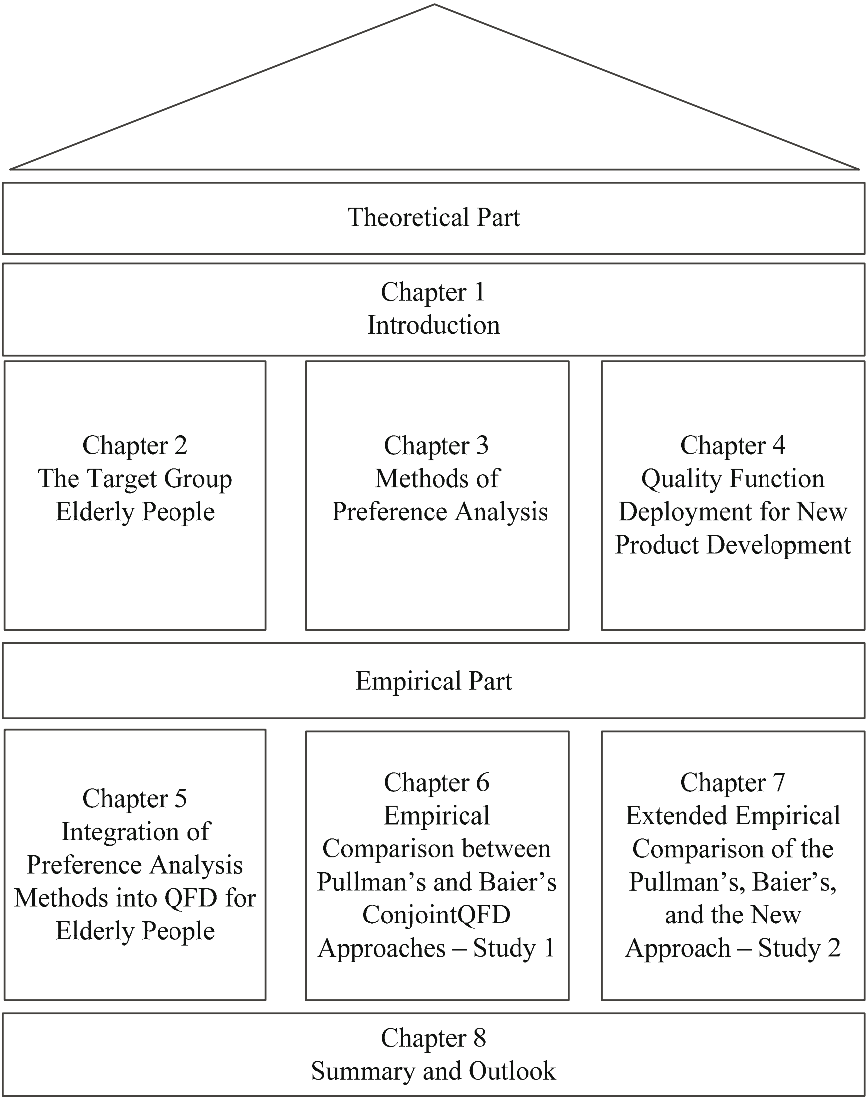

Figure 2: The structure of the work
(Own representation)

2 The Target Group: Elderly People

2.1 Overview of Elderly People

The common word used for elderly people is “seniors”. It originates from Latin and designates elderly people (e.g. Artho 1996, pp. 25-26). However, in this work, the term “seniors” will not be used because, according to the face-to-face interview and written questionnaire results conducted in the current work, it showed that most of the elderly people in the sample were not pleased with the term “seniors”. Therefore, the author will be using the term “elderly people”[5] instead throughout this work.

From an economic point of view, elderly people have been referred to by many different terms, such as: “silver ager”, “oldies”, “grumpies” (which refers to all grown up, mature people), “fifty plus”, “golden gray”, “uhus” (which is word play on “**u**nder **hu**ndred” and in German name for eagle owls), “woopies” (which means well-off older people), and “yollies” (which means old people living a life of leisure), (see, e.g., Artho 1996, p. 25; Meyer-Hentschel and Meyer-Hentschel 2004, p. 11; Gassmann and Reepmeyer 2006, p. 9).

Ageing is an inevitable natural process that occurs in our bodies like any other normal process. However, from a social point of view, it is difficult to define becoming old or reaching an age of retirement, since the definition is dependent on the measures defined in each society. These in turn depend on the economic situation there for defining the retiring age. However, it is associated with the time the person stops his/her working life (see Hoehn 2000).

In modern gerontology, ageing is known as a process that takes place at one time at different levels: physically, emotionally, socially, and socio-culturally. Usually it starts at one level and extends to all others (Baltes and Baltes 1994, p. 8). In the aging process, changes in both conditional and physiological aspects are partially expected. In return, these changes differentiate young from old.

Furthermore, according to d’Epinay et al. (1983), the life of an elderly person can be classified into four phases (see Table 1), starting from the pre-retirement phase and fin-

[5] At this point, it should be indicated that the elderly people considered in this work is from the age of 50 years old and over. It was necessary to consider the 50 years old elderly so that they could be also included in the experimental work conducted in the current work since they were the easiest group to reach for the questionnaires.

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ishing with the last, the dependent period of an elderly person's life. The four phases illustrate clearly that elderly people are a heterogeneous group. The duration of the phases differ according to many factors, such as lifestyle, eating habits, and chronic diseases.

The main four phases are as follows:

Phase 1 is the last working phase and approaching retirement in which the elderly person is still economically active and prepares for the after-work phase.

Table 1: The four phases of the lives of elderly people and their main characteristics

	Phase Name	Main Characteristics of the Phase
Phase 1	Last work phase and approaching retirement (e.g. 60-65)	economic active
		delineation of after-work phase
		some go to pension earlier
		others go to pension later
Phase 2	Autonomous retirement age (e.g. from 65-75 year old)	free from work
		high social and personal autonomy
		demands can be implemented and satisfied (generally)
		little health problems and limitations
		differs from one person to another in length and duration
		good economic and cultural situation
Phase 3	Increased fragility (differs from person to person, e.g. 75-80 years old)	main sign: hindrances and limitations in functions
		things are still possible but with complications
		frequently dependent on others in doing everyday tasks
		mentally healthier than physically
Phase 4	Dependent retirement age (differs from person to person, e.g. from 80 years old)	dependent and care-dependent
		cognitive limitations
		(partially) dementia
		dependent in easy daily tasks

(Own representation adapted from d'Epinay et al. 1983; Kroeber-Riel et al. 2009, p. 495)

As already mentioned, the age of retirement is defined according to a given society's norms. However, some elderly enter retirement or their pension earlier than others. A study conducted by Infratest (2003, p. 9) came to the conclusion that from a physical and mental point of view, a 65 year old person can imagine living around 15-25 years of their life without critical physical and/or mental limitations.

Phase 2, the autonomous retirement age, comes after the first phase and differs from one person to the next. However, it is a time where the elderly are free from work. They still possess a high social and personal autonomy, in which they can still satisfy their demands, generally speaking. This phase is characterised by a low number of health problems and limitations. The beginning and duration of the phase depend on the elderly person as well as the overall economical and cultural situation.

In phase 3, increased fragility, the elderly experience more hindrances and limitations, mainly physically, in daily functions. Generally, doing things and daily activities are still possible but come with many complications. Therefore they are more dependent on others in doing everyday tasks. The elderly in this phase are typically mentally fitter than physically.

In phase 4, the dependent retirement age, the elderly are dependent and also care-dependent. In this phase, elderly persons also suffer from cognitive limitations; some may even partially or totally suffer from dementia. Generally speaking, the elderly are dependent even in simple daily tasks.

After defining the term and characterising its main phases, the next section will handle the demographical development in Germany for the target group of elderly people until the year 2060.

2.2 Demographical Development in Germany until 2060

The age structure of the German population has changed in the last century. For example, compare the age structure of the population in Germany at four different points: end of Dec 1910, end of Dec 1950, end of Dec 2008, and end of Dec 2060 (see Figure 3). It becomes obvious that the changes until 2060 are drastic. For instance, the age structure in 1910 of the German Reich formed a pyramid at times where high birth-rates are accompanied by high death-rates. This situation represents a "classic" situation in which the children represent the strongest cohort and the older cohort incrementally decreases (Federal Statistical Office 2009, p. 14). However, the age structure of 1950, shows some informality in shape which resulted from the first and second world wars and the world economic crisis from 1930 (see Federal Statistical Office 2009, p. 14).

Today the German age structure of 2008 looks more deformed when compared to 1910 than that of 1950. Today the middle-aged cohorts represent the larger group among the young and old (see Figure 3). Many reasons may account for these changes, mainly the severely low birth rates that were recorded in the middle of the sixties until the seventies while at the same time the average life expectancy increased (refer to Federal Statistical Office 2003).

By 2060, the bracket of elderly people will increase and that of young people as well as the middle-aged will decrease proportionally. This will significantly change the different age groups' relations. For example, it is noticeable that the number of elderly people aged 65 to 80 will increase from 15% in 2008 to 20% in 2060. Moreover, the number of elderly people aged 80 and over will increase significantly from 4 million (5%) in 2008 to more than 10 million in 2050. However, between 2050 and 2060, it is expected that the population of elderly aged over 80 will decline to 9 million. In clear words, in 2060 14% of the German population is projected to be 80 years and older, which means every seventh person will be aged 80 and over (see Figure 4) (Federal Statistical Office 2009, pp. 14-16).

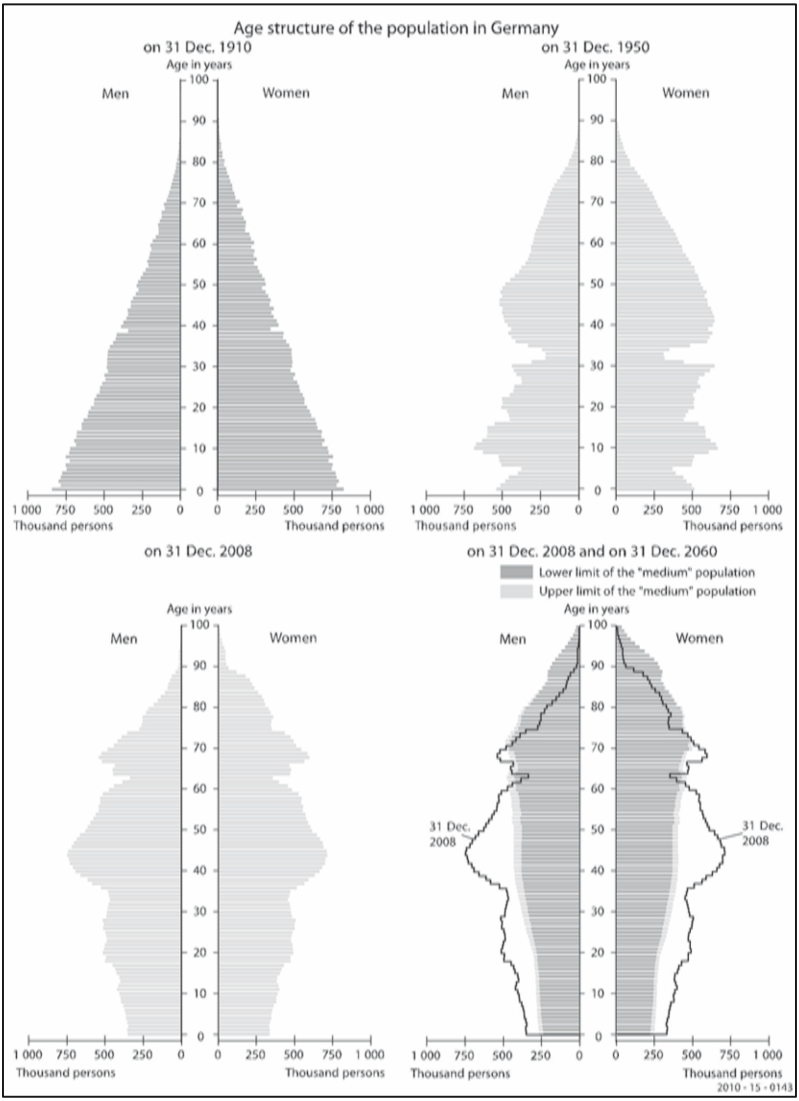

Figure 3: The age structure of the population in Germany in 1910, 1950, 2008, and 2060 according to the 12th coordinated population projection (Federal Statistical Office 2009, p. 15)

Concurrently the number of the young people aged less than 20 years, which totals about 16 million today, will shrink to 10 million in 2060, forming 16% of the population (Federal Statistical Office 2009, p. 16). According to the Federal Statistical Office

(2009, pp. 16-17), the changes in the population structure will be always more noticeable.

In the current decade until 2020, the groups of people aged 50 to 65 (+24%) and 80 and over (+48%) will increase in size. At the same time, the number of those aged under 50 will decrease (-16%) and those aged from 30 to under 50 will decline by an amount of almost 4 million (-18%).

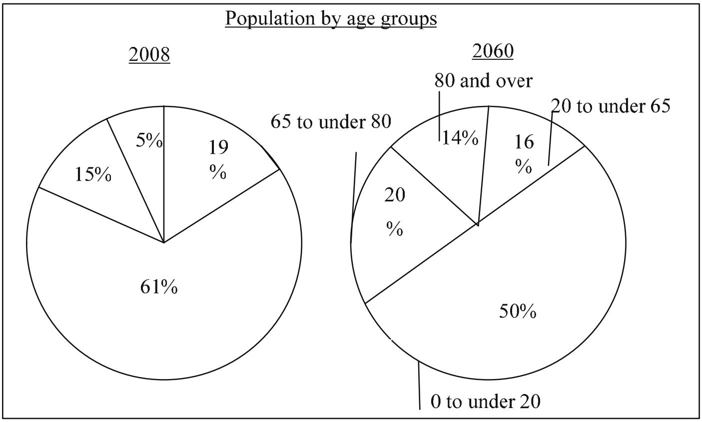

Figure 4: Population by age groups
(Own representation adapted from Federal Statistical Office 2009, p. 16)

As already mentioned, the proportion of elderly people in the population will keep increasing. In the last 60 years the age structure of the population has changed dramatically in Germany as well as in all other industrialised countries. The main reasons are the decrease in the birth-rates, the increase in the life expectancy, and the increase in the old-age dependency ratio. Additionally, immigration plays a role. In the next section, these reasons will be described.

2.2.1 Decreasing Birth Rates

Statistically, the development of birth-rates depends on two indicators: (1) on the number of children per woman and (2) the ages at which women have children. According to the Federal Statistical Office (2009, p. 23), the mother's age at birth today is higher than in the past. In 1990, the average number of children per woman[6] was 1.45 at an average age at birth of 27.6 years old; whereas in 2008, the number of children per woman was 1.38 at an average age at birth of 30 years (Federal Statistical Office 2009, p. 24).

2.2.2 Life Expectancy

Contrary to the declining birth rate, which is stabilising at a low rate in Germany, the life expectancy of people in the last century has been increasing. This increase bears witness to the development and progress achieved in medical care, better hygiene and nutrition, as well as housing among many other developments. In other words, a child that is born in Germany has a life expectancy over 30 years greater than that of a child born 100 years ago. The average life expectancy at birth is projected to be 85.0 years for men and 89.2 years for women. Generally, the gap in life expectancy between genders is getting smaller in the short term trend (Federal Statistical Office 2009, pp. 29-30).

2.2.3 Old-Age Dependency Ratio

The old-age dependency ratio shows the relationship between the population that is of a working age (between 20-59 years old) and those 60 years old and older. For instance, in the year 2001, the old-age dependency ratio was 44:100; whereas it is expected to be 71:100 by the year 2050 based on the assumption of minimum ageing of the population (for details refer to Federal Statistical Office 2003, p. 7; Federal Statistical Office 2009, pp. 38-41).

2.2.4 Migration

Migration plays a significant role in the situation in Germany. Migration could contribute to a deceleration of the process of aging in the country, which can be seen in many of the statistical data calculated for the different coordinated population projection. For example, one of the main assumptions that the calculations are based on is the number of the net migration rate (either 100.000 or 200.000 people per year) (refer to Federal Statistical Office 2009, p. 5).

[6] Woman includes German women of the old states, women of the new states, and foreigner women living in Germany (Federal Statistical Office 2009, p. 24).

After the demographical presentation of elderly people, it is a complementary part of the research about elderly people to view them from the various socio-economical aspects. Accordingly, the next sections will deal with this view.

2.3 The Socio-Economical Situations for Elderly People in Germany

In this section, selected socio-economical situations for elderly people will be overviewed which provide an overview of the elderly. The overview handles the situation of family and households, economical and purchasing power, health, the elderly consumer behaviour, and their leisure time.

2.3.1 Family and Household Structure

The family and household structure provide a measure of the living conditions of the elderly in Germany. According to Jung's (2002, p. 8) study, it shows that in the age group from 60-64 years old, most elderly are married (73%), compared to the low number of widows and widowers (16%). Almost the same structure could be still concluded for the age group 65-69 years old. However, it can be observed that the percentage of married individuals is slowly starting to decrease and the widowed status is starting to increase. By the Age group 70+, the trend becomes more drastic where the percentage of married elderly declines (42%) and the number of widows and widowers rapidly increases (51%).

Table 2: Family status in % of elderly people according to the different age groups

Age Group	Single	Married	Divorced	Widowed
60-64	2	73	7	16
65-69	3	71	5	22
70+	1	42	4	51

(Own representation adapted from Jung 2002, p. 8)

As for the household structure of elderly people, Jung's study (2002, p. 8) showed that most elderly live in a couple (two per household; 67%) in the age category 60-64, whereas 15% live in a more than two person per household in comparison to 19% living alone. In the age category from 65-69, the percentage of "two persons per household increases to 72%. At the same time, the percentage of single elderly person increases to 24%. Concurrently, a noticeable drop in the number of more than two persons per household occurs, reaching 4%. Finally, as expected, the number of one person per household dominates in the age category 70+ reaching 52%, and two person households decline to 42% while the two or more person households drop to 6% (see Table 2).

2.3.2 Economical and Purchasing Power of the Elderly Group in Germany

Elderly people (50+) are gaining more and more economical importance since they are older and therefore have the longest consumption time compared to the remaining younger consumers. On the other hand, almost 66.7% of the money spent in Germany comes from an elderly person (Krieb and Reidl 1999, p. 39). According to the Federal Statistical Office (2009, p. 11) the elderly group (50+) makes up more than 41.5% of the main earners of income in the households, although the elderly only make up 19% of the total population (see Figure 5).

Elderly people are well off in Germany in comparison to previous generations. There are many reasons for the high income of the elderly group at present. Above all, it is their higher levels of education or qualification that result in them being paid higher.

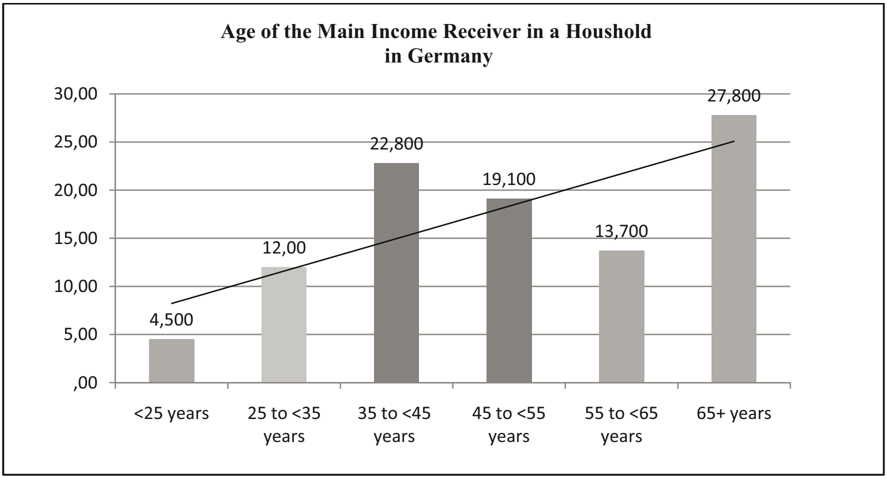

Figure 5: Age of the main income receiver in a household in Germany on 01.01.2008 (Own representation based on Federal Statistical Office 2009, p. 8)

The elderly people between 45 and 60 years old belong to the inheriting generation. For example, in the year 2003, this group inherited around 200 billion Euros (see Gassmann and Reepmeyer 2006, p. 34; Hupp 2000). Life insurances play a role in improving the economical situation of the elderly as well.

The elderly people are an economically interesting target group, a study by ACNielsen (2004) categorised the elderly people into five types of consumers as shown in Table 3.

Table 3: Various types of elderly consumers and their daily expenditure in billions of Euros and in (%) respectively

Types of elderly consumers	Expenditure for daily goods (billions of Euro)	Expenditure for daily goods (%)
oldies	27.4	23.9
don't know	9.1	8
up-to-date	14.1	12.3
well-educated	18.8	16.4
adventurous	3.2	2.8

(Own representation based on ACNielsen 2004)

The types are "oldies," "don't know," "up-to-date," "well-educated," and "adventurous," elderly and their expenditures. This shows how traceable the elderly people's impact is on a daily bases. For example, the "oldies" spend 27.4 billion Euros (23.9%) on their daily goods. From a demographical prospect, the share of elderly consumers will increase to 386 billion Euros that is to say more than 41% of total household's expenditure in Germany by 2050 (Schaible et al. 2007). In summary, the elderly consumers build a new confident consumption generation and a market force for marketers.

2.3.3 Health of Elderly People in Germany

According to Lehr (2002, p. 89), the elderly people of today are healthier than those from other generations. Today's elderly are more conscious of their health and take responsibility for living a healthy life. Despite the consciousness of the health issue by the elderly, however, ageing as a natural inevitable process results in that the elderly person becomes fragile sooner or later. For instance, ageing is defined mainly as a decline in the biological capacity of the human body (see Baltes and Baltes 1994, p. 10). Therefore the physical and cognitive declinations and changes of ageing will occur at a certain point for the elderly person (for a comprehensive presentation of the changes because of ageing, refer to Hupp 2000, pp. 14-61). The most frequent changes are summarized in Table 4 (see to Moschis 1992, pp. 77-108; Voelpel et al. 2007, pp. 210-213; Hupp 2000, pp. 14-61; Abu-Assab 2011, p. 267).

Table 4 illustrates that potential changes may occur in the muscle, heart circulation, respiratory, neurological, and gastrointestinal systems. Each row lists the possible effect as an example. However, the effect and its timing differ from one person to the next. Consequently, new needs emerge for elderly people in the process of adapting to the natural changes and coping with their new conditions.

Table 4: Conditional changes due to age and the possible potent effect on elderly persons

Body systems	Conditional Changes due to Age	Possible Changes due to Age
Muscle System	Muscle elasticity & mass diminish	Reaction time decreases
	Bones lose minerals	Bones become brittle & fracture easily
	Joints degenerate	Range of motion becomes limited
	Skeletal becomes instable & the discs in spine shrink	Spine is less flexible
Heart Circulation System	Cardiac output & recovery time shrink	Heart rates take longer to return to normal after exercise
	Heart rate becomes normally slower	Blood flow to all organs decreases
	Elasticity of the arteries decreases	Blood pressure increases
Respiratory System	Lung capacity decreases	Risk of pneumonia & lung infections increases
	Alveoli in lungs thicken	
Neurological System	Blood flow decreases and reduces oxygenation of brain	More time is taken for motor activities
	Nerve terminals that provide data to brain deteriorate	Motor activities are proceed slower
	Eye lenses become less elastic	Dim lights are difficult to be seen
	Eye lenses turn yellow	Colour perception is distorted; blurred vision
	Fluid within the eye is more consistence	Eye takes longer to adjust
	Neurons in ears decrease	Hearing becomes difficult
	Temperature and pain diminish	Pain is not easily felt
Gastrointestinal System	Salvia production decreases	Sense of taste diminishes
	Tooth enamel thins	Increased possibility of periodontal diseases

(Own representation adapted from Moschis 1992, pp. 77-108; Voelpel et al. 2007, pp. 210-213; Hupp 2000, pp. 14-61)

Gassmann and Reepmeyer (2006, pp. 31-58) categorised these needs into five main domains namely:

- Health
- Safety and security
- Independence
- Mobility
- Participation

The five categories above are comprehensive and comply not only with the needs of elderly people but also with the needs of young people. The main difference between demands of the elderly and the young is the degree of intensity. The elderly people demands are more intensive. Moschis (1992, pp. 155-193) stated that some products and services (daily newspapers, health insurance, blood pressure devices, vitamins, certain medications, garden devices, flowers and vegetables, and bus travel among many others) are more sought after by elderly consumers than compared to young consumers.

Although companies are aware of the acute changes of the demographical development and their consequences, much still lies ahead that must be done to deal with the situation. On the economical level, few studies investigated the potential products and services available to meet the needs of elderly people. The successful mix for the implementation of new innovative technologies and products for elderly people is based on both the technology push and the market pull controlled by the drive of the companies. In short, the success of the future market is dependent on bringing new technologies and new markets, consumers and applications together (Gassmann and Reepmeyer 2006).These changes should be also taken into consideration not only on the product development level, but also in the way to get and run market research.

2.3.4 Technology and Elderly People

Technology enhances societies and brings them forward. Technology used for the improvement of the daily life of elderly people is called "gerontotechnology" and/or "gerontechnology". The core purpose of gerontotechnology is to enable the elderly people to be independent and mobile despite of the degree of cognitive and/or physical limitations of ageing. This new field of study incorporates life science technologies, sensor technology, micro- and nanotechnologies, material technologies, and information and communication technologies (Gassmann and Reepmeyer 2006, p. 71). A prerequisite for a successful technology implementation in the market is its degree of diffusion. Rogers (2003, p. 5) defines diffusion as "the process in which an innovation is communicated through certain channels over time among the members of a social system." The diffusion of technologies and innovative products for elderly persons is dependent on their willingness to accept the innovations and technologies. However, the degree of readiness of the elderly is still disputable. Hence the willingness of the elderly people to accept new technologies is an important measure that affects the development of markets and technologies. Hock and Bader (2001) surprisingly showed in their work that elderly people accept new technologies relatively well. Furthermore, Hock and Bader (2001) also clustered the attitudes of elderly people towards technology into three main groups: technology freaks, technology enthusiasts, and technology deniers. The freaks are keen on new technologies and curious to test new things. The technology enthusiasts are rather interested in technology but they need support. As for the deniers, they have consciously decided against technology use. Other study results diverge with the idea that elderly people are neither “enemies” nor “uncritical users” of technology (e.g. Wahl and Mollenkopf 2003, p. 226).

After exploring the important issues of the socio-economical situations of elderly in Germany, it is interesting for the present research to view the market research methods for the elderly. The next section gives an overview of it.

2.4 Market Research Methods and Elderly People

Against this overview of the demographics and socio-economic situation of elderly people in Germany, the importance of this target group in general as well as in their role as consumers becomes obvious. Accordingly as consumers, it is essential to identify their wants and desires as well as their special needs that stem from the changes caused by ageing (e.g. see Section 2.3.3 and Section 2.3.4). In order to do so, among the tools available for companies and service providers[7] to identify and study their elderly customers, there are common research tools.

A review[8] of studies concerned with elderly people as target group reveals that researchers use the common research tools; however, certain research tools are used more frequently than others. As seen in Table 5, qualitative research methods were used more often when working with the elderly than quantitative research methods. Face-to-face interviews, focus groups, telephone interviews, and in-depth interviews are popular for use with the elderly (e.g. Becker and Atz 2008; Telser and Zweifel 2002; Kim et al. 2005). One reason for this can be related to the fact that quantitative research methods require more cognitive effort from the respondents; on the other hand, by using qualitative research methods, researchers can obtain more specific information from interviewees. In working with the elderly, researchers tend to observe their attitude and behaviour

7 Service providers like the healthcare and public transportation sectors, as well as any party dealing with elderly people.

8 The literature review was conducted using the research database services from Emerald, ScienceDirect, Business Source Premier EBSCOhost, and Wiley Interscience (n=40).

and use the usability test[9] (Schade and Amelung 2008; Jorge 2001; Tang and Kao 2005). In doing so, the researchers can conclude the needs and requirements of the elderly that they do not clearly express for one reason or another (e.g. old age). Another research form used in studying the elderly people is by reviewing literature or content analysis (Silverstein 2008; Kooij et al. 2007; Carrigan and Szmigin 1998).

With quantitative methods, researchers use often the written questionnaires (Lancaster and Williams 2002; Eastman and Iyer 2004; Joseph et al. 2008). However, researchers also use the combination of qualitative and quantitative research methods with elderly people which definitely enrich the field of research (Wray and Hodges 2008; Birtwistle and Tsim 2005). For the purpose of the present work, it is interesting to further investigate the use of preference analysis methods (see Chapter 3) and quality function deployment method (see Chapter 4) usage in market research for elderly people.

The review shows that the conjoint analysis is often used to obtain the preferences of the elderly people (Svensson 2003; Alves et al. 2008; Huang 2011; Okayama and Sawai 2010) and QFD is also used with elderly people in directly obtaining their requirements (Jung et al. 2008; Abu-Assab and Baier 2010).

However in this field, many researchers indicated that special considerations must be made when conducting the conjoint analysis for elderly people. For example, Svensson (2003) investigated whether conjoint analysis method is applicable for obtaining the preferences of the elderly people on the example of public transportation in Sweden. She concluded that the conjoint analysis is a possible method to be used for the elderly people; however, she added that special considerations must be made in the design of the experiment.

Table 5: Review of selected studies and the research methods used for the elderly

Study	Research methods used for elderly people
Bond (1991)	▪ Review of 33 segmentation of the mature market.
Carrigan and Szmigin (1998)	▪ Content analysis of a sample of magazine advertisements appearing in *Good Housekeeping*, *Women's Journal*, and newspaper advertisements appearing in weekday editions of the *Daily Telegraph*.
Markham et al. (1999)	▪ Conjoint analysis
Jorge (2001)	▪ Observed or predicted user behaviour and needs of elderly

9 For the definition of usability test refer to DIN EN ISO 9241.

Table 5: Review of selected studies and the research methods used for the elderly

Study	Research methods used for elderly people
Lancaster and Williams (2002)	▪ Written questionnaire ▪ Qualitative research: in-depth telephone interviews
Telser and Zweifel (2002)	▪ Face-to-face interviews with elderly
Skjoldborg and Gyrd-Hansen (2003)	▪ Interviews
Eastman and Iyer (2004)	▪ Survey questionnaire ▪ Review by a panel of elderly consumers for its legibility, length and overall usability ▪ Elderly people between 65-85 (purchased from a direct mail company; n=1496)
Mihailidis et al. (2004)	▪ Tracking module (through observation, real time tracking)
Carrigan et al. (2004)	▪ Collection of individual interviews
Birtwistle and Tsim (2005)	▪ Exploratory qualitative examination (qualitative and quantitative phase
Tang and Kao (2005)	▪ Usability test surveying the usability of mobile phone operations for elderly ▪ Structural interviews (to verbally express the elderly thinking processes)
Börsch-Supan et al. (2005)	▪ Questionnaire administered face-to-face by CAPI and self-completion drop off part
Kim et al. (2005)	▪ In-depth literature review ▪ 10-minute survey (n=419)
Loretto and White (2006)	▪ Literature review of existing research towards older workers ▪ Focus groups of employers conducted in four areas in Scotland
Kooij et al. (2007)	▪ Literature review (e.g. age-related factors and motivation to work)
Kim et al. (2007)	▪ Qualitative and Contextual research on elderly users
Niemela-Nyrhinen (2007)	▪ Mail survey (n=620)
Reisenwitz et al. (2007)	▪ Undergraduate students were asked to administer questionnaires to those respondents who were 65 years of age or older
Joseph et al. (2008)	▪ Written self-mailed questionnaire
Badras et al. (2008)	▪ Cooperation between producer and the elderly customers by "Senior work groups"
Becker and Atz (2008)	▪ Face-to-face interviews ▪ In-depth interviews
Eller (2008)	▪ Usability engineering (System Acceptance)

Table 5: Review of selected studies and the research methods used for the elderly

Study	Research methods used for elderly people
Grauel and Spellerberg (2008)	▪ Test of assisted-living house ▪ Questionnaire
Rieder et al. (2008)	▪ Qualitative study, Focus group and interviews with 25 elderly person
Schade and Amelung (2008)	▪ Usability test with elderly people
Silverstein (2008)	▪ Literature review (e.g. on demographic trends)
Ong et al. (2008)	▪ Based on a non-probability quota sampling (n=1500 older people) ▪ A questionnaire
Wray and Hodges (2008)	▪ A total of 50 females' participants aged 41-65 were asked to view two print advertisements. Participants then responded to a four-part questionnaire that included a measurement of cognitive age, physical activity, response to the advertisements, and purchase intent.
Alves et al. (2008)	▪ Choice-based CA for elderly; (n=237)
Cardona (2008)	▪ Qualitative interviews
Sudbury and Simcock (2009)	▪ Self-administered questionnaire (based on Quota sampling)

(Own representation)

Table 5 shows that different types of conjoint analysis are used in market research for elderly people. For instance, Alves et al. (2008) used choice-based CA for elderly. Many examples stem from the health care sector; health care researchers use different types of conjoint analysis to discover the elderly patients' needs and requirements in this important sector. In doing so, many researches try to fit the method to meet better the elderly respondent.

To sum up, it is obvious from Table 5 that qualitative and quantitative market research tools/methods are used to gather the requirements of elderly people as well as the combination between them. This literature review also shows that many researchers directly or indirectly adapted research methods to better fit the elderly respondent in order to make it easier for them to answer the research, and consequently to get better results. The literature overview conducted in this section, in a way or another, shed light on a number of deficits of using the available market research methods directly to obtain the needs and requirements of the target group of elderly people. The current research attempts to address this issue. To do so, this work used the preference analysis methods; self-explicated and conjoint analysis integrated into QFD and tested for elderly people to discover their needs and wants. The next chapter present the aforementioned methods.

3 Methods of Preference Measurement

3.1 The Compositional Approach: The Self-Explicated Method

3.1.1 Overview of the Self-Explicated Method

The compositional self-explicated (SE) method[10] is one of the three main approaches used in marketing to measure the preference structures of respondents (Green and Srinivasan 1990, p. 9). Its main underlying idea is that it asks respondents directly about their preferences of a product and is based on an additive model (Hensel-Börner 2000, p. 15). The SE method is considered an alternative to the decompositional conjoint analysis method.[11] In this section, an overview of the SE method is presented.

SE models were known in the early 60's by Hoffman (1960) and Pollack (1962) as well as Shepard (1964) (Green and Schaffer 1991, p. 476; DeFee 1982, p. 243). Since then, the SE method became one of the main research areas in consumer research (Kapur et al. 2008, p. 45). Accordingly, many researchers were interested in working with the method (e.g. Huber et al. 1969; Hoepfl and Huber 1970). With the introduction of linear additive models (Wilkie and Pessemier 1973) in marketing, further research was conducted especially on the question of the necessity of importance weights in SE methods (Green and Schaffer 1991, p. 476; see also Dawes and Corrigan 1974; McClelland 1978; Curry and Faulds 1986; Green and Krieger 1986).

The main trends in the research of the SE methods since its development are directed in three main streams: (1) comparing the SE method to conjoint analysis methods, for example many studies have compared the full profile method to the SE method (Green et al. 1981; Cattin et al. 1982; Cattin and Weinberger 1980; Akaah and Korgaonkar 1983; Srinivasan and Wyner 1989; Oppewal and Klabbers 2003), (2) suggesting new approaches to improve the SE methods in order to overcome its limitations (Srinivasan 1988; Srinivasan and Wyner 1989; Netzer and Srinivasan 2011), and (3) proposing new approaches to improve the conjoint analysis methods by combining them with the SE method in order to overcome some problems of the conjoint methods and to obtain the advantages of the other method (Green et al. 1981; Johnson 1987; Srinivasan and Park

[10] In this chapter, the compositional self-explicated and the decompositional conjoint analysis methods are handled because they are relevant to the empirical studies.

[11] For information about conjoint analysis see Section 3.2.

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1997; Park et al. 2008). Examples such as hybrid conjoint analysis (Green et al. 1981; Ter Hofstede et al. 2002), adaptive conjoint analysis[12] (Johnson 1987), and the partial Profile choice-based conjoint analysis method (Orme et al. 1997) were introduced (see Netzer and Srinivasan 2011, p. 141).

The SE approach is considered a good alternative to the decompositional conjoint analysis. The main advantages of the SE approach are the simplicity and easiness of the methodology for both the researchers and the respondents compared to the effort required by the conjoint analysis method (see Section 3.3). Consequently, it imposes less cognitive effort on the respondents when conducting the interviews (Srinivasan and Park 1997, p. 286). Because of this, SE methods are recommended for use with complex products consisting of a large number of product attributes (see Green and Srinivasan 1990, p. 9; Park et al. 2008, p. 563; Netzer and Srinivasan 2011, p. 140). For these main abovementioned reasons, the SE method is suggested to be more suitable for use with elderly people than the conjoint analysis method to figure out their preferences for the products. In the next section, the variants of the SE method are described.

3.1.2 Variants of the Self-Explicated Method

Self-explicated methods can be divided into two major categories: one-stage and two-stage SE methods (Dorsch and Teas 1992, p. 38). Recently, newly proposed SE methods have been developed taking into consideration the incentive effect (Park et al. 2008) and web-based data (Netzer and Srinivasan 2011).

3.1.2.1 One-Stage Self-Explicated Method

The one-stage SE method consists of a compensatory stage, which assumes that the respondents use a compensatory decision rule[13] in their evaluations of the product attributes (Dorsch and Teas 1992, p. 38). According to Huber (1974, pp. 1398-1399) the compensatory SE method consists of two main steps: (1) determining the utility of each level

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[12] For details about adaptive conjoint analysis see Section 3.2.2.2.

[13] Compensatory decision rule concerns trade-offs between the low utility on one attribute and a high utility on another (Hartmann and Sattler 2002, p. 5).

of each attribute on a 0-100 scale and (2) estimating the relative importance of each attribute on a 0-1 scale, where 1 is assigned for the most important attribute and set it as the anchor[14] attribute for determining the importance of the rest of the attributes and for the least important attribute (for detailed steps and calculations of the utilities and attribute importances refer to Huber 1974; see also Green et al. 1981; and Leigh et al. 1984). Though the method is simple and easy, it has its disadvantages, for example, the method of defining the attribute importances is ambiguous and the importance ratings should be defined as the range between part-worths within an attribute (see the discussion in Srinivasan 1988, p. 296). The conjunctive-compensatory SE method was proposed to overcome the problems of the compensatory stage SE method (see next Section).

The traditional conjoint analysis also assumes the compensatory behaviour of the respondents as does the one-stage SE method. This has encouraged researchers (see, e.g., Cattin and Weinberger 1980; Teas and Dellva 1985; Wind et al. 1968) to test the convergent validity (see Section 3.3.3) of the two approaches in order to measure the degree of correlation between the respondents' preferences in the two methods (Dorsch and Teas 1992, p. 38). The results of the comparisons do not favour either method over the other. Some studies yielded similar results (e.g. Cattin and Weinberger 1980); whereas others showed a low correlation value of the convergent validity between the two methods (e.g. Akaah and Korgaonker 1983, Wright and Kriewall 1980). The comparison between the SE and conjoint analysis methods are further handled in Section 3.3.

3.1.2.2 Two-Stage Self-Explicated Method

The two-stage SE method consists of a conjunctive and a compensatory stage (Klein 1986; Srinivasan 1988; Green et al. 1988). The main idea of the SE method is differently implemented by various researchers (Green and Srinivasan 1990, p. 9). In this section, the conjunctive-compensatory SE approach suggested by Srinivasan (1988) is described as an example of the two-stage SE method since it is implemented in the new suggested approach in the present work.

[14] An anchor attribute, in the sense, that the rest of the attribute is trade-off according to it (see Srinivasan 1988, p. 297; Huber 1974, p. 1399).

Srinivasan (1988) suggested an SE approach called "Conjunctive-Compensatory SE" (CC-SE) that incorporates conjunctive[15] and compensatory stages. The basic idea in the conjunctive stage is to ask respondents to identify one or two (if any) "totally unacceptable levels" of each attribute. On the other hand, the basic idea in the compensatory stage is to rate the attributes and levels on a 0-100 or 0-10 scale with the least preferred yet acceptable level assigned 0 and the most preferred level assigned 100 or 10, respectively (Bucklin and Srinivasan 1991, p. 61). In doing so, the respondents are explicitly asked to rate the attributes and their levels to elicit the part-worths of the levels (for more details see Jain et al. 1979, p. 248; Green and Srinivasan 1990, p. 9) and subsequently to obtain the overall utility for the choice alternatives based on the multi-attribute preference model, in which a product is considered as a bundle of attributes (see Wilkie and Pessemier 1973, p. 428). The model is represented as follows (see Baier and Brusch 2009a, p. 13):

$$y_j = \mu + \sum_{k=1}^{K} \sum_{l=1}^{L_j} \beta_{kl}.x_{jkl}$$

Such that:

y_j	= overall utility of alternative j
μ	= average preference value of all alternative
β_{kl}	= utility of level l of attribute k
x_{jkl}	$= \begin{cases} 1 & \text{when the level } l \text{ of attribute } k \text{ in the choice alternative } j \\ 0 & \text{otherwise} \end{cases}$

This formula represents an additive utility model originating from the compositional model identified by Wilkie and Pessemier (1973, p. 429) based on the main assumption that the total utility value of an attribute is the sum of the utility value of each of its levels (Hensel-Börner 2000, p. 16). Figure 6 presents the main steps of the procedure of the CC-SE method (Srinivasan 1988, pp. 296-297).

Two terms need to be clarified, the "totally unacceptable" level and the "anchor" attribute. In step 1, the respondents should understand that when a product has a "totally unacceptable" level that means that this product will be rejected regardless of the other levels.

15 Conjunctive decision rule: when a product with one or more "totally unacceptable" levels is eliminated (Srinivasan 1988, p. 295).

Moreover, in step 3, a critical attribute is the most valuable attribute to the respondent, which is used as an anchor to estimate the importance ratings of the other attributes (see discussion in Srinivasan 1988, pp. 296-297).

Inform respondents about all attributes and their levels and identify *"totally unacceptable"* levels
Determine the "most preferred" and the "least preferred" level for each attribute, excluding the "totally unacceptable" levels
Identify the *"critical attribute"* and set its importance to 100 and elicit the importance ratings (0-100) for other attributes using the critical attribute as an anchor
Rate the *desirability ratings* of the different acceptable levels within the attribute and for each attribute on the scale with the least preferred (but acceptable level) = 0 and most preferred level = 100
Calculate the part-worths for acceptable attribute levels
Set the part-worths to fall in the range from 0-100 (To make the part-worths more comparable and readable)

Figure 6: Main steps of self-explicated approach suggested by Srinivasan (1988) (Own presentation based on Srinivasan 1988, pp. 296-297)

Additionally, in step 5, the part-worths of the levels are calculated as follows (Dorsch and Teas 1992, p. 39; Srinivasan 1988):

$$PW_{kl} = \frac{\alpha_{kl} x_{kl}}{100}$$

Such that:

PW_{kl}	Part-worth of level l of attribute k
$\alpha_{kl} =$	Self-explicated desirability rating of level l of attribute k
$x_{kl} =$	Self-explicated importance rating of attribute k

The advantages and disadvantages of the CC-SE method are considered in Section 3.1.1.

3.2 The Decompositional Approach: The Conjoint Analysis

Conjoint Analysis is still an active research area after forty years since its introduction by Green and Rao (1971) in marketing. In this section, an overview of the conjoint analysis and its variants is given. The history and term are sufficiently handled in the next sections and references are given to thoroughly sources dealing with the subject.

3.2.1 Overview of the Conjoint Analysis

The underpinnings of conjoint analysis (CA) stem from the fifties and sixties.[16] It basically evolved from the seminal research of Luce and Tukey 1964. In their paper, the authors addressed axiomatic approaches to fundamental measurement (Luce and Tukey 1964, p. 2). Conjoint measurement's advent was fundamentally based on the progress achieved in the following years in applied psychology, decision theory, and economics. The basic work on the expectancy-value class of attitude models by Fishbein (1967) and Rosenberg (1956) above and beyond the fundamental work by Addelman (1962a; b) in fractional factorial design were the essential prerequisites that paved the path to the adoption and further development of conjoint measurement and later conjoint analysis[17] in marketing (see Figure 7).

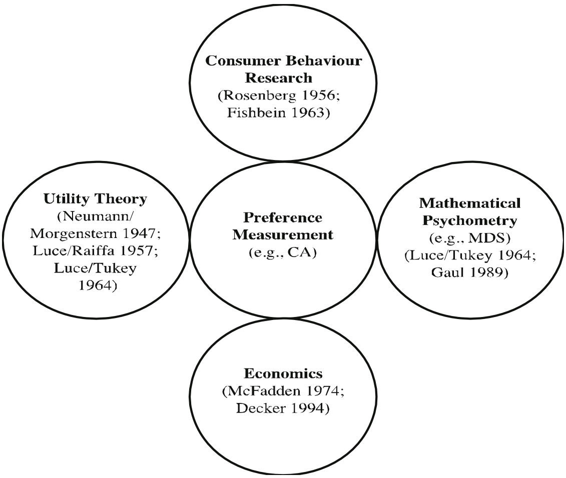

Figure 7: Mainstream theories behind conjoint measurement (Own representation based on Aust 1996, p. 21)

Conjoint analysis was first introduced in the beginning of the seventies by Paul Green (refer to Green 1970; Green and Rao 1971; Green at al. 2001) and further developed dur-

[16] The foundations of the field, however, go back to at least the 1920s (see Green and Srinivasan 1978, p. 103).

[17] Some authors use both terms as synonyms while others make a clear differentiation. Green and Srinivasan proposed the name conjoint analysis for the work done in the area of marketing to differentiate the method from psychological work (Green and Srinivasan 1978, p. 103).

ing the seventies until today (see also, e.g., Johnson 1974; Green and Srinivasan 1978; Green and Srinivasan 1990).

The main underlying idea of CA[18] is based on analysing trade-offs made by respondents relating to their preferences as well as their intentions to buy (Green et al. 2001, p. 57). In other words, "CA is a decompositional approach in which a researcher tries to infer a consumer's preference for each attribute level on the basis of his/her stated preferences/choices for selected versions of the product" (Park et al. 2008, p. 562). Orme (2010, p. 29) simplifies it as follows: "It is the proposition that the value of a product is equal to the sum of the values of its parts". The CA is based on the mathematical concept of calculating the total utility from the levels' utilities based on the additive utility and multiplicative models (Reiners 1996, p. 59).

3.2.2 Variants of Conjoint Analysis

In this section, the main variants of conjoint analysis for the purposes of the work are presented. The traditional conjoint analysis is basically needed to illustrate the main backbone of the methodology. Then ACA will also be presented as a major method used in the empirical part later in this work. After more than 40 years of conjoint analysis, the method is well presented in so many publications and books, for this reason the author will not be extensively handling the methods. However, the readers will be supplied with the appropriate resources to be (re)considered when needed.

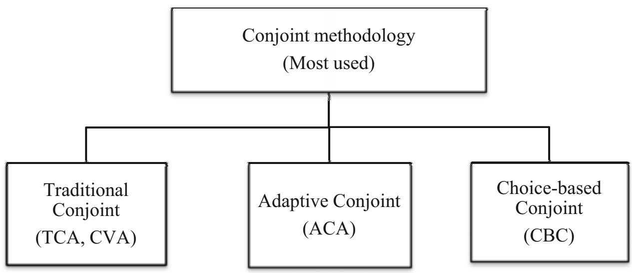

Figure 8: The three most used conjoint methodologies
(Own representation adapted from Hair et al. 2008, p. 274)

[18] A quick definition of the main terms used in CA in this work: **Attributes** are chosen characteristics that describe a product; **Levels** are the various values that an attribute takes; the **full profile** is a presentation of all attributes at a certain level to be evaluated (presents also **state preference**); the **choice set** is given to a respondent to make a choice (presents **stated choice**) from a pre-specified number of profiles (Rao 2008, p. 26).

Figure 8 illustrates the main conjoint variants used in research and practice: Traditional conjoint analysis (TCA), adaptive conjoint analysis (ACA), and choice-based conjoint analysis (CBC). Nevertheless, one of the important decisions in the methodology is to decide for a method that serves the research objectives.

To do so, the main decisive characteristics which help determine which method to use are summarised in: number of attributes, level of analysis, model form, choice task, and data collection format. For example, the number of attributes is crucial: CBC has been dominating recently, Green and Srinivasan (1990) recommend using CBC for a maximum of six attributes (see also Hair et al. 2008, p. 278). As for the ACA, there is a unanimous agreement by researchers that it should be used for large number of attributes (i.e. more than 10 attributes). The other factors that influence the decision are presented in Table 6 (for a detailed discussion of these points, refer to Hair et al. 2008, pp. 278-293; Green and Srinivasan 1990; Green and Srinivasan 1978.

Table 6: A comparison of different CA methods in regard to the main characteristics

	Conjoint Methodology		
Characteristics	**Traditional CA**	**ACA**	**CBC**
Max. of attributes	9*	30	6
Level of analysis	Individual	Individual	Aggregate or individual
Model form	Additive	Additive	Additive + interaction
Choice task	Evaluating full-profiles one at a time	Rating profile containing subsets of attributes	Choice between sets of profiles
Data collection format	Any format	Generally computer-based	Any format

(Own representation adapted from Hair et al. 2008, p. 278); Note (*): Hair et al. (2008) recommended 9, whereas Green and Srinivasan (1990) recommended no more than 6 attributes for a traditional full-profile conjoint analysis

The adaptive conjoint analysis is obviously more rigid than TCA and CBC in the data collection format since it can be only conducted using computer. This inflexibility-effect can be sensed when the target group is the elderly people as will be seen later in the work. All three common methods are rated on the individual levels and CBC can also be analysed on the aggregated level. As for the choice task, the TCA method uses the full-profiles one at a time which makes it unfavourable to use with many number of attributes compared to the ACA and CBC. In the next section the traditional conjoint analysis and adaptive conjoint analysis are further described. Choice-based conjoint analysis is not implemented in the present work and therefore is not handled.

3.2.2.1 Traditional Conjoint Analysis

The traditional CA method confines 6 basic steps. In each step, a number of decisions should be taken according to the purpose of the study. An overall view of the steps and issues involved to make a decision are summarised in Table 7.

Table 7: Basic steps description of the TCA and the main issues related to each step

Main step description of Traditional CA	Issues to be determined
Identification of the attribute and levels	Preference model: Ideal-point model, vector model, part-worth function model, mixed model
Selection of data collection	Data collection: full profile vs. two-factor Number of Stimuli: full vs. reduced design
Estimation of stimuli	Measurement scale: Metric scales: rating scale, dollar-metric, constant sum scale, weighted pair comparison Non–metric scales: ranking, ordinal pair comparison Presentation of the stimulus: verbal description, pictorial, 3 dimensional representation, multimedia, prototype or physical product
Estimation of utilities **Metric total utility value for all stimuli** **Relative importance of individual utility**	Estimation method: Metric methods, non-metric methods, other statistical approaches
Estimation of total utility	Individual analysis, aggregated analysis

(Own representation based on Green and Srinivasan 1978, p. 105; 1990, p. 5; Backhaus et al. 2008, pp. 456-473; Perrey 1998, p. 66; Gustafsson et al. 2007, p. 5; Reiners 1996, p. 23)

The first step is considered very crucial in designing the whole conjoint experiment. Any inappropriate design makes a consequence on the profiles as well as on the accuracy of results. Thereof; special attention should be given for this step (Hair et al. 2008, p. 278). The attributes and their levels respectively should be chosen to meet some aspects as listed in Backhaus et al. (2008, pp. 456-457) (see also Hair et al. 2008, p. 279; Alpert 1971; Green et al. 1978, p. 104; Braun and Srinivasan 1975; Reiners 1996, pp. 30-36; Brzoska 2003, p. 76). An important issue is to determine the preference model/function namely: ideal-point model, vector model, part-worth model, or a mixed model (refer to detailed discussion in Green and Srinivasan 1978, pp. 105-107; Gustafsson et al. 2007, pp. 6-9). Then in this regard, it is disputable which sequence for choosing the attributes and levels or the preference function should come first. While Gustafsson et al. (2007, p. 6) consider that the first step should be selecting the preference model which determines the influence that the attribute would have on the preferences of respondents, Vriens

(1995) emphasises the importance of considering the other sequence since the preference model is basically used to calculate the preferences of customers (see Gustafsson et al. 2000, p. 10; Schweikl 1985).

In the second step, two main issues are decisive at this point for the data collection: the type of stimuli/incentives that will be used, namely a full profile (pairwise comparison) or trade-off matrix, and then the relevance issue concerning whether the respondents will evaluate all stimuli/incentives (complete factorial design) or only subsets of stimuli (reduced design) (Hair et al. 2008, p. 275; Gustafsson et al. 2007; p. 12), which is usually preferred (for a detailed discussion consult Addelmann (1962a), for the orthogonal main-effect design plans; Addelmann (1962b) for fractional factorial design; for comprehensive discussion about the aforementioned issues refer to Green (1974); and Gustafsson et al. 2007, pp. 12-13). It is worth noting that in order to reduce the design systematically, an orthogonal design in which the independence of the attributes is maintained (for a comprehensive discussion see Green et al. 1988). Hereof another point could be mentioned regarding the distinction between the presentations/manifestations of attributes (i.e. equal or varied): symmetrical and asymmetrical types of fractionated factorial designs (refer to Kuhfeld 1997).

In the third step, three crucial matters have to be considered. The first is basically the essential running of the experiment in which the form of survey administration is decisive (e.g. personal interviews, mail surveys, computer interviews) (see Vriens 1995). The two other issues that should be considered in the preparation of the survey are: (1) the selecting of the preference measure, as shown in Table 7, (i.e. metric or non-metric scale) and (2) the presentation of the stimuli or incentives (as in Table 7, e.g., pictorial, multimedia). For an elaborated discussion refer to Gustafsson et al. (2007, pp. 13-15), for point (1) and (2) respectively.

In the fourth step, the major issue is the estimation of the partial utilities or benefit values of the attributes and their levels, respectively. There are many estimations methods. However, the method or methods that can be used depend on (1) the preference model used (refer to Step 1 in this section) and (2) the scale measure used (refer to step 3 in this section) (see Vriens 1995; Reiners 1996, p. 133). (For a comprehensive literature overview of the most valuable publications and estimation methods consult Gustafsson et al. 2007, pp. 16-18; Reiners 1996, pp. 130-134).

Finally in the *fifth step*, from the partial benefit values or utilities which contribute to the utility of a preference on the individual level, the aggregate utility and the normalised individual utilities and the relative importance are calculated which are important for the researchers (for a detailed description and formulas as well as comprehensive examples see Hair at al. 2010, pp. 294-299; Backhaus et al. 2008, pp. 470-485; see also Gustafsson et al. 2007, pp. 18-28). Afterwards comes the validation of the conjoint results (see next section for more details) as well as the managerial applications of CA (e.g. segmentation, profitability analysis, conjoint simulators) which can also be calculated according to the needed results (see an in-depth examples from Orme 2010, pp. 67-103).

3.2.2.2 Adaptive Conjoint Analysis

As per the traditional CA approach (general approach), for the present work, the adaptive conjoint analysis is also essential since ACA is the main method used in the first two approaches in the empirical part. ACA is comprehensively handled in the literature. Therefore, in this section, the procedures of ACA will be passably described and the reader will be given further references to consult.

ACA was first introduced by Johnson 1987 (see also Green et al. 1991) based on the two-factor method (refer to Johnson 1991; Johnson 2001). ACA is computer dependent whereby today adaptive methods incorporate the commercial ACA from Sawtooth Software Inc. (Sawtooth Software 2002) and the adaptive self-explicated approach (Netzer and Srinivasan 2008, p. 342). The main idea underlying the ACA concept is processing sequential questions depending on the answer from previous questions (Rao 2008, p. 27). Since the introduction of ACA by Sawtooth Software, it became the most widespread conjoint software as well as the most commonly used conjoint technique. Although CBC has already become trendier in the last decade, ACA still finds its use and has unique benefits for many situations (Sawtooth Software 2007). In this section, the procedures of Sawtooth Software ACA will be described which are also used in the experiments (for a graphical summary see Bond 1991, p. 751).

In the optional prior Phase, the unacceptable levels are eliminated. In other words, the respondents are asked if there exists a level or more that they would not accept in any case regardless with which other additional levels combinations could be chosen. Then these eliminated levels are removed (see, e.g., Johnson 1987, p. 259). In doing so, the duration of interview will be shorter and hence respondents are less strained (Klein 1986, p. 154). On the other hand, this action would lead to a biased result (for details see discussion in Hermann et al. 2009, p. 117; Dorsch and Teas 1992, p. 39; Mehta et al. 1992) and many empirical studies (see e.g. Green et al. 1988, p. 293; Klein 1986, p. 154) have shown that the misclassifying of these attributes can lead to lower values of internal validity (see Green et al. 1988, p. 298). To avoid such biases, it is generally recommended not to use this option (Sawtooth Software 2007; Green et al. 1988).

In phase 1, the preferences for levels of each attribute are captured. In each question, only the preference of one attribute is asked at a time. Questions for price and quality are usually omitted since the answers are clear. The order of levels in this section can be ordered in “best to worst”, “worst to best”, or “no prior ranking” (Sawtooth Software 2007, p. 4). Moreover, these questions can be ranked or rated on a scale from 2 to 9 categories, though often a 7-scale rating is applied (for recommendations on scales refer to Sawtooth Software 2007, pp. 4-5; Hermann et al. 2009, p. 118).

In phase 2, the relative importance of each attribute is determined for each respondent based on the magnitudes of differences among the levels of an attribute. Alternatively, the respondents are asked to which degree the difference between the least and most important levels of each attribute is on a polar-rating scale (for an example on this issue refer to Sawtooth Software 2007, p. 5). From this phase, two conclusions could be drawn: First, it reveals unimportant attributes that can be eliminated, thus making a shorter interview. Secondly, initial estimates for the utilities could be calculated for respondents (see again Sawtooth Software 2007, p. 5, King et al. 2004). At this point, the compositional phase with all the prior information collected is completed.

In phase 3, the customised paired-comparison trade-off questions commence. This “ACA Pair” section is the decompositional conjoint tradeoffs part and represents the crux of the method (Gutsche 1995, p. 96). In this part, the respondents are shown two product profiles to evaluate according to their preference and asked to indicate the strength of the preference on a rating scale (e.g. 7-point scale or 9-point scale). It should be noted that the number of trade-off pairs as well as the number of attributes (two or/and three) are assigned by the interviewer (for the recommendation of the number of attributes and pairs comparison, refer to Sawtooth Software 2007, p. 6; Johnson 1987, p. 261; for a comprehensive discussion on this issue see also Ernst 2001, pp. 52-53; Reiners 1996, p. 79. The special feature of the adaptive conjoint analysis is that the pair comparison phase starts with a crude set of utility values for respondents, and is then updated after each pair question.

These crude sets of values are the result of the prior phase. Each question selected by the computer for the respondent provides the most incremental information, based on the respondent's utilities calculated previously in prior phases. The process continues until a termination question is fulfilled (Sawtooth Software 2007, p. 7).

As for the parameter estimation of the ACA-pair, the software calculates the estimation of utilities in an indirect way depending on the first two phases and then refined by the third phase (for the parameter estimation refer to Baier and Gaul 2003, p. 126; Reiners 1996, pp. 119-120).

Finally in phase 4, the calibration phase, the software suggests a combination of fictional product profiles consisting of the most important attributes ranging from unattractive to very attractive to the respondent. The respondents are then asked to state their likelihood of purchasing these products (i.e. profile). The likelihood is entered in a sliding scale or as a numeric value into a box on a scale from 0-100% (Sawtooth Software 2007, p. 7). The purpose of this phase is to calibrate the utilities estimated from the prior phases of the interview for later utilisation in the purchase likelihood (Sawtooth Software 2007, p. 7). For a detailed interpretation of correlations between the prior estimation and calibration phase refer to Herman et al. (2009, pp. 122-123).

3.3 Comparison between Conjoint Analysis and Self-Explicated Methods

3.3.1 Advantages and Disadvantages of the ACA and the CC-SE

The advantages and disadvantages of the ACA and CC-SE methods are differentiated[19] in 9 criteria as follows (see Table 8):

The **form of the interviews** in traditional CA is indirect. The form of ACA interviews is direct in the conjunctive phase and indirect in the main conjoint phases (Section 3.2.2.2). One of the advantages of ACA is that it is adaptive, which means the questions are customised according to the respondent's prior answers to preferences. This makes ACA interactive. On the other hand, the form of interviews in the CC-SE method is direct in the conjunctive and compensatory phase.[20] In the CC-SE this might cause some

[19] For advantages and disadvantages of the CA and SE methods, in general, refer to Green and Srinivasan (1990), Vriens (1995), Hensel-Börner (2000).

[20] In the SE compensatory phase, respondents are asked to use the constant sum to rate the desirability of the attributes.

biases in the answers due to socially desired answers or the social effect (Netzer and Srinivasan 2011, p. 142; Srinivasan and Park 1997, p. 290). However, this issue is more critical in the SE method which consists of one phase (see the discussion in Oppewal and Klabbers 2003, p. 298; Hensel-Börner 2000, p. 40; see also Slovic and Lichtenstein 1971).

Another advantage of the ACA is that it simulates realistic purchase situations that respondents have to follow through in answering during their interviews which is not so in SE methods. However, the ACA in allows for individual preferences its conjunctive and conjoint phases but does not allow for heterogeneity in the choice process of the respondents (i.e. when the conjunctive phase is used, respondents have to do it); whereas the CC-SE allows for variation in the heterogeneity in the choice processes of respondents (i.e. respondents can use only compensatory choices by assigning "no unacceptable levels" in the conjunctive phase) or they can use the variation of the conjunctive-compensatory choices (see the discussion in Srinivasan 1988, p. 298).

Furthermore, ACA is also more realistic in the sense of using trade-offs; however, in designing the ACA interviews, researchers have to clearly explain the tasks involved; in contrast to the CC-SE method which consists of four steps (Srinivasan 1988) that respondents have to do, thus requiring less explanation.

The first software for conjoint analysis was the Sawtooth Software for ACA (Johnson 1987). Consequently, ACA became known in the late 80s and 90s of last century, as well as in the last decade. Currently, many conjoint software packages are available in the market not only for ACA but also for the other variants of CA.[21] On the other hand; CC-SE requires no software. Hence, it is more flexible in the presentation of the questions than the specific software to design ACA. ACA interviews have to be run online and/or have to use the Computer Aided Personal Interview (CAPI) in order for the questions to be customised to the preferences of the respondent after each new page. In contrast, the CC-SE method can be run in face-to-face, written, or online interviews. Recently, the SE method has become present in the scientific scene with a focus on web-

[21] (E.g. Bretton-Clark 1988; Intelligent Marketing Systems 1993; SAS Institute 1992; SPSS 2003; Sawtooth Software 2002; 2003a; 2003b; 2003c).

Table 8: Overview of a comparison of the advantages and disadvantages of ACA and CC-SE

Criterion	ACA	CC-SE
Interviews form	**Direct + Indirect** (+) evaluation of the product simulates a real purchase situation (+) adaptive; interactive questions (-) no heterogeneity in choice	**Direct** (-) distortions by social effect (-) not adaptive, static questions (+) flexible on individual behaviour (allow heterogeneity in choice)
Questions design	**Realistic** (+) respondents evaluate more than one attributes at a time (+) allows trade-offs (-) requires more explanation	**Less realistic** (-) direct questions (-) compensatory stage "constant sum" (+) requires less explanation
Software	**Require** (-) requires software (-) limited presentation possibilities	**Does not require** (+) no software is required (+) many presentation possibilities
Interview design	Online; CAPI	Face-to-face; written questionnaire; online
Number of attributes	**Many with more burden** (+) up 10 attributes and 9 levels (-) respondents can use simplification strategies	**Many** (+) reasonably large number of attrib-utes (-) difficult to allocate a constant sum across many attributes
Complexity	**High** (-) increases with an increase in number of attributes (-) requires high cognitive effort from respondents	**Low** (+) to some extent independent from the number of attributes (+) less cognitive load for respondents
Time requirement	**High** (-) high time used for conception (-) high time used for the evaluation of questionnaire (-) longer Interview's time	**Low** (+) less time for conception (+) data collection and evaluation are easy (+) shorter interview duration
Cost	**High** (-) high cost caused by Software pur-chase, interview design, incentives for respondents	**Low** (+) low cost to design the interview
Researcher's effort	**High** (-) high involvement and knowledge from researcher	**Low** (+) less involvement and knowledge from researcher
Model assumptions	**Flexible** (+) non-linearity in the preference func-tion can be considered	**Inflexible** (-) the additive preference model is assumed

(Own representation based on Hensel-Börner 2000, p. 39; Dubas and Mummalaneni 1997, p. 38; Dorsch and Teas 1992, p. 290; Baier 1999, p. 200; Brusch 2005, p. 25; Srinivasan 1988, p. 298); Legend: CAPI: Computer Aided Personal Interview; (+): advantage; (-): disadvantage.

based application (for further details refer to Park et al. 2008; Netzer and Srinivasan 2011). Regarding the number of attributes (see Section 3.2.2) in traditional conjoint analysis interviews, respondents can manage up to six or fewer attributes (Srinivasan and Park 1997, p. 286). Beyond six attributes, the respondents are faced with an information overload. As a result, respondents tend to simplify the process by using simplifying tactics. Thereupon the results of the relative importance of attributes and utility-values of the levels can be distorted, thus lowering the validity of the results (Srinivasan and Park 1997, p. 286). In an ACA interview, up to ten attributes[22] with nine levels can be managed. On the other hand, the CC-SE method can manage a large number of attributes (e.g. Pullman et al 1999, p. 126; Green and Srinivasan 1990, p. 11). However, it will be overwhelming even for diligent respondents as well as for elderly people to allocate a constant sum for a large number of attributes (Netzer and Srinivasan 2011, p. 142), therefore, the number of attributes used in CC-SE should be reasonable to manage for the respondents.

ACA being more realistic, results being more complicated and more cognitive effort being required from the respondents results in longer interviews. In this sense, the CC-SE method results in less complexity of the interview design when a reasonable number of attributes is used. This also means that less cognitive effort and less time are needed for the respondent and the interview, respectively.

On the researcher's side, a high effort is required in designing the ACA interview, running the questionnaire, and in evaluating the results. In contrast to the ACA, the CC-SE method requires reasonable effort but less than that required for ACA. Consequently, ACA results in higher than the CC-SE.

In summary, it is obvious that the balance of the advantages and disadvantages are not equal for both the ACA and CC-SE methods. In Table 8, the CC-SE method shows more positive points than the ACA. In the literature, it is agreed that SE as well as CC-SE's main advantages are that they are easier to design and to answer, require less time, thus demand less cognitive effort from the respondents. Consequently, the resulting cost of running the CC-SE is convenient (Green and Srinivasan 1990, pp. 9-14; Hensel-Börner 2000, pp. 42-43).

On the other hand, ACA's main advantage is the flexibility of the preference model in comparison to the fixed model of CC-SE (see Table 8). The conjoint analysis and ACA methods are implicitly considered superior to the SE in almost all cases because of the expected higher predictive validity of the conjoint methods due to the fact that they are

22 According to Pullman et al. (1999, pp. 125-126), roughly speaking, the individual maximum ability to reasonably manage profiles is 30 as a benchmark.

more realistic than SE methods (Hensel-Börner 2000, p. 43). The question is if the main advantage of conjoint methods is more decisive than the many advantages of SE methods. This argument is investigated in the following section.

3.3.2 Comparison of Empirical Studies between CA and SE

In her work, Hensel-Börner (2000) compared the (1) CA and SE, (2) hybrid methods of CA, and (3) ACA and SE methods according to (1) reliability, (2) predictive validity, (3) external validity, (4) internal validity, and (5) discriminant validity, from 1970 until 2000. She concluded that most of the studies compared show that SE methods are comparable to CA, and that SE methods have even given better results than various adaptive methods.

This realisation has brought SE methods back on the research track. Consequently, researchers have tried to develop and improve on the existing SE and conjoint methods to improve their results and validities. In this section, the author further investigates the various methods of CA and SE in the period from 1990-2011 based upon and extending the work of Hensel-Börner (2000).[23] Generally speaking, it can be concluded from Table 9 that the evidences are mixed when considering the various validities' results of the comparison between the conjoint analysis methods and SE methods during the last 20 years. This conclusion agrees with the conclusion reached by Hensel-Börner (2000, p. 65). For example, predictive validity was investigated in 19 studies: Seven studies did not give clear preference of one method over the other, whereas eight other studies showed that SE methods outperformed CA, and four studies proved that conjoint analysis is better in estimating the predictive validity. Moreover, four studies tested the discriminant validity of the two methods; however the results of the comparisons did not show any clear superiority of any method. Similar results were concluded by the four studies that investigated the external validity. On the other hand, the convergent validity gave mixed results, ranging from no clear preference to the CA method outperforming the SE methods.

[23] For an extensive discussion of the compared methods refer to Hensel-Börner (2000, pp. 43-67).

Table 9: Overview of the comparison between SE and CA studies from 1990-2011 including Srinivasan's (1988) study

Study	Methods	Quality of Measure	Experimental Design		
			Product	n	N
Unclear statement, different results, no significance					
Green, Krieger, and Agarwal (1993)	SE ACA	Reliability	Automobiles	133 (Students)	8
Müller-Hagedorn et al. (1993)	SE CA	Discriminant validity	TVs	120	5
Müller-Hagedorn et al. (1993)	SE CA	Discriminant validity	Soft drinks	50	5
Stallmeier (1993)	SE CA	Discriminant validity	Spa marketing	268	3 /5
Baalbaki and Malhotra (1995)	CA SE	Discriminant validity	Marketing strategies	74	18
Agarwal and Green (1991)	CA SE	Predictive validity	Apartments	170 (Students)	6
Van der Lans and Heiser (1992)	CA SE	Predictive validity	Apartments	177 (Students)	6
Green, Krieger, and Agarwal (1993)	CA SE	Predictive validity	Automobiles	133 (Students)	8
Huber et al. (1993)	SE CA	Predictive validity	Refrigerators	393	5 9
Green, Krieger, and Agarwal (1993)	SE ACA	Predictive validity	Automobiles	133 (Students)	8
Hensel-Börner and Sattler (2000)	ACA SE	Predictive validity	Coffee	144	8
Hensel-Börner and Sattler (2000)	CCC SE	Predictive validity	Coffee	144	8
Hensel-Börner and Sattler (2000)	ACA SE	External validity	Coffee	144	8
Hensel-Börner and Sattler (2000)	CCC SE	External validity	Coffee	144	8
Dorsch and Teas (1992)	CA/SE	Convergent validity	Job offers	69 (Students)	9
Aggarwal and Vaidyanathan (2003)	FP (CBI) SER	Convergent validity	Refrigerators	42 (Students)	6
Scholz et al. (2010)	PCPM ACA CASEMAP	Convergent validity	Summer vacation packages	241 242 245	10
Kapur et al. (2008)	FP SE	Association (Chi-square test)	Tooth paste	100	6
Self-Explicated delivered better results					
Green, Krieger, and Agarwal (1993)	CA SE	Reliability	Automobiles	133 (Students)	8

Table 9: Overview of the comparison between SE and CA studies from 1990-2011 including Srinivasan's (1988) study

Srinivasan[24] (1988)	CC-SE CA	Predictive validity	Job offers	45 48 (Students)	8
Agarwal and Green (1991)	SE ACA	Predictive validity	Apartments	170 (Students)	6
Green and Krieger (1996)	Hybrid SE	Predictive validity	Telephones	600	15
Srinivasan and Park (1997)	FP SE	Predictive validity	Job offers	57 (students)	8
Srinivasan and Park (1997)	SE CCA	Predictive validity	Job offers	57 (students)	8
Park et al. (2008)	SE IAUM	Predictive validity	Digital cameras	88 (Student)	11
Netzer and Srinivasan (2011)	ASE ACA FPM	Predictive validity	Digital cameras	52 49 50	12
Netzer and Srinivasan (2011)	ASE ACA FPM	Predictive validity	Laptop computers	65 66 58	14
Conjoint analysis delivered better results					
Green, Schaffer, and Patterson (1991)	SE ACA	Predictive validity	Automobiles	96	8
Huber et al. (1993)	SE ACA	Predictive validity	Refrigerators	393	9 5
Pullman et al. (1999)	SE FP-CA	Predictive validity	National parks	390 (Students)	17
Oppewal and Klabber (2003)	FP SE	Predictive validity	Design of semi-detached houses	70 (Students)	13
Dubas and Mummalaneni (1997)	FP SE	Cross validity	Customer focus courses	173 (Students)	5
Scholz et al. (2010)	PCPM ACA CASEMAP	Convergent validity	Mobile phones	241 242 245	10

(Own representation based on Hensel-Börner (2000, pp. 45-47, 63-64) and updated by the author; see again Hensel-Börner for the duration from 1971-2000 listed according to CA methods); Legend: PCPM: Paired Comparison Preference Measurement (AHP); CBI: Conjoint Based Inference; SER: Self-Explicated Ratings; HII: Hierarchical Information Integration (Louviere 1984); CCA: Customized Conjoint Analysis

Interesting in this case are the two studies[25] concerned with the CC-SE method. According to Srinivasan (1988, p. 304), the CC-SE method yields a slightly better predictive

[24] Srinivasan's (1988) work is considered in the comparison because the conjunctive-compensatory SE method is the major method used in this work.

validity than that of the conjoint method. However Dorsch and Teas (1992, p. 45) tested the convergent validity of the CC-SE method to the full-profile method and concluded that the CC-SE method had a low convergent validity in both the relative part-worths as well as the attribute importances.

Recently, the trend is to use the preference methods with web-based applications or improve them by using the web (e.g. Dahan and Hauser 2002; Häubl and Murray 2003; Lee and Bradlow 2007; Park et al. 2008; Netzer and Srinivasan 2011). In the SE method context, Netzer and Srinivasan (2011, p. 140) suggested a web-based adaptive SE approach for multi-attribute preferences with more than ten attributes. As shown in Table 9, the new approach of the SE method outperformed the ACA in the predictive validity and solves some of the problems of the SE methods. This approach seems to be promising; however, it should be tested on other examples.

3.3.3 Assessment of Preference Analysis Results

In this section, the commonly used quality measures for the assessment of the results of the conjoint analysis as well as the self-explicated methods are described.[26] For conclusions and inferences from the results of an experiment to be accepted, the criteria objectivity, reliability, and validity must be tested (Berekoven et al. 2009, p. 80; Hermann and Homburg 2000, pp. 23-24).

The **objectivity** of a measurement depends on whether its results are independent of the person doing them (Berekoven et al. 2009, p. 80; Hermann and Homburg 2000, p. 23). In other words, when other persons, independent from each other, do the same experiment and get the same results, then the measurement is said to be objective (Berekoven et al. 2009, p. 80).

The **reliability** of a measurement is concerned with the accuracy of the gathered data. The measurement is reliable when it is precise and stable. That is to say, through the replication of the experiment the same measurements should be producible (Berekoven et al. 2009, p. 81; see also Cattin and Wittink 1982, p. 50; Berekoven et al. 1999, p. 8; as

[25] Green et al. (1988) investigated the "completely unacceptable" levels and came to a number of conclusions (see p. 298 for a detailed conclusion). His conclusion agrees with Klein (1986) as well as with Dorsch and Teas (1992) but not with Srinivasan (1988).

[26] In this section, the quality measures described are those handled in this work, for the remaining ones, literature sources are given.

well as the discussion in Green and Srinivasan 1978, pp. 114-116). In conjoint analysis, the reliability test is considered to be also a cross validity test for the method (for details see Green and Srinivasan 1978, p. 115).

Moreover, the validity of a measurement is when it measures what it should actually measure (Berekoven et al. 2009, p. 82). There are many types of validities that can be measured for an experiment, e.g., the internal validity, external validity, and convergent validity. The common validity types are described next in consideration of the conjoint analysis method.

The **internal validity** of a conjoint analysis measures the "goodness of the model". It is defined as the correlation between the estimated values and the observed values of the dependent variable presented by Pearson's (r) or Spearman's rho[27] (Green and Srinivasan 1978, p. 115). According to Sawtooth Software (1997, p. 1), the internal validity (consistency) is the correlation between the estimated utility values and the observed utilities in the calibration question, which is measured by the determination coefficient (R^2) (for further details see also Baier and Säuberlich 1997, p. 968).

The **external validity** of conjoint analysis, which is usually found in hypothetical settings, is defined as estimated by comparing the actual and predicted preferences using holdout question (Cattin and Wittink 1982, p. 50).

Moreover, the **predictive validity** is often calculated by comparing the predicted ranking from the individual's preference model and the respondent's preference ranking of brands in the market (Cattin and Wittink 1982, p. 50). The predictive validity is calculated by using various measures such as the rank correlation using Kendall tau and Spearman rho (for detailed measures, refer to Reiners 1996, p. 165; Brusch 2005, p. 32).

The convergent validity and the discriminant validity are assessed for the construct validity. The **convergent validity** tests if the measures of the constructs that are expected to correlate in fact do so (Straker 2006; see also Bühner 2006, p. 39); whereas the **discriminant validity** tests if the measures of the constructs that are expected not to interrelate in fact do not (Straker 2006; see also Bühner 2006, p. 39).

[27] Using Pearson's (r) or Spearman's rho depends on the dependent variable scale (see the discussion in Green and Srinivasan 1978, p. 115).

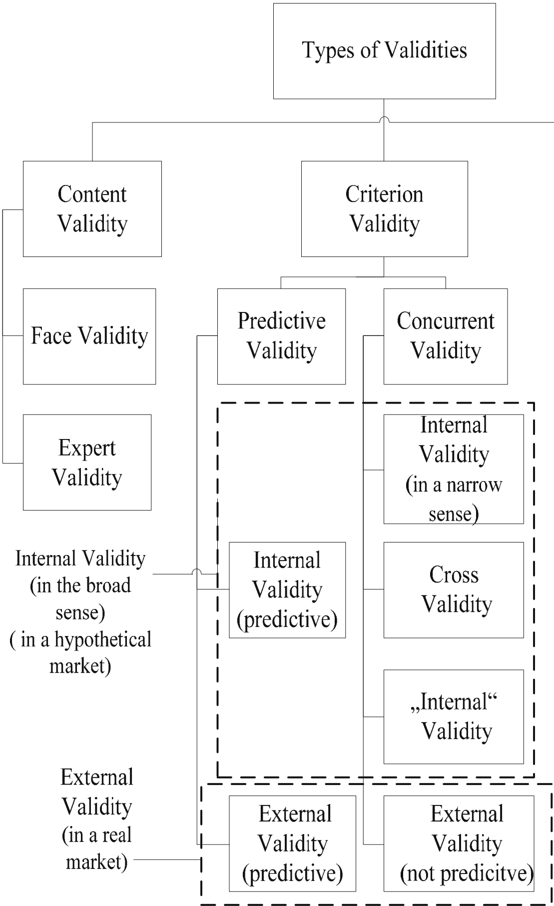

Figure 9: Overview of the types of validities
(Own presentation based on Brzoska 2003, p. 48; Hillig 2004, p. 120; Braun 2004, p. 106; Bühner 2006, pp. 38-41)

In Figure 9, an overview of the types of validities is schematically given. Its purpose is to help locate the described validities under their main categories, namely the criterion validity and the construct validity.[28]

[28] The remaining types of validities are not used in the work, and hence will not be described, however for a detailed description for all the types of validities mentioned in Figure 10 refer to, e.g., Brzoska (2003, pp. 46-51), Braun (2004, pp. 105-111), Hillig (2004, pp. 118-126), and Bühner (2006, pp. 34-44).

4 Quality Function Deployment in New Product Development

4.1 Basics of QFD

4.1.1 History of QFD

QFD was developed in Japan in 1966 as a result of extensive efforts to reach product development based on originality and not imitation. The method was introduced as part of the total quality control (TQC) concept, as a method for new product development (Akao and Mazur 2003, p. 20). Nevertheless, the real starting point of QFD was in 1972 with the publication of an article by Mitsubishi Heavy Industry and Akao's first publication in the monthly magazine *Standardization and Quality Control* (1972). However, it was not until the first book about QFD edited by Mizuno and Akao (1978) was published that the application of QFD increased in Japan (see Table 9 for the main milestones in QFD's history). In 1975, the Japanese Society for Quality Control (JSQC) created the Computer Research Committee.[29] This group dedicated the next 13 years to research on the method of QFD. Their final report in 1987 analysed the status of QFD applications in 80 companies in Japan (Akao and Mazur 2003, p. 22).

The success based on the quality of Japanese products during that time drew the attention and interest of United States (U.S.) companies (see, e.g., Bounds et al. 1994, p. 53; Clark and Fujimoto 1991; Garvin 1988, p. 217). Consequently, the introduction of QFD in the U.S. and Europe began with Akao's article published in *Quality Progress* in 1983 (Kogure and Akao 1983), (See Table 10).

This was followed by Bob King's GOAL/QPC[30] invitation to Akao to give a series of annual lectures presented to U.S. audiences for a period of four years (1986-1990) starting in Massachusetts (e.g. Akao and Mazur 2003, p. 23).

[29] In 1978, the Computer Research Committee was named QFD Research Group (Akao and Mazur 2003, p. 22).

[30] GOAL/QPC: stands for Growth Opportunity Alliance of Lawrence, Massachusetts/Quality Productivity Centre

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Table 10: The main milestones in QFD history in Japan, United States, and the world

Year	Key Name	Main milestones	Key references
QFD development in Japan (1966-1994)			
1966	**Oshiumi**	Process assurance items table by Bridgestone Tire Corp	Oshiumi (1966)
1972	**Akao**	First publication: the new approach “hinshitsu tenkai”	Akao (1972)
1972	**Nishimura; Suzuki**	Quality chart to quality deployment by Kobe shipyards of Mitsubishi Heavy Industry	Nishimura (1972); Suzuki (1972)
1972	**Ishihara**	Business process function deployment (narrowly defined QFD)	Akao and Mazur (2003)
1975	**JSQC**	Computer Research Committee devoted 13 years to QFD research	Akao and Mazur (2003)
1978	**Mizuno and Akao**	First book about QFD in Japanese (translated to English in 1994 by Mazur)	Mizuno and Akao (1978; 1994)
1987	**Akao**	Final survey report on QFD status in Japan	Akao et al. (1987); Akao and Ohfuji (1989)
1987	**JSA**	Book with a focus on QFD case studies in Japan translated & published in U.S. and Germany	Akao (1988)
1990; 1994	**JUSE**	Published a book and workbook about QFD	Akao (1990a; c); Ohfuji and Ono (1990;1994)
QFD introduction in the United States (1983-1988)			
1983	**Akao**	Introduction of QFD to U.S. & Europe: Akao published an article in *Quality Progress*	Kogure and Akao (1983)
1983	**King**	Akao was invited to introduce QFD at workshop in Chicago, Illinois	Akao and Mazur (2003); Cohen (1995)
1984-1991	**King; Clausing; Sullivan**	Presentations, seminars, courses, and trainings about QFD	King (1987); Cohen (1995)
1985	**Sullivan and McHugh**	A QFD project incorporating Ford Body and Assembly and its suppliers	King (1987); Cohen (1995)
1986	**Sullivan**	First article in *Quality Progress*	Sullivan (1986)
1986-1990	**King of GOAL/QPC**	Invitation of Akao for annual lectures about QFD in U.S.	Akao and Mazur (2003)
1988	**Hauser and Clausing**	Publication about QFD	Hauser and Clausing (1988)
QFD in other regions in the world (1987 and after)			
1987	**Germany**	First application in Germany	Saatweber (2007)
1988	**Sweden**	Three dissertations about QFD from the Linköping University	Andersson (1991); Gustafsson (1993); Gustafsson (1995)
1994	**China**	Invitation of Akao to QFD seminars	Akao and Mazur (2003)

(Own representation adapted from Akao and Mazur 2003 pp. 20-26; Cohen 1995, pp. 16-21; King 1987, pp. 34-38; Chan and Wu 2002a; pp. 464-466)

During the same period, the American Supplier Institute (ASI) in Dearborn, Michigan, started advertising QFD to the automotive industry, mainly to the “big three” car manufacturers General Motors, Ford, and Chrysler under the supervision of Akashi Fukuhara of the Central Japan Quality Control Association (CJQCA). At the same time, Don Clausing contributed with his lectures and seminars (see Cohen 1995, pp. 20-21) to the diffusion of QFD in the United States. Another important contribution to QFD dissemination was made by Robert M. Adams in 1989 through the initiation of the North American QFD Symposium, which provides an incubator for QFD research and case studies for viewing. Eventually, the QFD Institute in the United States was founded as a platform for all the rising activities in the QFD field by Glenn H. Mazur, Richard Zultner, and John Terninko in 1994 (Akao and Mazur 2003, pp. 23-24).

In Europe, for example, the United Kingdom started with QFD promotion since the eighties, whereas Ireland was active through Ian Fergusons' efforts (for details see Akao and Mazur 2003, p. 29). Sweden played a special role in the integration of QFD with other multivariate techniques, e.g., with Gustafsson's (1996) publication at the Linköping University (see Table 9 for other examples). On the other hand, Germany's first application was as recorded in 1987 by Saatweber (2007, p. 30). The German QFD Institute "QFD-Institut Deutschland" was established in 1996. This institute is an association of people interested in the methodology of QFD (QFD-Institute 2011) and its main function is the dissemination of QFD in the German-speaking region[31]. Similar to the United States annual QFD Symposium, the German-Institute offers an annual QFD Symposium of its own (Saatweber 2007, p. 31). In this year, the 17th International QFD Symposium (ISQFD'11) will take place in Stuttgart under the motto: "Achieving Sustainability with QFD". Moreover, the QFD-Institute offers certified QFD training since 2006 especially for its members (QFD-Institute 2011).

QFD has spread globally during the last three decades, reaching Latin American as well as far-eastern countries. For instance, companies in China and India have recently begun to adopt TQM and QFD respectively to improve their competitive position in the world market (see, e.g., Zhao et al. 1995; Sun et al. 2006; Yusuf et al. 2007, p. 509). Indeed, the interest in QFD in China was shown a little later, as the new product development started to gain attention, shown by inviting Akao to give lectures about QFD in China in 1994 (see Table 10). For other countries, refer to Akao (1997, p. 2), Akao and Mazur (2003, pp. 26-29), and Chan and Wu (2002a, p. 466).

[31] For further information about the QFD-Institute history and functions, refer to the website: www.qfd-id.de

Today, QFD has continued to grow and to develop, which could be observed in the various publications and the annual QFD symposiums that are well visited by researchers from all over the world.[32]

4.1.2 Definition of QFD

This section is concerned with the various key definitions of quality function deployment. However, first it is essential to define the two important terms “Total Quality Control” (TQC) and “quality”, which are the ultimate goal of using QFD. According to Feigenbaum (1961; 1991, p. 4): “Total quality control is an effective system for integrating the quality-development, quality-maintenance, and quality-improvement efforts of the various groups in an organisation so as to enable marketing, engineering, production, and service at the most economical levels which allow for full customer satisfaction.” On the other hand, quality as defined by Bergman and Klefsjö (1994, p. 16), “The quality of a product (article or service) is its ability to satisfy the needs and expectations of the customers” (see also Crosby 1979; 1996; Deming 1982; 1986; Feigenbaum 1951; 1983; 1991, p. 7; Ishikawa 1985; Juran 1951; 1992).

QFD focuses on the voice of the customer (VOC) and translates it into engineering quality or engineering characteristics. QFD is shaped from the combination, integration, and development of many concepts, starting with the quality assurance items (Oshiumi 1966), the quality deployment (Akao 1972) and continuing with the quality chart (Nishimura 1972; Suzuki 1972; Takayanagi 1972), value engineering which defines a function of a product, to the narrowly defined QFD,[33] and to the quality charts (Akao and Mazur 2003, pp. 21-22).

Quality function Deployment is the translation of the Japanese words “hinshitsu kino tenkai”. In its literal sense, it means deploying the attributes/features of a product/service accepted by customers throughout the relevant department of a company (ReVelle et al. 1998, p. 6; see also Cohen 1995, p. 17; Xie et al. 2003, pp. 1-2; Akao and Mazur 2003, p. 25; Mizuno and Akao 1994, p. 344).

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[32] For details concerning the expected development direction in QFD in recent years, refer to, e.g., Akao and Mazur (2003, pp. 30-32).

[33] For an exact definition of narrowly defined QFD refer to Mizuno and Akao (1978), and also Mizuno and Akao (1994, p. 16).

Table 11 summarises the key definitions of QFD by its founder, Akao (1990b, p. 3), by Sullivan (1986), by the American Supplier Institute (ASI) (1989), by King (1987, p. [1-9]) of GOAL/QPC, and eventually by Hauser and Clausing (1988, p. 63). All QFD definitions focus on the VOC. QFD transports the VOC throughout the organisation to produce/improve a product that meets or even exceeds customer satisfaction. In this sense, all key QFD definitions are customer-oriented. Moreover, according to King's (1987, p. [1-9]) definition, QFD is sometimes considered as the most advanced form of total quality control (TQC) (Xie et al. 2003, p. 2); whereas according to Hauser and Clausing (1988, p. 63), their QFD definition emphasises on the communication within the organisation and between its different departments (Chan and Wu 2002b, p. 24).

In summary, QFD enables the companies to focus on the customer and brings better communication between different departments in the company to achieve the optimum customer satisfaction. Afterwards, QFD enables the companies to make the necessary trade-offs between the customer requirements and their abilities and capacities to produce the optimum product (Bouchereau and Rowlands 2000, p. 9).

Table 11: Key definitions of QFD from key persons and institutes

Author/Institute	Key Definition
Akao (1990b, p. 3)	"A method for developing a design quality aimed at satisfying the **consumer** and then translating the consumer's demand into design targets and major quality assurance points to be used throughout the production phase."
Sullivan (1986, p. 39)	"An overall concept that provides a means of translating **customer** requirements into the appropriate technical requirements for each stage of product development and production (i.e. marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, sales)."
ASI (1987)	"A system for translating **customer** or user requirements into appropriate company requirements at every stage from research through production design and development, to manufacture, distribution, installation and marketing, sales, and service."
King (1987, p. [1-9]) of GOAL/QPC	"QFD is a system for designing product or service based on **customer** demands and involving all members of the producer or supplier organization."
Hauser and Clausing (1988, p. 63)	"A set of planning and communication routines, quality function deployment focuses and coordinates skills within an **organisation**, first to design, then to manufacture and market goods that **customers** want to purchase and will continue to purchase."

(Own representation)

4.1.3 The House of Quality

According to Akao (1997, p. 4), the House of Quality (HoQ) was given this name because of its "triangular top shape" which looks like a roof (Akao and Mazur 2003, p. 25;

see also Figure 10). The main purpose of the HoQ is to transform the "Customer Requirements" (CRs) into "Engineering Characteristics" (ECs) and assign target values for the product (van de Poel 2007, p. 21). Clausing (1994) described the HoQ as a matrix that provides a conceptual map for the product design process. Thus it is a construct for gathering and understanding the CRs as well as finding and prioritising the ECs. The cooperation among the marketing, the engineering, and the manufacturing departments of a company is necessary for building the HoQ. This cooperation leads to a greater new or improved product success and more profits for the company (Griffin and Hauser 1993, p. 3).

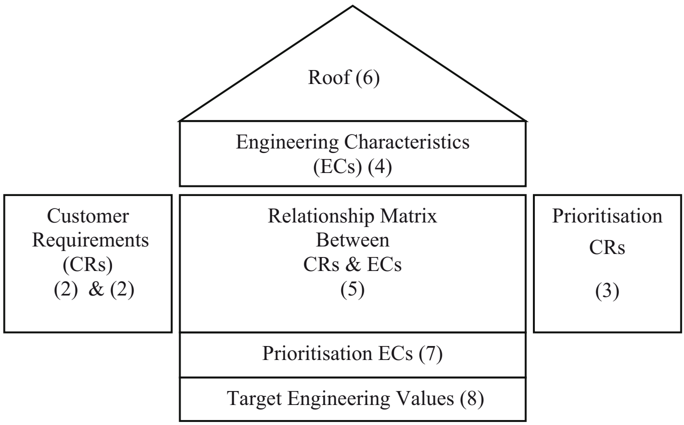

Figure 10: The house of quality (HoQ)
(Own representation)

The HoQ main steps can be summarised as follows (Griffin and Hauser 1993; Cohen 1995):

(1) Collecting the CRs,
(2) rating the importances of the CRs
(3) the customer rating of competitive products,
(4) determining the ECs,
(5) rating of the relationship matrix,
(6) rating of the correlation matrix,
(7) calculating the importances/priorities of the ECs, and
(8) determining the target engineering values for ECs.

Step 1 in the HoQ begins with the collection of the CRs. CRs are listed in the left side of the matrix (see Figure 10). Those CRs are the description of customers' needs, wishes, and expectations in their own words (see Terninko 1997, pp. 50-51; for further explanations see also Griffin and Hauser 1993, p. 4; King 1989, pp. [3-1]-[3-8]). Typically, the customer needs are also called “customer attributes” and “customer requirements” and they are usually structured in a hierarchy of primary, secondary, and tertiary demands. In this work, the term “Customer Requirement” is used instead of “Customer Attribute” in the context of QFD in order to avoid confusion with the method “Conjoint Analysis”. CRs are usually gathered in focus groups, face-to-face interviews, customer surveys and trials (e.g. refer to Saatweber 2007, pp. 78-93), analysing competitors, and listening to customers. For example, many Japanese companies listen to their customers by placing their products in public areas and encouraging potential customers to test these products (e.g. Hauser and Clausing 1988, p. 65). According to Griffin and Hauser (1993), in the case of face-to-face interviews, more than 12 interviews are assumed to be enough to elicit the main relevant attributes (for details refer to Griffin and Hauser 1993, pp. 9-12). However, a major problem related to the CR issue is the correct translation of the words and inferences of customers by the cross-functional expert team (Hauser and Clausing 1988, p. 5; and for CRs’ calculation methods see Terninko 1997, pp. 70-74).

In step 2, rating the importance of the CRs, the expert team members rate the CRs based on their direct experience or, e.g., through questionnaires. This step is very critical in the HoQ, since the different interpretation or calculations of the importance of the CRs lead to different results. Because of this, various methods are used in the literature to deal with this sensitive issue (see Section 4.5.1). For instance, some researchers use statistical techniques while others use revealed preference techniques. In the former technique, the customers state their preferences for existing and hypothetical products whereas customers are judged by both their actions and their words for the latter (Griffin and Hauser 1988, p. 6; see also Cohen 1995, pp. 115-121).

Further in step 3, competitive products are rated by customers. In order for companies to match or exceed their competitors, they have to know where they stand in relation to them first (Hauser and Clausing 1988, p. 66). The part dealing with benchmarking is located on the right side of the CRs which gathered the customers’ evaluations and assessments of the “company’s product” and the “competitors’ products”. This step helps the company identify areas of strengths and weaknesses. It should be seen as an essential step for the company to improve itself against its competitors.

In step 4, determining the engineering characteristics, an interdisciplinary expert team from various departments of the company is formed, usually from the marketing, sales, R&D, engineering, and production departments, to translate the VOC into ECs. It should be noted that any EC may affect more than one CR. For example, in the smart home product study of the present work, the EC “jalousie control” influences five CRs, namely: “secure at home”, “absence simulation”, “saving energy”, “automatic control of jalousie”, and “automatic light control” (for further details see section 6.3.1). In other words, an EC that is included in the EC list has to affect at least one CR in order not to be irrelevant (see Hauser and Clausing 1988, p. 66; Baaken et al. 2009). Another important issue is that it is expected that the ECs describe the CRs in measurable terms and thus affect the customer perceptions (e.g. Hauser and Clausing 1988, p. 66). As shown in the mobile phones example of the present work, the weight of the mobile is a substantial attribute: The customers needed to feel the weight of a mobile to judge its effect on their satisfaction with the product.

Afterwards, in step 5, rating the relationship matrix, the interactions or dependences between CRs and ECs are estimated by the cross-functional expert team. A consensus is required in this step (Franceschini and Rossetto 1995, p. 272; Hauser and Clausing 1988, p. 67; van de Poel 2007, p. 28). Symbols or measuring systems are often used to rate the strength of the relationship between the CRs and ECs. The two most known measuring systems used in this step are the 1-3-9 and the 1-3-5 ordinal scales (for a description of scales refer to Franceschini and Rossetto 1995, p. 272).

Subsequently, in step 6, rating the correlation matrix (roof of the house), the dependency within the ECs is assessed. The expert team assesses the effect of each EC on the other ECs (refer to Saatweber 2007, p. 69). Sometimes, the expert team has to take the right decisions between possible conflicts within ECs. This happens when the increase of an EC affects at least one other EC negatively. This results in a conflict concerning the product’s design. Objective measures and comparisons (e.g. with the competitors) as well as cost-benefit comparisons help engineers, marketers, and managers of the expert team to decide about the correlations of the ECs process.

In step 7, the importance of the ECs is calculated. The importance of an EC is equal to the summation of the CRs affected it affects, each multiplied with the corresponding importance of the CR. Mathematically expressed, in the relationship matrix a cell (i, j), where the i^{th} defines the row and the j^{th} defines a column is, given a value according to the scale used, e.g., 1-3-9 corresponding to the strength of the relationship between the CR_i and EC_j which is called the relationship coefficient and designates a weak, medium, or strong relationship f_{ij}. The absolute and the relative importance are calculated according to the following equations shown in Table 12 (Kim et al. 2003, p. 462):

Table 12: The absolute and relative importance of ECs in the HoQ

	Absolute importance of EC		**Relative importance of EC**
	$AI_j = \sum_{i=1}^{m} w_i * f_{ij}$		$RI_j = AI_j / \sum_{k=1}^{n} AI_k$
AI_j	Absolute importance of EC_j (j=1,..., n)	RI_j	Relative importance of EC_j
w_i	Relative importance of CR_i (i=1, ..., m)	AI_j	Absolute importance of EC_j
f_{ij}	Relationship coefficient between EC_j and CR_i		

(Own representation adapted from Kim et al. 2003, pp. 462-463)

Finally, in step 8, to determine the target values for the ECs, it is essential for the multi-disciplinary team to consider the customer satisfaction values and to be careful not to emphasise tolerances (Hauser and Clausing 1988, p. 70). The setting of target EC levels is accomplished in a subjective, ad hoc manner, e.g., by expert team consensus (Kim et al 2003, p. 463).

In summary, the house of quality aggregates a lot of information in one table. Another way to see the house is as a common place for the various functional teams of a company, which enables them to communicate together and understand the priorities and goals of one another (Hauser and Clausing 1988, p. 68).

After finishing the HoQ, a second matrix called "part deployment" could be further implemented in a similar way. The expert team decides on which important and selected ECs from the HoQ shall be deployed to the second matrix. In the second matrix, the ECs from the HoQ become the rows of the matrix and the part characteristics become the columns (for more details and examples refer to Hauser and Clausing 1988, pp. 71-72; Saatweber 2007, pp. 237-241).

The main goals of the part deployment matrix are: (1) To determine the important and critical parts or product parameters, (2) to select the best development concept, (3) and to determine the important elements for the next house (for detailed description, see Saatweber 2007, p. 239).

Hauser and Clausing (1988, p. 71) show in their example of a car door's design that setting target values for ECs does not deliver a complete product. Accordingly, the company needs to specify the right product parts, the right processes to manufacture the parts and assemblies, and the right product plan to be able to manufacture a product. These phases of new product development are presented in the next section.

4.2 Beyond the House of Quality: Various QFD Approaches

In this section, an overview of the conceptual approach of the processes of QFD is given to the extent that meets the goals of the work.

In the literature, there exist many approaches for QFD. In this work, however, the three main approaches of the continuing work-processes are presented in Table 13.

Table 13: A summary of the processes of QFD

	Four-Phase Approach	**Matrix of Matrices Approach**	**Comprehensive Approach**
Year	-	In 80's	Early 90's
Person	Fukuhara/ASI[34]	Akao	King
Advantage	Easy to understand, Straight forward	For complex design, Flexible	Flexible
Disadvantage	Not flexible, no adaption (Anderson 1991)	Complex to simulate mentally	Demanding

(Own representation based on gathering information from Hauser and Clausing 1988, pp. 71-73; Sullivan 1986; Gustafsson 1996, pp. 24-25)

These are the ASI approach/model, also known as the Clausing model (Chan and Wu 2002b, p. 24; Sullivan 1986; Hauser and Clausing 1988, p. 73; see also Eureka and Ryan 1994; Cohen 1992), the matrix of matrices approach (Akao 1990b; Mizuno and Akao 1994), and the comprehensive QFD approach (King 1987).

4.2.1 The Four-Phase Approach

An overview of the ASI four-phase approach is herein conceptually presented. It is the most commonly implemented approach for QFD in the United States (Cohen 1995, p. 311; Chan and Wu 2002b, p. 24). The main goal of the four-phase approach is to deliver the consumer requirements from marketing to manufacturing (Hauser and Clausing 1988, p. 73). The approach was introduced by Sullivan (1986) and Hauser and Clausing (1988, p. 73) as shown in Figure 11.

[34] ASI had further developed the four-phase approach.

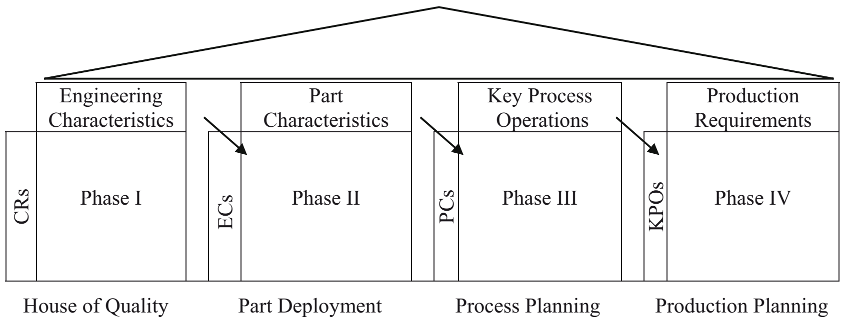

Figure 11: The ASI approach
(Own representation adapted from Hauser and Clausing 1988, p. 73); Legend: PCs: Part Characteristics; KPOs: Key Process Operations.

Cohen (1995, p. 310) considers the four-phase model as "a blueprint for product development in a mature, efficient, disciplined organization".

In phase 1, the HoQ (also called product planning, see Cohen 1995, p. 311) goal is to directly collect the customer requirements and transfer them to engineering characteristics to gain the customer satisfaction (e.g. Gustafsson 1996, p. 25).

In phase 2, the most important ECs are translated into part characteristics in the part deployment matrix. The most important part characteristics have to be determined according to the customer requirements.

Afterwards, the most important part characteristics are deployed to phase 3, namely to the process planning. In this phase, the deployed part characteristics are translated into key process operations.

Finally, the process operations are deployed to the production planning in phase 4. In this phase, the key process operations are transformed into production requirements (Sullivan 1986; Gustafsson 1996, p. 26; Chan and Wu 2002b, pp. 24-25).

At the end, the deployed important process operations can be adapted to the practical level of the organisation, e.g., to work instructions concerning control and reaction plans, in order to assure that the quality level of the main key parts and processes is preserved (Cristiano et al. 2000, p. 289). For other sources for the four-phase approach see also American Supplier Institute (1994); Kim et al. (1998); Day (1993); Xie et al. (2003); Sullivan (1986).

4.2.2 The Matrix of Matrices

Akao's generic approach, which is described as "gigantic and far-reaching" (Cohen 1995, p. 317, 315), was introduced in the United States in 1984 by Bob King. Its main goal is to link QFD matrices to value engineering and reliability charts (e.g. FMEA) (King 1989, p. [p.4]). This classical approach of Akao (Saatweber 2007, p. 57) consists of 30 matrices (e.g. the HoQ is the first matrix), as well as charts, tables (like the VOC table), and other quality tools to evaluate the CRs (Cohen 1995, p. 315). This approach deals with quality management, planning of technologies, costs, and reliability issues as well as with New Product Development (NPD) issues (Saatweber 2007, p. 58). For a further description of the matrix of matrices approach as well as the measuring system, additional matrices, and extensive presentation of each matrix, refer to Cohen (1995, pp. 315-316). One of the advantages of the approach is its flexibility (ReVelle et al. 1998, p. 315). In other words, each company has to adjust the approach to its needs and eventually develop its own tool kit (Saatweber 2007, p. 60). Another advantage of this approach is that it supplies various formats for QFD matrices. On the other hand, the approach also has its drawbacks. For example, the complexity of the approach in addition to the fact that no exact instructions exist on its implementation. (King 1989, p. [p. 4]) For an illustration of the approach refer to King (1989, p. [p. 4]), ReVelle et al. (1998, p. 314).

4.2.3 The Comprehensive QFD

The comprehensive QFD was suggested by King and others in the early 90's (Cohen 1995, p. 317). It is basically an integration of the best features of both aforementioned approaches: the four-phase approach and the matrix of matrices (ReVelle et al. 1998, p. 315; Moran et al. 1991). It is a subset of the matrix of matrices containing 17 matrices and the VOC table, the concept selection activity, and Deming's Plan, Do, Check, and Act (PDCA) cycle (Deming 1982; Cohen 1995, p. 317; and ReVelle et al. 1998, p. 315). The main purpose of the approach is to facilitate the design process of complex situations (e.g. in mass production, especially concerning systems that need a lot of planning) and produce better solutions (Gustafsson 1996, pp. 26-27). The approach should be considered as a guide that presents the available tools to be used at the company's different levels (Gustafsson 1996, p. 27). In this sense, the approach is flexible; however, the approach's main drawback is that no exact working instructions are available (Saatweber 2007, p. 58).

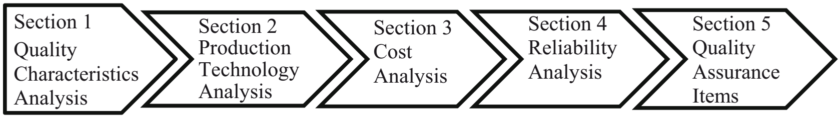

Figure 12: The comprehensive approach summarized on the section level (Own representation based on Gustafsson 1996, p. 28 from the Japanese source Ohfuji 1994)

The comprehensive approach is summarised in Figure 12 on the secfyfcr1tion level for brevity reasons. For a complete presentation of the model and the activities conducted in each section see Gustafsson (1996, p. 28); Ohfuji and Ono (1994); and Cohen (1995, p. 317). This approach is expected to provide an overall view rather than to give an evaluation of a design solution (Gustafsson 1996, p. 27).

Although the comprehensive approach is not too complex in comparison to the matrix of matrices, it is not always possible to implement it. For this reason, the Blitz QFD was developed by Richard Zultner in the 90s (Zultner 1995). Generally, the Blitz QFD is a subset of the comprehensive QFD which is mainly applicable when constraints exist due to limited time, human resources, and money (ReVelle et al. 1998, p. 316).

Table 14: QFDs' applications shown by key category

Key Category	Selected sub-category	Selected Examples
Transportation and communication	Shipbuilding	Nishimura (1972); Lyu and Gunasekaran (1993)
	Automobile	Ferguson (1990); Gould (2006)
	Airlines	Ghobadian and Terry (1995)
	Aerospace	Jacobs et al. (1994)
Electronics and electrical utilities (electronics related companies)	AT&T	Nolle (1993)
	Intel	Kerr (1989)
	Hewlett-Packard	Thompson and Chao (1993)
	Philips	Groenveld (1997)
Software systems	Software (in general)	Herzwurm and Schockert (2003); Sharma et al. (2006c);
	Expert systems	Büyüközkan and Feyzioglu (2005)
	Decision support systems	Moskowitz and Kim (1997); Sarkis and Liles (1995)
	Information systems	Han et al. (1998)
Manufacturing	Manufacturing general	Barad and Gien (2001)
	Equipment	Matzler and Hinterhuber (1998); Maduri (1992)
Services	Services (in general)	Partovi (2001)
	Banking	González et al. (2004b)

Table 14: QFDs' applications shown by key category

	Food distribution	Costa et al. (2000); Charteris (1993)
	Online-bookshops	Barnes and Vidgen (2001)
	Healthcare	Dijkstra and Bij (2002); González et al. (2005); Moores (2006); Lim and Tang (2000); Mohiuddin et al. (2006)
Education and Research	Colleges and universities	Duffuaa et al. (2003); Bier and Cornesky (2001); Ho et al. (2009)
	Educational institutes	Singh and Deshmukh (1999); Singh et al. (2008)
	Business schools	Hwarng and Teo (2001)
Others	Textile	Weiß (2009); Fischer (2007); Stellmach et al. (2007)
	Beautiful enterprises	Chan (2000)
	Agriculture	Milan et al. (2003)
	Environmental protection	Halog et al. (2001); Masui at al. (2003); Zhou and Schoenung (2004)

(Own representation adapted from Chan and Wu 2002a; Carnevalli and Miguel 2007; Sharma et al. 2008; and updated by the author); Note: related to next section (Section 4.3), for space matter.

4.3 Applications of QFD

This section shows some applications of the QFD method in the broad spectrum areas from manufacturing and services to education and research (see Table 14). Since the inception of QFD (Akao 1972) in Japan and the success of the Japanese products in the world market, the QFD technique was applied in many countries of the world (see, e.g., Sharma et al. 2008; Carnevalli and Miguel 2007). Consequently, organisations and companies worldwide have used the technique in a broad range of applications (see Table 14), such as in transportation and communication, in electronics, as well as in software systems, and in manufacturing. Nevertheless, QFD is applied in specific applications such as disaster prevention (Kara-Ziatri 1996; Kabeil 2010) or peacekeeping force design (Partovi and Epperly 1999), as well as in the healthcare sector (Mohiuddin et al. 2006) (for a detailed list of applications refer to, e.g., Chan and Wu 2002a).

4.4 Advantages and Disadvantages of QFD

This section discusses the advantages and disadvantages of the QFD method. During 40 years of QFD history, the method proved to show many benefits for its users. As a result, organisations have worldwide used QFD and have already implemented the method in almost all areas (see Section 4.1.1 and 4.3). Notwithstanding the advantages of the

QFD, researchers and practitioners have revealed some drawbacks as well as problematic issues of the method.

On one hand, the QFD method has many advantages that have encouraged organisations and companies worldwide to use the method. QFD ensures that the VOC is effectively heard in the organisation which contributes in improving the customer satisfaction (Griffin and Hauser 1992, p. 360; Papic 2007, p. 264, 273; Franceschini and Rossetto 1995, p. 270; see also Vonderembse et al. 1997; Vonderembse and Raghunathan 1997). As a result, the utilisation of the QFD technique (Kanda 1995) enhances quality and its culture in the organisations (e.g. Franceschini and Rossetto 1995, p. 270; see also Zairi and Youssef 1995); since an organisation's quality is "its ability to satisfy the needs and expectations of the customer" according to Bergman and Klefsjö (1994). Accordingly, QFD not only brings, on the external level, the company in a direct contact with the customers, but also, on the internal level, initiates and improves the communications between and within the various departments in the company (e.g. Bouchereau and Rowlands 2000, p. 12). Furthermore, QFD, e.g., HoQ presents a lot of information in a compact and brief way in one schema (e.g. Bouchereau and Rowlands 2000, p. 12; see also Vonderembse et al. 1997).

In today's market, QFD helps companies to stay competitive by improving the design of the product (Vonderembse et al. 1997; Vonderembse and Raghunathan 1997) by reducing the number of changes on a product; designers can determine the key manufacturing requirements earlier, and thereby lowering the initial costs (Bouchereau and Rowlands 2000, p. 12).

On the other hand, QFD has many drawbacks and methodological problematic issues. The QFD matrix could prohibitively grow large (Kazemzadeh et al. 2009, p. 1020; Prasad 1998; Tan and Shen 2000), hence be time consuming and requires a big effort from the user (Kazemzadeh et al. 2008, p. 1020; Huang and Mak 1999, p. 184; see also Hsiao 2002; Chan and Wu 2005; Temponi et al. 1999; Büyüközkan et al. 2007; Lager 2005). Moreover, many problematic issues are encountered, when considering the customer requirements; for instance, sometimes the CRs are "ambiguous" (Bouchereau and Rowlands 2000, p. 12) or contradictory and/or vary very much; these contradictions and variations between the CRs are not easy to be solved (Kazemzadeh et al. 2009, p. 1020; see also Ho et al. 1999; Balthazar and Gargeya 1995; Benner et al. 2003; Tu et al. 2003). In addition, CRs are dynamic, which is not taken into consideration when the VOC is collected at the time of data collection (Chong and Chen 2010, p. 96; see also Mittal et al. 1999; Raharjo et al. 2006; Wu and Shieh 2006).

On the ECs level, there are also some drawbacks and issues to be considered when using the QFD. By translating the CRs into ECs, sometimes large numbers of ECs are suggested, however, not all of the ECs can be further considered in the HoQ because of time and complexity considerations among others (Reich and Levy 2004; Fung et al. 2003; Lai et al. 2005; Karsak 2004; Bode and Fung 1998). Another problem of the QFD is the subjective way in which the expert team decide upon the relation between the ECs and the CRs (Baier 1998; Zhou 1998; Kwong and Bai 2002; Fung et al. 2005; Kim et al. 2000; Chen and Chen 2006) as well as by the prioritizing of the CRs and ECs using the ordinal scale, e.g., 1-3-9 or 1-5-9 (Wasserman 1993; Erol and Ferrell 2003; Kahraman et al. 2006; Iranmanesh and Salimi 2003; van de Poel 2007).

Table 15: Summary of the advantages and disadvantages of the QFD method

Advantages of QFD	**Disadvantages of QFD**
VOC is effectively taken through the processes of planning and design.	Complex and time consuming
Improve customer satisfaction	Matrix size is too big
Improve quality	Differentiating between diverse and contradictory CR is difficult
Presentation of a lot of information in one graphic (e.g. HoQ)	Contradictory CRs are not easy to solve
Companies get connected with their customers	Difficulty to prioritize CRs & ECs using the ordinal scaling or ratings
Communication is improved within the departments	CR are dynamic, only collecting the current CR is not enough
Reduction of number of changes on a product	Difficulty to meet all customer segments
Initial cost is minimized	Many ECs could not be considered because of many constraints in time, budget, and feasible technology
Key manufacturing requirements are earlier determined	The CRs and ECs are handled in subjective and vague terms

(Own representation adapted from, e.g., Papic 2007, p. 273; Franceschini and Rossetto 1995, p. 270; van de Poel 2007, pp. 21, 25; Kazemzadeh et al. 2009, p. 1020)

A summary of the advantages and disadvantages is given in Table 15. In this section the advantages and disadvantages and the generally critical problems of QFD method was described.

4.5 Suggested Solutions to Some Problems of QFD

4.5.1 Integration of QFD with Different Methods

This section offers an overview of some suggested solutions found in the literature of QFD for some of its problems (see Section 4.4). The mainstream of the suggested solutions of QFDs' problems as well as improvements focuses on integrating QFD with other methods and tools.

Table 16: A summary of selected integrated methods to QFD

Methods	Examples	References
Quantitative methods	AHP	Armacost et al. (1994); Park and Kim (1998); Chuang (2001); Raharjo and Dewi (2003); Ho et al. (2010); Zultner (1993)
	AHP + other methods	Chan and Wu (1998); Ho et al. (1999); Askin and Dawson (2000); Han et al. (2001)
	Others	Partovi (2001); Lee and Kusiak (2001)
Marketing research methods	Benchmarking	Shen et al. (2000b); Partovi (2001)
	Regression analysis	Cristiano et al. (2001); Yoder and Mason (1995); Hauser and Simmie (1981); Askin and Dawson (2000)
	Conjoint analysis	Gustafsson 1996; Baier (1998); Abu-Assab and Baier (2010); Abu-Assab et al. (2010)
Fuzzy logic methods	Fuzzy logic	Lopez-Gonzalez (2001); Shen et al. (2001); Harding et al. (2001)
	Fuzzy multi-criteria methods for QFD	Kim et al. (2000a); Sohn and Choi (2001)
	Fuzzy QFD	Bahrami (1994); Khoo and Ho (1996); Shen et al. (2001); Vinodh and Chintha (2011)
Extensions or modifications of QFD	Comprehensive QFD	Gustafsson (1995); Nakui (1991); Sharma and Singh (2010)
	Dynamic QFD	Adiano and Roth (1994)
	Enhanced QFD	Burchill and Fine (1997); Clausing and Pugh (1991)
	Extended QFD	Hales et al. (1994); Herrmann et al. (2000); Prasad (1998a)
	Green QFD	Zhang et al. (1999); Cristofari et al. (1996); Dong et al. (2003)
Models and Quality tools	Six sigma	Huber and Mazur (2002); Souraj et al. (2009); Lazreg and Gien (2009); Claribel et al. (2008); Cheng (2010)
	S-model	Cook and Wu (2001)
	Kano's model	Shen et al. (2000a); Tan and Shen (2000); Garibay et al. (2010)
	Target costing	Brusch et al. (2001); Hales and Staley (1995)

(Own representation based on the categorization made by Chan and Wu 2002a and updated by the author)

For example, Mazur (2000, p. 1) considers that "Competitiveness in the new millennium may belong more to those who can integrate a multitude of disciplines into a system, rather than to those who expect a single unnuanced tool to do it all." In this sense, Mazur considers QFD as a "great room" for other methods to be used in order to improve the new product development. Furthermore, in reviewing the QFD literature, it is obvious that there exist many contributions from researchers to try to solve QFDs' problems or to improve QFDs' results and reliability (see Table 16). The major problems of QFD addressed in the literature according to Park and Kim (1998, p. 570):

(1) Prioritization of the CRs importances

(2) Determination of the ratings of the relation between ECs and CRs, and

(3) Prioritization of ECs (for details, refer to Park and Kim 1998, pp. 570-571).

To solve these problems of QFD, researchers have combined different methods to QFD. They have used the quantitative methods, e.g., Analytical Hierarchy Process (AHP) to QFD, AHP and mathematical models to QFD. Marketing research methods like conjoint analysis and regression analysis were also integrated into QFD. Through reviewing the literature, one can see that the fuzzy logic methods have been intensively used in this area. In addition to the aforementioned methods, researchers have tried to modify and extent the QFD method and so there exist, e.g., the comprehensive QFD, the extended QFD, and even the enhanced QFD. Moreover, researchers have also linked models and quality tools to QFD like the S-model, Kano model, and Six Sigma. A summary of the methods, examples and references is shown in Table 16.

AHP[35] (Saaty 1980; Saaty and Kearns 1985; Saaty 1990) was integrated into QFD in a vast number of studies mainly to prioritize the CRs. For instance, Armacost et al. (1994, p. 72) used AHP to prioritize the CRs of an essential component in industrialized housing, a manufactured exterior structural wall panel. Likewise, Park and Kim (1998, p. 572, 579) used the AHP method to prioritize the CRs in their new integrative HoQ model. Other researchers have combined AHP as well as other methods to QFD. For example, Ho et al. (1999, p. 553) tried to assign the importances of CRs by aggregating the expert team opinion when they have similarities concerning some criteria (e.g. AHP) and differences concerning other criteria (e.g. linear programming technique). In doing so, the authors (1999) have suggested an approach that despite the differences in opinions within the expert team, a consensus could be reached.

On the other hand, the fuzzy logic methods were also intensively integrated to QFD. The purposes of using the fuzzy set theory (see Zadeh 1965) in QFD are to transform the vagueness and inaccuracy of the CRs as well as the vagueness of the relations used in ECs into a precise context. Vinodh et al. (2011, p. 1627) have used the fuzzy numbers in

[35] AHP is Multi-Criteria Decision-Making technique (MCDM) for prioritizing decision (Saaty 1980) which "enables us to make effective decisions on complex issues by simplifying and expediting our natural decision-making processes" (Saaty 1995, p. 5).

combination with QFD to solve the vagueness of relationships and correlations in the example of an Indian electronic switches manufacturer. Shen et al. (2001, p. 67) proposed a model using the linguistic variable, fuzzy numbers, fuzzy arithmetic, and defuzzification to deal with QFD based on linguistic input data. Other researchers have tried to use not only the fuzzy method but also other methods and techniques in combination to QFD. For example, Bouchereau and Rowlands (2000, p. 8) combined the techniques, fuzzy logic, artificial neural networks (Hammerstrom 1993), and the Taguchi (Taguchi 1986) method to overcome some of QFD disadvantages.

Modifications and extensions of QFD are also proposed to improve it. Adiano and Roth (1994, p. 25) suggested a dynamic QFD applied by an IBM assembly plant, which uses feedback loops to finally translate the CRs into product and process parameters. Moreover, Cristofari et al. (1996) suggested the Green QFD (GQFD). This method combines the Life Cycle Costing (Fiksel 1996) and QFD with the target to select the best product. Zhang et al. (1999, p. 1075) proposed the GQFD-II, and Dong et al. (2003, p. 12) proposed GQFD-IV. In GQFD-IV, life cycle cost and AHP are used in QFD to develop products and processes that are friendly to the environment.

Quality methods and tools are also integrated into QFD in order to improve the new product development process. Garibay et al. (2010, p. 125) combined the Kano model (Kano et al. 1984) with QFD to assess the service quality in the example of a digital library; and Lazreg and Gien (2009, p. 676) combined Six Sigma and maintenance excellence with QFD. In this case, QFD consists of 5-oriented matrices which help the company to identify its improvement priorities and thus strengthen its competitiveness in the market (for a detailed quality tools used in NPD and in QFD refer to Mazur 2000).

Finally, marketing tools were also integrated into QFD to overcome many of the problems aforementioned in this section. For example, Shen et al. (2000b, p. 282) provided a roadmap for small and medium-size companies through benchmarking the customer satisfaction into QFD to improve the quality. On the other hand, Gustafsson (1996) suggested the use of conjoint analysis to calculate the CRs' importances; whereas, Baier (1998) has used conjoint analysis to evaluate the importances of the CRs and to assess the relationship between the ECs and CRs. In the same way, Abu-Assab and Baier (2010) have used the conjoint analysis in QFD in the example of a mobile phone for elderly people. Table 16 provides an overview of the methods combined to QFD and examples.

Similarly, this work contributes in the improvement of the QFD method. The work investigates the integration of conjoint analysis into QFD (see Section 5.1 and Section 5.2) and suggests a new combination of the self-explicated method with QFD (see Section 5.3). For this reason, a literature review of the integration of the preference methods: conjoint analysis and self-explicated into QFD will be given in the next section.

4.5.2 Integration of Preference Analysis Methods into QFD

In this section, a review of studies that integrate the QFD and the preference analysis CA and SE methods is reviewed. The review summarizes the last 20 years in Table 17. Accordingly, the following categories are concluded in the integration of CA into QFD:

(1) Some authors have generally mentioned CA as a possible solution to QFD (e.g. Andersson 1991; Urban and Hauser 1993; Kanda 1994a; 1995; Katz 2004 –as a commentary-; Gustafsson 1996).
(2) Other authors suggested the use of CA and QFD for evaluating the CRs to overcome their vagueness and inaccuracy (e.g. Schmidt 1996; Gustafsson 1996; Kazemzadeh et al. 2009).
(3) Others suggested the use of CAs' results for QFD as a complementary approach and simultaneously (e.g. Pullman et al. 2002; Abu-Assab and Baier 2010).
(4) Others suggested the use of CA to evaluate both the CRs and determine the strength of the relationship between ECs and CRs (e.g. Baier 1998; Baier and Brusch 2005; Abu-Assab et al. 2010; Olwenik and Hariharan 2010).
(5) Others suggested the use of CA as a segmentation tool in QFD (e.g. Gustafsson 1996; Kazemzadeh et al. 2009).
(6) Others have suggested the use of QFD results for CA (e.g. Chaudhuri and Bhattacharyya 2009).

Others mentioned CA in the framework of QFD in a brief (e.g. Aungst et al. 2003).

Table 17: An in-depth review of studies integrating conjoint methods into QFD

	Study	Product	Type of integration/ comparison	Target group
1	**Andersson (1991)**	-	CA as a tool supporting the use of QFD	-
2	**Urban and Hauser (1993)**	Only indication, no example	-	-
3	**Kanda (1994a, 1995)**	-	CA and quality tables as a part of the 7 planning tools[36]	-
4	**Schmidt (1996)**	Wind turbine	TCA to calculate CRs (Only indication)	Simulation
5	**Gustafsson (1996)**	Only indication, no example	CA as a tool supporting the use of QFD	-
6	**Gustafsson (1996)**	Only indication, no example	SE as a tool supporting the use of QFD	-
7	**Baier (1998)**	Laptops	ACA to calculate CRs and ECs	Students
8	**Pullman et al. (2002)**	Climbing harness	CA attribute is implemented in the part deployment matrix in design features	Customers of a sport shop
9	**Aungst et al. (2003)**	Printer/copier scanner for the internet	Comparison between VDM and QFD with CA[37]	Customers
10	**Katz (2004)**	A commentary on Pullman (2002)	QFD results is suggested to be used in CA	-
11	**Baier and Brusch (2005)**	Laptops (R); Luxury purse	CA in HoQ, a replication study of Baier (1998)	Students Male customers
12	**Baier and Brusch (2006)**	-	Monte Carlo Comparison	Monte Carlo Simulation
13	**Baier and Gaul (2007)**	German market for mobile phones	CA into HoQ based on the probabilistic ideal vector model	Monte Carlo Simulation
14	**Baier and Brusch (2009b)**	Football sport shoe	CA/regression analysis is integrated into QFD	Leisure football player
15	**Kazemzadeh et al. (2009)**	Office chair	CA to identify CRs and CA for each segment after clustering the market	Prospective customers of chairs brand company
16	**Chaudhuri and Bhattacharyya (2009)**	Commercial vehicle with hypothetical data	QFD results used in CA and integral programming is also used	Customers
17	**Abu-Assab and Baier (2010)**	Mobile phone	ACA implemented in the part deployment matrix, a comparative study	Elderly people

36 The 7 product planning (PP) tools were developed by the Union of Japanese Scientists and Engineering (JUSE). For details about 7 PP tools refer to Kanda (1994a and 1995).

37 In their paper they designated the traditional design approach with the use of conjoint analysis. The use of conjoint analysis method is only indicated but not further explained (refer to Aungst et al. 2003, pp. 565, 571, 576-577).

Table 17: An in-depth review of studies integrating conjoint methods into QFD /(cont.)

	Study	Product	Type of integration/ comparison	Target group
18	**Abu-Assab et al. (2010)**	Mobile phone	ACA to identify CRs and ECs, a comparative study	Elderly people
19	**Olewnik and Hariharan (2010)**	Hair dryer (Simulation)	Conjoint in HoQ/ Internal and external validity	Simulation of customer market

(Own representation); Legend: VDM: Virtual Design Method

In the various ways of integrating CA into QFD, the researchers have tried to solve two main weaknesses of QFD, namely that (1) CRs are subjective and (2) the relationship between ECs and CRs is handled in a subjective way. Therefore, the purpose of CA integration into QFD is to quantify it.

It should be noted that self-explicated methods were once indicated briefly by Gustafsson (1996) as possible to be used with QFD.

In this work, two approaches are tested in this work based on Pullman's et al. (2002) work and Baier's (1998). Additionally, a new approach is suggested by integrating the conjuncture-compensatory self-explicated method into conjoint analysis. The three approaches will be extensively described in the next chapter.

5 Integration of Preference Analysis Methods into QFD for Elderly People

5.1 Pullman's ConjointQFD Approach

5.1.1 Description of the Approach and Experiment

In the work of Pullman, Moore, and Wardell, they compared the QFD and conjoint analysis methods on the example of a new all purpose climbing harness for the beginning/intermediate ability climbers. They view the two methods QFD and conjoint analysis "as complementary approaches that should be conducted simultaneously," in which each method's result supports the other. They concluded that QFD and conjoint analysis provide two "different lenses" that combine the product developers and the marketers in producing new or improved product (Pullman et al. 2002, p. 354).

Figure 13 provides an overview of the major three phases conducted to compare between the QFD and conjoint analysis in Pullman et al.'s experiment:

Phase 1: Conducting the conjoint analysis study (see section 3.2).

Phase 2: Running the HoQ (see section 4.1.3).

Phase 3: Carrying the part deployment matrix (see section 4.1.3 and 4.2.1).

Each phase is described in the following three subsections in the example of climbing harness.

5.1.1.1 Phase 1: Conducting the Conjoint Analysis Study

An expert team was built to run the experiment. In the data collection step, the expert team identified many attributes and attribute levels for the "climbing harness", gathered from various sources such as catalogues and discussions with others. For the attainable purposes of the study, nine attributes were ultimately selected for the CA study upon a managerial decision. The attributes are: "brand", "harness construction", "waist belt width", "buckle", "belay loop", "gear loops", "dedicated tie-in loop", "leg loops", and "price" as shown in Figure 14 (for details see Pullman et al. 2002, pp. 355-356).

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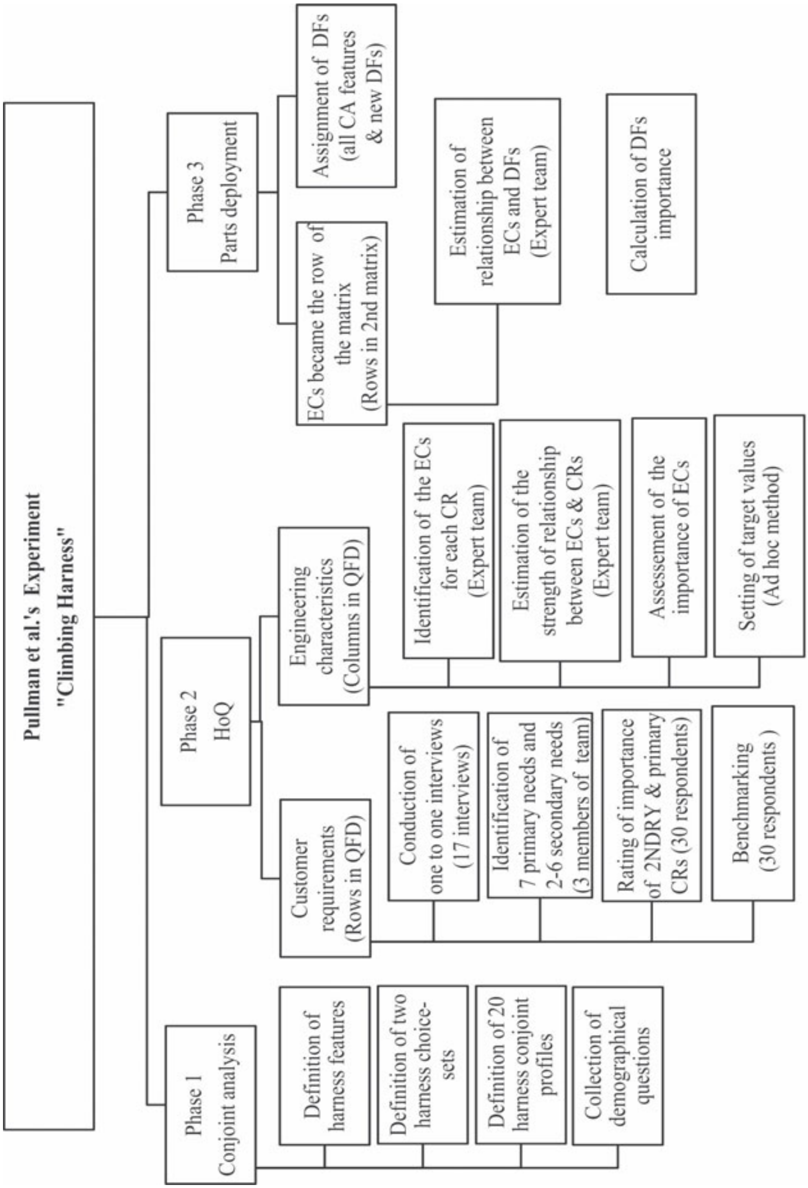

Figure 13: Pullman et al.'s experiment including the major phases (Own representation); Legend: 2NDRY: Secondary

Afterwards, the conjoint analysis study was conducted by sending the questionnaires to randomly selected persons of the outdoor equipment retailer's list and by distributing questionnaires in five climbing gyms. The questionnaire was divided into four phases: (1) definition of harness features, (2) two-harness choice sets, (3) 20 harness conjoint profiles, and (4) the demographic questions (Pullman et al. 2002, p. 355).

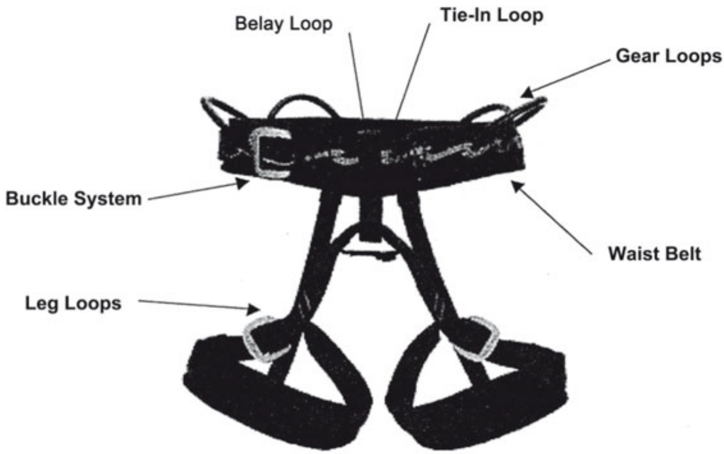

Figure 14: Climbing harness and its major attributes used in Pullman's experiment (Adapted from Pullman et al. 2002, p. 356)

The individual level utility weights were evaluated using a hierarchical Bayes logistic regression. The result of the CA study shows that the preferred climbing harness, according to the average respondent, has the following attributes:

"brand B", "stuffed webbing harnesses", "wide waist belts", "threaded buckles", "belay loop", "four gear loops", "dedicated tie-in-loop, "adjustable leg loops", and "the lowest price". Then the competitive harnesses were selected for benchmarking from the four best selling harnesses and the likelihood of purchase of harnesses was calculated. Market share and contribution for managerial estimations were also calculated in the study (for detailed results see Pullman et al. 2002, pp. 356-358).

5.1.1.2 Phase 2: Running the HoQ

In this phase, the same expert team conducted the traditional HoQ as described in Section 4.1.3, detailed steps of this phase is shown in Figure 14. The team started with identifying the customer requirements by conducting face-to-face interviews for the HoQ.

The main contents of the interviews were intended for the researchers to gain the knowledge on various issues such as what the climber liked or disliked about their harnesses and which harnesses were the best in the market among many other questions. The process continued until no more ideas were suggested. The interviews were then evaluated by three team members. They grouped CRs in primary and secondary needs. Then their importances were assessed by other group of respondents and another 30 respondents rated the competitive harnesses (benchmarking part) (see Pullman et al. 2002, p. 358).

Afterwards, in the engineering characteristics step, the expert team assigned for each CR one or more ECs and assessed the relationship between CRs and ECs. Finally, the importances of the ECs were calculated and the target values of the ECs were set and recorded in the HoQ (see all results of the HoQ in Pullman et al. 2002, p. 359). The most important ECs were then further deployed to the next phase, to the parts deployment.

5.1.1.3 Phase 3: Carrying the Parts Deployment

In this phase, the ECs became the rows of the parts deployment matrix and then the same expert team assigned one or more design features or product characteristic to each EC. The expert team assigned the attributes used in the conjoint analysis study as DFs along with new DFs. In the next step, the expert team assessed the relationship between ECs and DFs and finally, the importances of DFs are calculated (for all details refer to Pullman et al. 2002, pp. 359-360). The target harness resulted from the parts deployment is shown in Table 18. In the same table, the results of the preferred harness that resulted from the conjoint analysis study are also shown for comparison.

A direct comparison of results of the target harnesses from both methods show that is not the same in all DFs or attributes. Some attributes or DFs were different. For example, the target harness resulted from parts deployment should have a "*web* fleece construction", "*narrow* waist belt", "*non-threaded* buckle", and "*no dedicated* tie-in loop"; whereas, the preferred harness resulted from the CA study for these DFs or attributes are "*stuffed* webbing harness", "*wide* waist belts", "*threaded* buckles", "*dedicated* tie-in loop". Other attributes or DFs were the same in both methods. The attributes are "a belay loop", "four gear loops", "adjustable leg loops", "lowest price". Table 18 shows all the results.

By comparing the importances of the design features of the part deployments and the importances of the attributes of the CA study, a low correlation between the two methods can be shown (correlation coefficient r=.32) and the result is not significant (for detailed calculations see Pullman et al. 2002, p. 361).

The differences between the target harnesses resulted from the parts deployment and CA study were not surprising for Pullman and her colleagues. They emphasised that the two methods provided similar recommendations on most dimensions; nevertheless, they differed on both the optimal level of some substantial attributes (see table 18). They justified the differences between the two methods to the fact that there is a difference between what customers want and the way engineers and "managers" interpret these needs (Pullman et al. 2002, p. 362).

Table 18: Comparison of the results of target harness from parts deployment and the harness with the highest utilities from CA

Target harness from parts deployment	**equal**	**Target harness from conjoint analysis**
Web fleece construction	≠	Stuffed webbing harness
Narrow waist belt	≠	Wide waist belts
Non-threaded buckle	≠	Threaded buckles
A belay loop	=	A belay loop
Four gear loops	=	Four gear loop
No dedicated tie-in loop	≠	Dedicated tie-in loop
Adjustable leg loops	=	Adjustable leg loops
Lowest price	=	Lowest price

(Own representation based on Pullman et al. 2002, pp. 356, 360); Note: the darker color of a row shows the same result between the parts deployment and conjoint analysis study)

Thus they were limited in generalising the result from one study and recommended that more studies should be conducted to test (Pullman et al. 2002, p. 363):

(1) whether the differences in the results of CA and QFD are "typical" or "norm"

(2) when the differences are "norm", which of the two method's design would be more successful in the market

They recommended a hybrid approach of the two methods which begins with identifying the CRs and then simultaneously conducting the CA and the QFD.[38] In the two empirical studies in this work, the idea of using the attributes of the conjoint analysis study into QFD (in the parts deployment or in the HoQ[39]) is referred to as "*Pullman's Con-*

[38] In his comments on this postulation, Katz (2004, p. 63) emphasises that the two approaches are complementary as suggested by Pullman et al. (2002); however, they should be used sequentially rather than simultaneously, and he added from his extensive experience that QFD should be first employed followed by the conjoint analysis method.

jointQFD" and in short "*Pullman's Approach*" to differentiate it from other ConjointQFD combinations used in this work.

5.2 Baier's ConjointQFD Approach

5.2.1 Description of the Approach and Experiment

In the work of Baier (1998), he integrated the conjoint analysis into the QFD on the example of high-quality notebooks for students. The main purpose of the combination between the conjoint analysis and the QFD is to overcome some of the problematic issues of the QFD method, namely the subjectivity in which CRs are identified and rated as well as ECs are assessed by the expert team. In this approach, the adaptive conjoint analysis is used to identify the CRs and to assess the ECs additionally another ACA is used to assess the importances of the ECs in the HoQ. Figure 15 provide an overview of the major three phases conducted in the approach in the HoQ (Baier 1998, p. 78):

Phase 1: Selection and evaluation of customer requirements

Phase 2: Selection and assessment of the engineering characteristics

Phase 3: Estimation of the importances of the engineering characteristics

Each phase is described in the following subsections on the example of the high-quality notebooks for students.

[39] Originally, Pullman et al. (2002) used the attributes of CA study in parts deployment as DFs. In this work, however, the attributes of CA study are used in the HoQ as ECs under the same name "Pullman's ConjointQFD" for simplicity reasons. In doing so, the required adjustments are taken into consideration in the work.

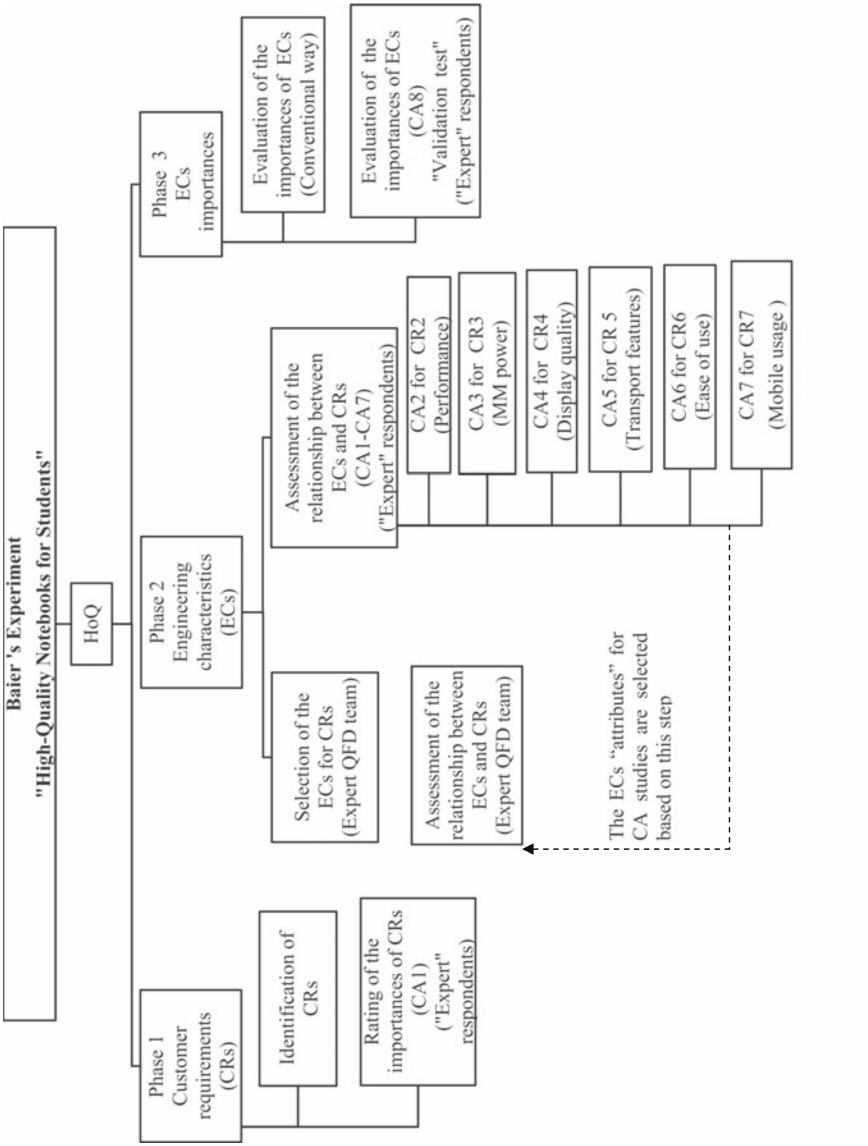

Figure 15: Baier's experiment for new product development on the example of "high quality notebooks for students"
(Own representation); Legend: MM: Multimedia; CA:conjoint analysis

5.2.1.1 Phase 1: Selection and Evaluation of CRs

In this experiment, the respondents were university students who were considered "expert" in using notebooks. For the purposes of the experiment, a small expert QFD team was formed including students who possess very good knowledge and experience of technical issues. In this phase, first the CRs were selected by the expert team in the conventional way (e.g. journals, internet, and retailers). Accordingly, seven CRs were chosen, namely "performance", "multimedia power", "display power", "transportation features", "ease of use", "mobile usage", and "price" (Baier 1998, p. 80; Baier and Brusch 2005, p. 192). Then, the importances of the CRs were estimated using an ACA (ACA1) study. In this study, the aforementioned CRs formed the attributes and the attribute levels were assigned with "convenient" and "inconvenient" options for each attribute (for the detailed matrix refer to Baier 1998, p. 80). In using the CA to rate the CRs, the subjectivity of estimating the CRs is overcome.

5.2.1.2 Phase 2: Selection and Evaluation of ECs

In this phase, the expert QFD team determined for each CR one or more ECs. In total 20 ECs were determined for the seven CRs, namely "processor", "memory", "cache", "hard drive", "display type", "resolution", "display size", "colour", "CD-Rom", "soundboard", "speakers", "operating time", "removable battery", "weight", "size", "transport bag", "keyboard", "pointer", "network interface", and "price" For instance, for the CR "display power" four ECs were assigned, namely "display type", "resolution", "display size", "colour" and so forth (for the detailed matrix see Baier 1998, p. 85; Baier and Brusch 2005, p. 193). Then for each of the 20 ECs, two levels were assigned a "convenient" and "inconvenient" level, e.g., for "weight" the levels "2 kg" and "4 kg" were selected. In this phase, the influences of the ECs on the CRs were assessed using 7 ACA for each CR except for price which has only one EC. In total, 40 "expert" respondents participated in the ACAs. In doing so, the relationship matrix (see Section 4.1.3) is assessed in a quantitatively way hence overcoming a big problematic issue in calculations in QFD.

5.2.1.3 Phase 3: Estimation of the Importances of the ECs

In this phase, the importances of the ECs are calculated in the conventional way and an additional ACA (ACA8) is conducted to evaluate the ECs by the "expert" respondents. ACA8 is conducted to estimate the predictive validity of the approach and it is not included in the calculation of the HoQ. In ACA8, a pre-determined orthogonal design consisting of 32 profiles and a hold-out question was used (Baier 1998, p. 82). Baier (1998, pp. 84-87) reported a high internal validity (using the determination coefficient) of the approach and when compared to the traditional QFD, the approach proved to have a higher predictive validity (using the Pearson's correlation coefficient r) than the traditional QFD. The average interview duration was 42 minutes and the questionnaire was generally considered interesting and varying by the young "expert" respondents.

In this work, the integration of the conjoint analysis method into the QFD method as suggested by Baier (1998) which is called "*ConjointQFD"* is referred to as "*Baier's ConjointQFD*" or also "*Baier's Approach*" to differentiate it from "*Pullman's ConjointQFD" or also "Pullman's Approach"* used in this work (see Section 5.1.1.3).

5.3 Proposal of the New Approach CC-SEQFD for "Elderly People"

5.3.1 Description of the New Approach for "Elderly People"

This work is concerned with the idea of tailoring market research methods to elderly people on the example of the two combinations of conjointQFD method for new and/or improved product development for the elderly. To do so, two measures are considered in this work, namely (1) a new combination is suggested to the QFD. Additionally, (2) a number of adjustments in presenting the methods for the elderly respondents are taken into consideration for the two conjointQFD approaches as well as for the new approach. In this section, the new suggested approach is described in details.

The conjuncture-compensatory self-explicated (CC-SE) method proposed by Srinivasan (1988) is suggested to be used in combination to the QFD for the elderly people (for a description of the method see Section 3.1.2.2) instead of the conjoint analysis, mainly to make the method easier and lower the cognitive burden on respondents in comparison to the other two conjointQFD methods.

Analogously to the argument of using SE method for complex products, in this work, the author suggests that CC-SE method be used in combination to QFD for elderly people instead of conjoint analysis for new and/or improved product development. Park et al. (2008, p. 562) argued that the technological products are complex, which presents a big challenge for the marketers to understand the customer needs and requirements. The conjoint analysis method is not suited for complex tasks mainly because of the huge cognitive burden exerted on respondents (see Park et al. 2008, p. 562; Green and Srinivasan 1990, p. 8). As a matter of fact, when a large number of attributes are involved in a conjoint analysis study, it requires a large number of product profiles. In their fundamental paper, Green and Srinivasan suggested the SE method as one of the alternatives along with ACA and hybrid CA to handle large number of attributes (e.g. Green and Srinivasan 1990, p. 9). Moreover, in his wish list, Bradlow (2005, pp. 320-321) addressed the importance of the issue of handling large number of attributes in conjoint analysis. However, Park et al. (2008, pp. 562-563) clearly state that the compositional approach (SE method) is an alternative to the decompositional approach (conjoint analysis) for complex products. They explain that SE approach is "much easier" and "imposes less cognitive burden on participants" (Park et al. 2008, p. 563).

The use of CC-SE method conforms to the consumer behaviour research that empirically recognises the heterogeneity in the choice process across individuals (see Srinivasan 1988, p. 298; Srinivasan 1997, p. 287). The approach models the customer choices in two stages: conjunctive and compensatory. Individuals can purely choose in a conjunctive way in which they eliminate all the levels that are totally unacceptable, thus excluding them from further processing or they choose to different degrees in a compensatory way in which they trades off the remaining levels and attributes; whereas, the hybrid conjoint analysis does not allow for such heterogeneity in the individual choices. However, both methods, the CC-SE and CA allow the "idiosyncratic parameters" (Srinivasan 1988, p. 298). Against this background, the author assumes that the CC-SE method would be more suitable to elicit the preferences of the elderly people especially for products with many attributes.

In this work, the new approach which integrated the CC-SE method into QFD is referred to as "*CC-SEQFD*". Figure 16 provides an overview of the major three phases conducted in the CC-SEQFD approach for elderly people as follows:

Phase 1: Selection and evaluation of customer requirements

Phase 2: Selection and assessment of the engineering characteristics

Phase 3: Estimation of the importances of the engineering characteristics

Each phase is described in the following subsections for the target group of elderly people.

5.3.1.1 Selection and Evaluation of CRs

The respondents are elderly people[40] and the expert team is built from experts including a number of elderly people who are also considered expert in the selected product for study. In this phase, first the CRs are identified by conducting face-to-face interviews with elderly people (e.g. 17-20 face-to-face interviews can be a sufficient number to collect the CRs according to Griffin and Hauser 1993). The identification process of the CRs is conducted in the same way as described by Pullman's conjointQFD. That is to say, three members of the expert team separately identify primary and secondary CRs and then conclude their work with a final list of primary and secondary CRs (see Pullman et al. 2002, p. 358). Then 30 elderly respondents are asked to evaluate the primary and secondary CRs by a one-phase SE method in which the elderly respondents are directly asked to rate their preferences of the CRs on a 1-10 Likert scale. The CRs are then rescaled so that the sum of secondary needs is equal to their corresponding primary CR in the same manner as done in Pullman et al.'s (2002, p. 358). Additionally, a check is done to make sure that the importances or preferences of CRs ranking correspond to the evaluation given by elderly respondents, otherwise they are then corrected according to the evaluation of the elderly respondents. Afterwards, 30 elderly respondents are asked to evaluate a number of competitive products of the selected product on a 1-10 Likert scale for the benchmarking part in the HoQ. It should be indicated that by the present, this step was conducted in the example of the mobile phone only; however, it was not conducted in the example of the smart home to lower the complexity of the study.

5.3.1.2 Selection and Assessment of ECs

In this phase, the expert team determine for each CR one or more ECs. Then for each ECs, two or three levels are assigned "convenient option", "inconvenient option", and "between option". Additionally, the influences of ECs on each CR are determined as in the traditional HoQ. Afterwards, the relationship matrix is evaluated using the CC-SE method. For each CR, which is assigned more than one EC, a CC-SE questionnaire is made. The questionnaire is done by elderly respondents. By using the CC-SE method the relationship matrix is quantitatively assessed thus overcoming this problematic issue of the HoQ (see Section 4.4).

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[40] In this work, elderly people in the two studies are taken from 50 and above.

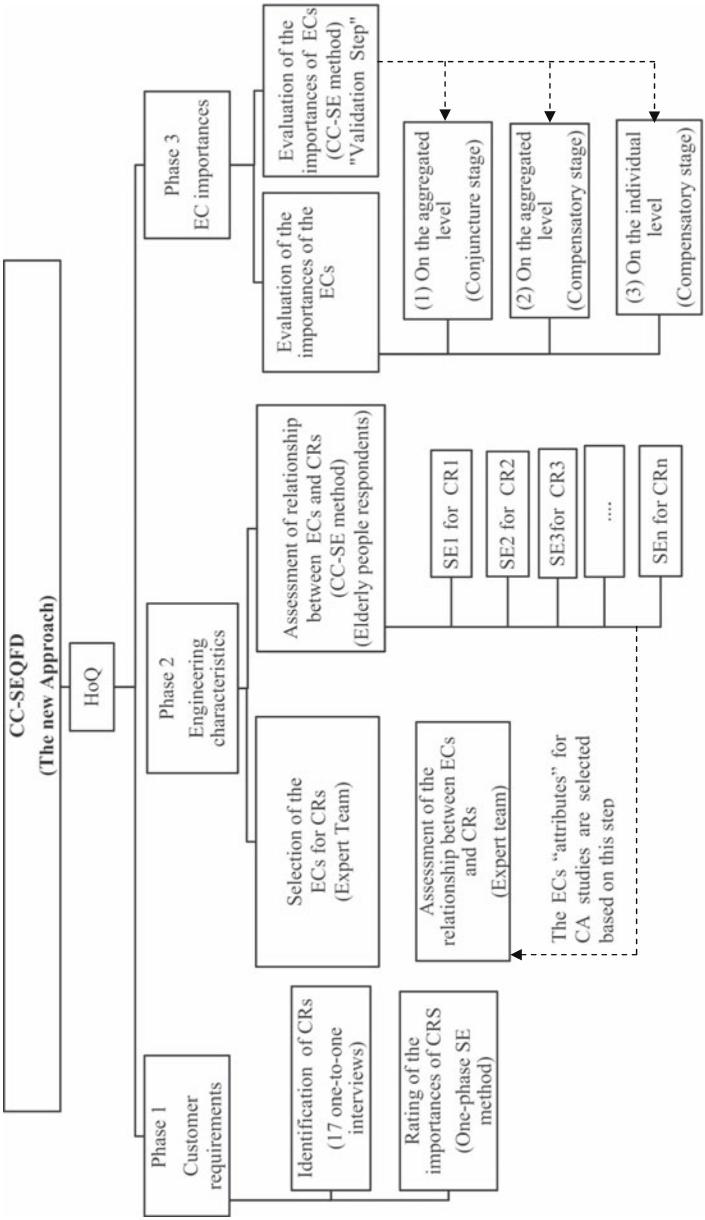

Figure 16: The CC-SEQFD method "new approach" for new and/or improved product development for elderly people.
(Own representation)

5.3.1.3 Estimation of the importances of the ECs

From the CC-SE method, three HoQ were constructed, namely a HoQ for:

(1) the conjuncture stage on the aggregated level
(2) the compensatory stage on the aggregated level
(3) the compensatory stage on the individual level

For the aggregated level, the importances of the ECs are calculated in the conventional way, each EC importance is calculated by summing its influences over the CRs multiplied by the weight of each corresponding CR. On the individual level, the importances of the ECs are calculated for each respondent in the conventional way and then the average of the importances of ECs are presented in the HoQ for of all respondents is presented in the HoQ on the individual level.

An additional CC-SE interview is conducted to test the validity in which all the ECs are included in the interview to investigate the elderly people preferences for the ECs. The "within approach" convergent validity is calculated on each of the three results, as shown schematically in Figure 17.

5.4 Summary of the Pullman's and Baier's ConjointQFD and CC-SEQFD Approaches

A summary of the previous description of the Pullman's conjointQFD (Section 5.1.1), Baier's conjointQFD (Section 5.2.1), and CC-SEQFD (Section 5.3.1) approaches is summarised in Table 19.

Table 19: Summary of the Pullman's and Baier's ConjointQFD approach and the new approach

		Pullman's Approach	**Baier's Approach**	**New Approach**
	Method	CBC/ACA	ACA	CC-SE
	Step 1: Selection of the customer requirements (CRs)			
Phase 1	Number of CRs	Arbitrary	ACA: max. 30	Arbitrary
	Number of levels	Arbitrary	ACA: max. 9	Arbitrary
	Selection method	Face-to-face interviews	ACA interviews	Face-to-face interviews
	Step 2: Evaluation of CR importances			
	Inquiry method	Direct questionnaire	Estimation, e.g., using ACA	Direct questionnaire
	Respondents	30 Respondents	Respondents	30 Elderly people
	Data collection and analysis	Direct ratings of CRs	Rating of profiles analysed by OLS or HB	Direct ratings of CRs

Table 19: Summary of the Pullman's and Baier's ConjointQFD approach and the new approach /(cont.)

	Normalised values	Ratio of CRs	CRs normalised as in CA study	Ratio of CRs
	Step 3: Selection of the engineering characteristics (ECs)			
Phase 2	Number of ECs	Arbitrary	ACA: max. 30	Arbitrary
	Number of levels	Arbitrary	ACA: max. 9	Arbitrary
	Step 4: Assessment of the influences of ECs on the CRs			
	Inquiry method	QFD team	ACA's estimation	CC-SE estimation
	Respondents	QFD team	Expert respondents	Elderly people
	Scale	E.g. 1-3-9 or 1-3-5	Attribute Importances (ACA)	Attribute importances (CC-SE)
	Normalised values	Ratio of individual EC of CR	As in ACA	As in SE
	Step 5: Calculation of the importances of ECs			
Phase 3	Calculation method	Conventional way (see Section 4.1.3)	Conventional way on the individual and aggregated level	Conventional way on the aggregated and in-dividual level

(Own representation, based on Baier (1998, p. 78) and extended by the author); Legend: OLS: Ordinary least square; HB: Hierarchy Bayes

5.5 Adaptation of ConjointQFD and CC-SEQFD Approaches to "Elderly People"

5.5.1 Adaptation of Pullman's ConjointQFD Approach to "Elderly People"

As already mentioned in Section 5.3.1.1, to adapt the methods investigated in this work for the target group of elderly people, some adjustments mainly in the presentation of the interviews are taken in order to make it easier to understand and to lower the cognitive burden on the elderly people as well as to avoid overly long questionnaires.

In Pullman's conjointQFD approach, the QFD is conducted as in the traditional QFD. Thus the elderly people are directly involved in the collection of the CRs which are collected using face-to-face interviews, that are suitable for elderly people. As for the rating of the CRs, elderly people are asked in a separate short simple questionnaire to rate directly their preferences.

For the conjoint analysis study, a number of attainable measures are taken to simplify the interview and make it easier for the elderly. In making the questionnaire, the colours of the online questionnaire are selected to be clear as possible to many elderly. The font and font size are selected to present clearly the questions to be readable in an acceptable way. Additionally, a video is made to represent the product, the attributes, and attribute levels involved in the questionnaire instead of writing it on a number of pages that elderly people have to read first and very often they do not or they read them and become quickly bored and do not continue with the questionnaire. Other measures are also implemented, information on the attributes, attribute levels, and the product are available in each page using the mouse-over technique on each attribute and attribute level. Finally, photos of the parts are used when required or are always attainable by a mouse click on the product, attributes, and attribute levels. For more details and examples see Section 6.3 and Section 7.3.

5.5.2 Adaptation of Baier's ConjointQFD Approach to "Elderly People"

Baier's conjointQFD approach consists of a sequence of interviews depending on the number of CRs used to represent the product. Generally speaking, the approach is a long questionnaire for complex products which pose a cognitive burden especially on the elderly respondents. As a result, many considerations are taken into account in constructing the questionnaire in the two examples conducted in the present work. All the measures taken in the Pullman's conjointQFD are also taken in this approach. However, the video is not used (video duration around 5 minutes) in the questionnaire in order not to increase the questionnaire time. Instead of the video, the attributes and attribute levels are posted in a paper form to the respondent to be viewed before running the interviews and also to be available during the interviews. Additionally, a username and/or password are used to give the possibility of doing the questionnaire at different times.[41]

In this approach, the elderly respondents are given the choice of doing the interviews with support in using the computer and they are also given general information about the product prior the interview after making an appointment for the interview to make sure that they do it till the end. For more details and examples see Section 6.4 and Section 7.4.

5.5.3 Adaptation of the CC-SEQFD Approach to "Elderly People"

As already mentioned in Section 5.3.1.1, the two measures taken in this work to better adapt the research methods to elderly people are used in the new approach, namely a new combination, the CC-SE method is integrated into the QFD and some adjustment

[41] The option of using a username or/and a password is a general option in doing an ACA interview using the Sawtooth Software. In the case of elderly respondents, this option should always be used to lower the cognitive burden of conducting the questionnaire at one time.

measures are taken into consideration in designing and presenting the questionnaire to elderly people. A written questionnaire is made to overcome the deficiency of computer use by some elderly people. The questionnaire provided information about the product, attributes, and attribute levels as well as a clear presentation of the four steps of the questionnaire.

Prior to the interview, the elderly respondent was given a coloured presentation of the attributes and attribute levels of the product to study as well as a description on the product. Additionally, an example of the four steps of the CC-SE method was explained for them. Afterwards, the questionnaire was conducted in face-to-face interviews form.

5.5.4 A Summary of the Adjustment Measures Considered in the Three Approaches

A summary of the previous description of the adaptation of Pullman's conjointQFD (Section 5.5.1), Baier's conjointQFD (Section 5.5.2), and CC-SEQFD (Section 5.5.3) approaches is summarised in Table 20.

Table 20: A summary of the adjustments considered in the three approaches

	Pullman's Approach	**Baier's Approach**	**New Approach**
General adaptation measures			
Interview form	Online questionnaire	Online questionnaire	Written questionnaire
Support	Support is offered	Prior information phase and technical support	Prior phase and face-to-face interviews
Password	No password	Password	Not relevant
Language	German	German	German
Presentation adaptation measures			
Colour	++	++	+
Font	++	++	+
Font size	++	++	+
Information	Mouseover attribute	Mouseover attribute	Not relevant
Multimedia	Photos of attributes Video	Photos of attributes	Photos of attributes
Incentives measures			
Prize	eBook Theatre tickets (2)	eBook	eBook

(Own representation)

The summary includes the main adjustments taken into consideration in general measures, presentation measures, and incentives measures.

Other adjustments for elderly people can still be made. In this work, the attainable technical and financial adjustments possible were taken into consideration. However, other possibilities should be tried. For example, Web 2.0 and new techniques can be used for this case, but the adjustments should be adapted according to the need and limitations of the elderly people and should be simplified as much as possible depending on the product and its complexity.

5.6 Overview of the Empirical Design of the Present Work

In the empirical part, two studies were conducted study 1 “mobile phones” for elderly people and study two “smart home” for elderly people (see Figure 17).

In study 1”mobile phones” for elderly people, the two approaches “Pullman’s approach” (refer to Section 5.1.1) and “Baier’s approach” (refer to section 5.2.1) are conducted in which some adjustments are taken to tailor the two approaches for the target group. The aim is to test how good the two approaches perform in estimating improved or new product for the elderly people. The results of each approach are presented. Afterwards, a comparison between the two approaches is made by evaluating the convergent validity “within” and “between” the two approaches.

In study 2, Pullman’s approach, Baier’s approach, and the new approach were conducted on the example of the smart home for elderly people. The goal is to investigate how good the approaches perform in estimating improved or new product for the elderly as well as to test the new approach and compare its results to the other two approaches. In this study, more adjustments are made on the presentation of the questionnaires of all the approaches for elderly people.

The main results of the approaches are presented. Afterwards, the three approaches were compared on two measures, convergent validity “within” the approaches and the convergent validity “between” the approaches. Additionally, a time analysis of the three approaches is made. Finally, the approaches are indirectly compared (see section 7.6.4).

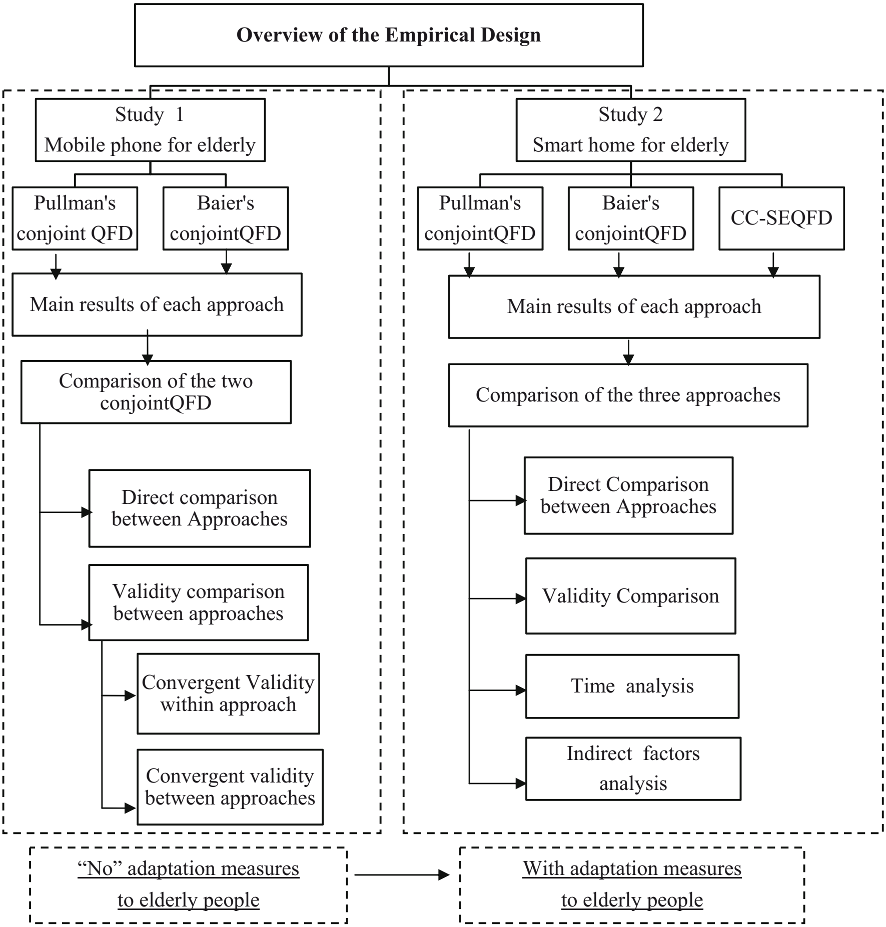

Figure 17: Overview of the experimental design of the empirical part (study 1 and study 2) (Own representation)

6 Empirical Comparison of Pullman's and Baier's ConjointQFD Approaches on the Example of Mobile Phones for Elderly People – Study 1

6.1 Experimental Design of Study 1

6.1.1 An Overview of Study 1

Study 1 consists of the Pullman's and Baier's conjointQFD approaches to be tested on the example of mobile phones for elderly people. The goal of the study is to investigate the two approaches exclusively on the target group of elderly people and to compare the direct results and convergent validities of the two conjointQFD approaches for elderly people. This study is a pre-test before presenting the new approach for elderly people and introducing the adaptations measures in study 2 in Chapter 7.

In the first part of study 1, Pullman's conjointQFD approach is conducted on the example of mobile phones for elderly as described in Section 5.2.1. The three phases conjoint analysis, HoQ, and parts deployment are conducted and their results are reported. In the second part of study 1, Baier's conjointQFD is conducted on the same example according to the three phases described in Section 5.2.1. The HoQ is conducted by using the conjoint analysis to identify the CRs and to assess the relationship matrix. The results are then reported. Finally, the results of the two approaches are directly compared and the validities. The convergent validities of the two approaches are compared on two levels, namely within the approach and between the approaches. An illustration of the experimental design of study 1 is shown in Figure 18.

In this study, no specific adaptations on the two methods are taken for the elderly people. In Pullman's conjointQFD approach, the conjoint analysis study is conducted without any adjustments to the elderly and the HoQ and the parts deployment are conducted as described in 5.1.1; whereas, by the Baier's conjointQFD approach, respondents were given a pre-information phase in the conjoint analysis part and a username and password were used to give the respondents the chance to continue the questionnaire at different times. These adjustments can be also generally used for all age-category respondents; therefore study 1 is considered with no particular adjustments to the elderly people.

S. Abu-Assab, *Integration of Preference Analysis Methods into Quality Function Deployment,*
DOI 10.1007/978-3-8349-7075-6_6, © Gabler Verlag | Springer Fachmedien Wiesbaden 2012

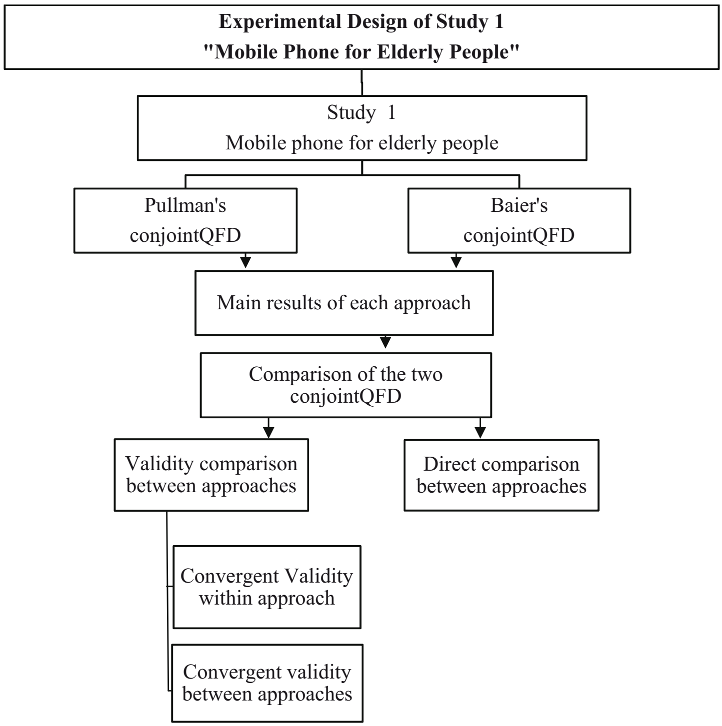

Figure 18: An overview of the design experiment of study 1 on the example of mobile phones for elderly people
(Own representation)

As already mentioned, the main idea of study 1 is to test the approaches for the elderly people as a pre-test without any adaptations to figure out how "appropriate" or "fit" are the approaches for the elderly people.

The product for study 1 "mobile phone" is selected for many reasons. Mobile phones are a convenient example of technological complex product with many attributes and attribute levels, which is the matter of the current research. Additionally, mobile phone is a familiar product to the elderly people although it is a complex product. According to Burkart (2007, p. 187), no such product has penetrated and changed people's lives in a short time like the mobile phone. The product is found everywhere in the market, indeed many mobile phones for elderly are available in the market. Study 1 investigates the needs of these users for mobile phones.

In the next section the sample of the two approaches are presented and tested for homogeneity.

6.1.2 The Sample

The two conjointQFD approaches were carried out separately building two independent samples. The advantages of two separate groups of respondents are (1) the results are not influenced by any sequence and learning effects (see Huber et al. 1993, p. 110; Agarwal and Green 1991, p. 145). Additionally, (2) the respondents are not overwhelmed with second lengthy questionnaire (see Sattler 1994, p. 34) otherwise they would be over-challenged. In order to exclusively investigate the differences and the similarities between the two approaches involved in study 1, it is necessary to make sure that no differences are caused from the independent samples so that these effects (if any) could be also considered in analysing the results. For this purpose, a between-subject-design for Pullman's conjointQFD approach (n=62) and Baier's conjointQFD approach (n=39) are tested according to their structural equality using the Chi-square homogeneity test (see Falk et al. 1995).

The two groups were found to be homogeneous in their gender and age structures when the number of respondents was 35 corresponding to the determination coefficient $R^2 \geq 0.7$ in Pullman's approach. Therefore, in Pullman's study, only respondents with $R^2 \geq 0.7$ are included in estimating the results. Other demographic factors are not available for this study; however, it could be assumed that they won't vary much since the interviews were conducted in the same area. However, one could not totally exclude the other possibility.

Table 21: Important sample characteristics (mainly gender and age) and Chi-square test for homogeneity of the samples for study 1

Characteristics		**Pullman's Approach**		**Baier's Approach**	
		Frequency	in %	Frequency	in %
		n=35	n=100%	n=39	n=100%
Gender	Male	21	60.0	22	56.4
	Female	14	40.0	17	43.6
Age	50-59	21	60.0	28	71.8
	60-79	14	40.0	11	28.2
Chi-square test (Gender)		n. s.		n.s.	
Chi-square test (Age)		n.s.		n.s.	

(Own representation); Legend: n: number of respondents; n.s.: Not significant

In the next section, the Pullman's approach will be described for the product mobile phones for elderly people. In the first part the conjoint study will be presented with its results (e.g. relative importance of attributes and normalised part-worths of levels), and the QFD will be detailed as conducted in the approach and its results will be illustrated.

6.2 The Pullman's ConjointQFD Approach

6.2.1 Constructing and Running the Adaptive Conjoint Analysis

An expert team was formed from six persons who are competent in dealing with mobile phones; among them were an elderly person (in her sixties), a mobile phone dealer, two students who are very familiar with the product, one research assistant at the university, and the author. After identifying a large number of possible important attributes of the product from internet, catalogues, and expert interviews, the expert team decided on nine most relevant attributes and 3 attribute levels for each attribute for the mobile phone, taking into consideration the target group involved (for description see Section 5.1.1). In a full factorial design for this experiment, 19,683 combinations would have been created from 3 levels for each 9 attributes (3*3*3*3*3*3*3*3*3= 19,683). However, this is clearly not possible to ask. Because of this, the design must be reduced, ACA uses a reduced design. Therefore ACA was chosen to be conducted for this experiment since it is used for many attributes (see Sawtooth Software 2000; see also Section 3.2.2, Table 6). ACA uses the pairwise comparison method, which involves a comparison of two profiles (e.g. see Figure 19). For the ACA questionnaire/interview, the well-known Sawtooth Software SSI Web 2002 was used. The ordinary least square (OLS) method was used for the data analysis. The questionnaire was conducted in the German language since it was targeted at elderly people in Germany.

Generally, the ACA interview includes the following steps (Brusch 2005, p. 108; see also Section 3.2.2.2): (1) presentation of attributes and attribute levels, (2) evaluation of the profiles to calculate the utilities, and (3) a calibration question to calculate the internal validity of the results.

In step 1, the attributes and attribute levels investigated in the ACA study are listed in Table 22 and were presented in the first phase (For ACA phases see Section 3.2.2.2). Steps 2 and 3 can be done after the data collection phase. Figure 19 shows an example of the pair question with three attribute levels comparison (see ACA's phase 3 in Section 3.2.2.2). In the "ACA pairs", the author decided on the number of attributes that would appear in each concept or profile.

Table 22: Attributes and levels of the Pullman's approach for mobile phones for the elderly people used in ACA study

Attributes	**Level 1**	**Level 2**	**Level 3**
Form	Folding	Sliding	Standard
Volume	Big	Medium	Small
Display	Big normal	Medium normal	Small sensitive
Battery capacity	3 days	7 days	10 days
Mobile phone price	30 Euro with contract	80 Euro without contract	150 Euro without contract
Running costs	25 Euro/mo.	Prepaid card	10 Euro/mo.
Intelligent functions	Emergency call with position localisation	Programmed emergency number	Defined emergency number
Keyboard	Big	Medium	Small
Additional functions	SMS Voice output Voice command	Medium Voice output	Small Voice command

(Own representation, based on Abu-Assab and Baier 2010, p. 520); Legend: mo.: month

Here, researchers always have to weigh the benefits of more questions (means more effort for respondents) versus the information gained in this case. Experiments have shown that respondents can complete up to 30 choice tasks (threshold level), but with more than that the respondents become overwhelmed, thus the quality of the data comes in question (Sawtooth Software 2003; Hair et al. 2010, p. 293).

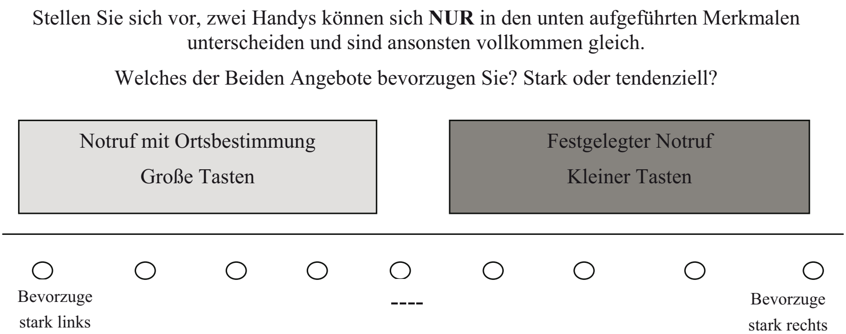

Figure 19: A pair question from phase 3 of the ACA interview of Pullman's approach for mobile phones for elderly people
(Own representation)

However, this threshold could already be too demanding for elderly people. In this experiment, seven "two-pair" and seven "three-pair" questions were asked. In step 3, the calibration question, the interviewees were presented with 5 product profiles each with 6 attribute levels to choose from by assigning it a value from 0 (means "I will certainly not buy it") to 100 (means "I will certainly buy it"). The last part of the questionnaire was dedicated to the demographical questions. Finally, the respondents were thanked and asked to take part in the raffle for two theatre tickets.

A pre-test was made on 6 elderly respondents. Then the questionnaires were sent to 500 elderly respondents per email and post (website was given). 92 responded (response rate 18.4%) from which only 63 were valid responses. However, only n=35 corresponding to $R^2 \geq 0.7$ were further included in the calculations (see Section 6.1.2 for details).

6.2.1.1 The Results of the Conjoint Analysis Study

In conjoint analysis studies, the aggregated results are always of more interest than the individual ones. The attributes and attribute levels can be evaluated either on the individual level and then be aggregated or are evaluated on the aggregated level. In this part of the study, all the calculations for the attributes and levels were performed on the individual level and then aggregated for all respondents.

Table 23 shows the relative importances of the attributes and their standard deviation multiplied by 100% so that it would be easier to read and compare for n=35 corresponding to $R^2 \geq 0.7$.

Table 23: Mean and standard deviation of the relative importances of the attributes in the ACA study of Pullman's conjointQFD approach for mobile phones multiplied by (100%)

Attribute	Relative Importance (%)	Standard Deviation (%)	Ranking (descending order)
Form	8.6	4.3	9
Volume	10.75	4.2	4
Display	9.74	4.0	7
Battery capacity	13.23	5.3	3
Mobile phone price	14.17	3.6	2
Running cost	14.42	4.8	1
Intelligent functions	9.85	5.1	6
Keyboard	10.42	4.0	5
Additional functions	8.83	4.6	8

(Own representation; adapted from Abu-Assab and Baier 2010, p. 520)

The results of the attributes show that the "running cost" and the "mobile phone price" have the two highest ranked relative importances with "14.42%" and "14.17%", respectively. The attribute "battery capacity" comes in the third rank with a relative importance of "13.23%", then followed by the "volume" with a value of "10.75%" then closely after follows the attribute "keyboard" with "10.42%". The "intelligent functions" with relative importance of "9.85%" ranked in the sixth position before the attribute "display" with value "9.74%". The attribute "additional functions" with a relative importance of "8.83%" ranked in the eighth position and finally the "form" of mobile phone landed in the last position with a relative importance of "8.6%".

The normalized part-worths results of attribute levels is calculated on the individual level and then aggregated for n=35 corresponding to $R^2 \geq 0.7$. The results are listed in Table 24 and displayed in percent (%) so that it would be easier to read and compare (see Section 6.2.1, Table 22) and correspondingly, it lists their mean standard deviation in percent (%). The results of the part-worths show obviously, that the level "80 Euro without contract" is the most important level with a part-worth of "11.9%" and directly after, comes the level "Prepaid card" with a part-worth of "10.8%". These two top ranked levels are related directly to price, which is expected to play a crucial role in the preferences of the respondents in a CA study. One can infer from the above two choices that elderly respondents are looking for no commitments in contracts and they rather prefer to be free from what they call "contract stress" as the face-to-face interviews conducted in the QFD part confirmed.

The interesting results for indication are those levels considered especially for the elderly people; the level "emergency call with position localisation" with a value of "7.3%" is ranked in the sixth position. Furthermore, the level "SMS, voice output, and voice command" is ranked in the eighth position with a value of "6.5%" which can be endorsed during the face-to-face interviews. Many of the elderly people have mentioned that they need the mobile phones for calling and receiving calls and nothing more. Few elderly considered that "SMS" is important; however, most of them are in their 50's and they have an affinity to technology; whereas, few of the elderly "were happy and leading a normal life without ever owning any mobile", most of them were in their late seventies. In the last rank landed the level "folding" with a value of "5.3%" which comes in agreement with the interviews. The reason they gave for their preference was that one is sure the call is ended and that the mobile phone is closed. The results of the CA study for elderly people show face validity with the face-to-face interviews conducted for the

QFD purposes. For the rest of the results and their ranking as calculated for elderly respondents refer to Table 24.

Table 24: Mean and standard deviation of levels' part-worths calculated on the individual level in the conjoint analysis study of mobile phone displayed in (%)

Attribute	**Levels**	**Mean of normalised Part-worths (%)**	**Mean Standard Deviation (%)**	**Ranking (descending order)**
Form	**Folding**	**5.3**	4.6	9
	Sliding	3.4	4.6	
	Standard	4.0	4.4	
Volume	Big	3.1	4.7	3
	Medium	**8.9**	4.5	
	Small	3.4	5.0	
Display	Big normal	5.4	4.7	7
	Medium normal	**6.9**	5.3	
	Small sensitive	1.4	3.1	
Battery capacity	3 days	0.8	3.2	5
	7 days	7.8	5.1	
	10 days	**11.9**	6.3	
Mobile phone price	30 Euro with contract	4.4	6.8	1
	80 Euro without contract	**11.9**	5.0	
	150 Euro without contract	3.6	4.8	
Running costs	25 Euro/mo.	3.1	5.4	2
	Prepaid card	**10.8**	7.0	
	10 Euro/mo.	6.8	6.1	
Intelligent functions	**Emergency call with position localisation**	**7.3**	6.2	6
	Programmed emergency number	4.2	5.0	
	Defined emergency number	3.9	5.0	
Keyboard	Big	5.8	5.7	4
	Medium	**8.1**	5.0	
	Small	1.5	3.3	
Additional functions	**SMS Voice output Voice command**	**6.5**	5.6	8
	Medium Voice output	3.6	3.9	
	Small Voice command	2.2	4.0	

(Own representation, see also Abu-Assab and Baier 2010, p. 520); Legend: mo.: month

It is interesting to mark that the choices of the elderly people and comments about the mobile phones, about their preferences and needs are not yet met of the products in the market. For example, elderly peoples' preferences for the levels of "volume", "display", and "keyboard" tend to be for "medium size" rather than "big" or "small". Looking at the so-called "senior mobile phones" in the market, they are "big".

In the next section, the second part of the study was conducted, namely the QFD part. A description of the experiment will be presented as well as the results and implications.

6.2.2 Application of QFD to Pullman's Approach

The same expert team was again used in the QFD experiment part (see Section 6.2). The HoQ steps are as follows (see Section 4.1.3 and Section 5.1.1.2, respectively). In step 1, the customer requirements and needs are collected in 17 face-to-face interviews (for the discussion on the number of face-to-face interviews necessary see Griffin and Hauser 1993). The 17 interviews were conducted in the Germany for the elderly people (50 and above). During the interviews, respondents were asked to talk about the way they deal with their mobile phones. For example, they were asked how frequently they use them, whether they send SMS or not, what advantages they see in using mobile phones, and how much they paid for it (see Abu-Assab and Baier 2010, p. 520).

Then three expert team members independently read and analysed the interview transcripts and grouped the statements into CRs from the point of view of the interviewees. Accordingly, 6 primary CRs with one to three secondary CRs were summarised (see Table 25 for a list of the primary and secondary CRs).

Table 25: List of the primary and secondary CRs summarized from the face-to-face interviews by 3 members of the expert team for the mobile phone

Primary Requirements		**Secondary Requirements**
Usefulness	1	Easy to use
	2	Easy to read and see display
Mobile phone functions	3	Basic functions
	4	Additional functions
	5	Emergency call
Robustness	6	Robustness
Battery duration	7	Battery duration
design	8	Comfortably lie in the hand
	9	Easy to read keyboard
Price	10	Price

(Own representation)

In step 2, 30 respondents rated the importance of the secondary and primary CRs on a six-point rating scale. Then the secondary CRs were rescaled so that the sum of all secondary CRs under an attribute was equal to the primary CR importance (see Pullman et al. 2002, p. 358).

In step 3, elderly customers rated three competitor mobile phones from their perception; namely "Nokia 6300", "Nokia E45", and "Motorola V8" (see Figure 21).

Figure 20: Comparing 3 mobile phones: Nokia 6300, Nokia E65, and Motorola RAZR2 V8 (GSM Arena 2011; Siddharth 2011; Chip Online 2011)

"Nokia 6300" has a standard form, "Nokia E65" has a sliding form, and "Motorola RAZR2 V8" has a folding form. It should be noted that the current study was conducted in 2008 where these mobile phones were somehow new in the market. Accordingly, 30 respondents rated those products on a six-point rating scale, evaluating all mobile phones on the same secondary need before moving to the next. Finally, each respondent rated the likelihood of purchasing each mobile phone on a ten-point buying intention scale. The results of the comparison showed that "Nokia 6300" lies comfortably in the hand and has a very "long battery duration" time. However, it was perceived to be the least preferred mobile phone. For "Nokia E65" it was considered to have the most "convenient price" and to "lie comfortably in the hand" with a very "long battery duration", at the same time, it was considered to be the least "easy to use", the least "easy to call", and the least "easy to read"; whereas the Motorola V8 was clearly perceived to be the most "easy to use", the most "easy to call", the easiest "to hang up on a call with", and as having the most "easy to read keyboard". Consequently, the Motorola V8 was best rated in the survey by the group of elderly people. This step was collected in case it is needed to be used in estimating the target values for further processing and as part of the QFD.

In step 4, the expert team identified one to three engineering characteristics (ECs) for each CR. In total 24 ECs were assigned to the 10 CRs. The ECs are "menu layer", "size of keys", "distance between keys", "display size", "display font size", "display reflection", "display brightness", "strength of signal", "reception strength", "tone quality", "sound intensity", "SMS/MMS", "reminder function", "installation assistant", "emergency button", "impact strength", "waterproof", "energy consumption", "battery capacity", "weight", "volume", "colour contrast of keys", "font size of keys", and finally "cost". The HoQ in Table 26 shows the ECs and their corresponding CRs. It is worth noting that by the selection of the ECs for the mobile phone, the requirements of the elderly people were taken into consideration. For example, the "font size of keys", "colour contrast of keys", "size of keys" should be considered especially to overcome the seeing limitations by elderly. By "menu layer" which corresponds to the CR "easy to use", the reduced learning ability and cognitive burden by ageing is addressed. Other ECs are also considered to address the limitations of the hearing, touching, reaction time by ageing, e.g., "tone quality", "reminder function", "emergency key", "distance between keys". Then in step 5, the expert team assessed the influence of ECs on CRs (relationship matrix) on a -5 (very strong negative relationship) to +5 (very strong positive relationship) scale[42] for each EC. Further, the impact of the preferences (importances) for the ECs was calculated by summing the EC influence on CRs multiplied by the importance of the corresponding CR. It is worth noting that for the assessment of the correlation matrix (influence within ECs) was not made under the assumption that the relationships are small between ECs for simplification purposes.

Finally, all the steps were summarised in the HoQ in Table 26.[43] The results of the HoQ show that the battery capacity" has the largest impact on preferences for elderly people with a value of "27.4". In the second rank is the "energy consumption" with impact on preferences "26.1" and in the third rank, both "impact strength" and "waterproof" comes with an impact on preferences of "23.8". Then in the fifth position comes "cost" with a value of "22.9". It is interesting to notice the ECs that are specifically considered for elderly people.

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42 The -5 to +5 scale was used in this experiment mainly because it was used by Pullman et al. (2002). However, in the next study, the 1-3-9 scale is used to avoid the negative values.

43 The benchmarking of the three competitive products, shown in Figure 21, is not shown in the HoQ because of space limitations. The comparison of the three mobile phones is described and will not further be used in the comparison of the approaches.

Table 26: The HoQ for the product mobile phone for elderly people, Pullman's approach

Customer Requirements (CRs)	Weights	1 Menu layers	2 Size of keys	3 Distance between keys	4 Display size	5 Display font size	6 Display reflection	7 Display brightness	8 Strength of signal	9 Reception strength	10 Tone quality	11 Sound intensity	12 SMS/MMS	13 Reminder function	14 Installation assistant	15 Emergency key	16 Impact strength	17 Waterproof	18 Energy consumption	19 Battery capacity	20 Weight	21 Volume (h*w*d)	22 Colour contrast of keys	23 Font size of keys	24 Cost
Easy to use	1.96	5	3	1									-1	-1	3	3						1			
Good to read and see display	3.78				5	5	3	5																	
Basic functions	2.0								5	5	3	3													
Add. functions	1.28												5	5	1				-1						
Emergency call	1.81															5									
Robustness	4.76																5	5			1				
Battery duration	5.47	1			-3			-5	-5	-1		-1	-1	-1					5	5					
Comfortably lie in the hand	1.62																				3	5			
Easy to read keyboard	1.93		3	1																			5	5	
Price	4.57																								5
Impact on Preferences		15	11.7	3.89	2.49	18.9	11.3	-8.5	-17	4.53	6.0	.53	-1.0	-1.0	7.2	14.9	23.8	23.8	26.1	27.4	9.62	10.1	9.65	9.65	22.9
Ranking		8	10	20	21	6	11	16	7	19	18	24	22	22	17	9	3	3	2	1	15	12	13	13	5

Engineering Characteristics (ECs)

(Own representation); Legend: Add.: Additional

For example, the "emergency key" ranks in the ninth position with impact on preference "14.9"; whereas the "reminder function" and "SMS/MMS" have a low impact on preferences with "1.0" and both have an overall negative correlation in the product design. Indeed the elderly respondents in the interviews were also not excited about the "SMS/MMS". As for the "installation assistant", it settles in position 17 with an impact of preference of "7.2". The rest of the results are shown in Table 26.

The parts deployment was conducted in the experiment (see Abu-Assab and Baier 2010, p. 523); however, in this work, the comparison is conducted on the HoQ level and not on the parts deployment level in order to be consistent in the two studies in this work.

6.3 The Baier's ConjointQFD Approach

6.3.1 Constructing and Running the Adaptive Conjoint Analysis

The following experiment is constructed according to the Baier's conjointQFD described in Section 5.2.1. In the approach, the adaptive conjoint analysis method is applied to evaluate the entire HoQ matrix (i.e. for identifying and rating of CRs and for evaluating the relationship matrix). However, for the comparison purposes between Pullman's and Baier's conjointQFD approaches, the 10 CRs and 24 ECs used in the first experiment are used in this experiment (see Table 26) and accordingly, the questionnaire was constructed. It consisted of the following phases:

Phase 1: Introduction including the username and password

Phase 2: Filter question and demographic questions

Phase 3: The 10 ACAs

Phase 4: Acknowledgement and the raffle.

In phase 1, in the introduction, the elderly people were given a short introduction about the questionnaire. A username and password were used to identify the respondent in the ten ACAs. In phase 2, a question about the respondent's age was used to filter the respondents and make sure that only elderly from 50 and above years old participate in the questionnaire. Respondents passing the filter's question were asked further about their other demographical data whereas for respondents under 50 years old, the questionnaire ended there.

Phase 3 consisted of the main questionnaire, namely the 10 ACAs. In ACA1, the customer requirements are evaluated by the elderly respondents. The ACAs from ACA2 to

ACA9 assessed the strength of the correlation between each CR and its corresponding ECs based on the HoQ in Table 26.[44] That means that for each CR a corresponding ACA is constructed with the ECs representing the attributes of the ACA matrix and the attribute levels are introduced with "convenient" and "inconvenient" options. In total eight ACAs are constructed for the 10 CRs (see Table 27). Both the CRs "emergency call" and "price" correlate with one EC and thus are directly evaluated with 1. Finally, ACA10 is constructed to evaluate the importance of ECs and is used for the validity issue and not for the assessment of the CRs.

Table 27: List of the ten ACAs conducted in Baier's conjointQFD questionnaire

	ACAs	**Evaluation of the importances of the following**
1	ACA1	Importances of CRs
2	ACA2	ECs corresponding to CR1 "usability"
3	ACA3	ECs corresponding to CR2 "display definition"
4	ACA4	ECs corresponding to CR3 "quality of calling"
5	ACA5	ECs corresponding to CR4 "additional functions"
6	ACA6	ECs corresponding to CR6 "robustness"
7	ACA7	ECs corresponding to CR7 "battery duration"
8	ACA8	ECs corresponding to CR8 "comfortability of the mobile phone"
9	ACA9	ECs corresponding to CR9 "readability of keyboard"
10	ACA10	Importances of ECs

(Own representation)

The ten ACAs questionnaires are similarly constructed using Sawtooth Software SSI/Web 2002 in the German language for the elderly respondents in Germany (for details of the ACA phases as used in Sawtooth Software refer to Section 3.2.2.2); Figures 22 and 23 show two questions from two different ACAs. Finally, in phase 4, the respondents were thanked and they were asked to participate in the raffle.

By running the online questionnaire, the elderly people were addressed and invited to participate in the questionnaire by many methods: (1)1600 flyers were distributed in the resident areas of elderly people, (2) 250 emails were sent to various elderly individuals as well as organizations and companies, (3) 150 advertising papers were distributed in the university (e.g. by the area of the Senior-University).

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44 It should be noted that the ECs selection for each CR is determined by the expert team and in this case is taken from the previous experiment for the comparison purposes.

Umfrage zur Kundenorientierten Optimierung eines Mobiltelefons Teil 1: Ermittlung der Wichtigkeit der Kundenforderungen							
Wie wünschenswert sind die folgenden Merkmale eines Mobiltelefons für Sie?							
	nicht wünschenswert			---			besonders wünschenswert
viele Zusatzfunktionen (z.B. Wecker, Terminplaner, SMS/MMS, …)	○	○	○	○	○	○	○
keine Zusatzfunktionen (z.B. kein Wecker, kein Terminplaner, keine SMS/MMS,…)	○	○	○	○	○	○	○
Wie wünschenswert sind die folgenden Merkmale eines Mobiltelefons für Sie?							
mit integrierter Notruffunktion	○	○	○	○	○	○	○
ohne integrierter Notruffunktion	○	○	○	○	○	○	○
Lehrstuhl für Marketing und Innovationsmanagement							

Figure 21: A question from ACA1 of Baier's conjoint QFD of "mobile phone" (Own representation)

Umfrage zur Kundenorientierten Optimierung eines Mobiltelefons Teil 1: Ermittlung der Wichtigkeit der Kundenforderungen				
Bitte Benoten Sie folgende Mobiltelefone mit Punkten zwischen 0 und 100 (0 Punkte: sehr schlecht; 100 Punkte: sehr gut)				
leicht bedienbar	kompliziert zu bedienen	leicht bedienbar	kompliziert zu bedienen	leicht bedienbar
Display leicht erkennbar	Display schwer zu erkennen	Display leicht erkennbar	Display schwer zu erkennen	Display leicht erkennbar
angenehmes Telefonieren	unangenehmes Telefonieren	angenehmes Telefonieren	unangenehmes Telefonieren	angenehmes Telefonieren
viele Zusatzfunk-tionen (z.B. Weck-er, Terminplaner, SMS/MMS, …)	keine Zusatzfunk-tionen (z.B. Weck-er, Terminplaner, SMS/MMS, …)	viele Zusatzfunk-tionen (z.B. Weck-er, Terminplaner, SMS/MMS, …)	keine Zusatzfunk-tionen (z.B. Weck-er, Terminplaner, SMS/MMS, …)	viele Zusatzfunk-tionen (z.B. Weck-er, Terminplaner, SMS/MMS, …)
mit integrierter Notfunktion	ohne integrierter Notfunktion	mit integrierter Notfunktion	ohne integrierter Notfunktion	mit integrierter Notfunktion
sehr robust	wenig robust	sehr robust	wenig robust	sehr robust
Lehrstuhl für Marketing und Innovationsmanagement				

Figure 22: The calibration question in ACA10 of Baier's conjointQFD of "mobile phone" (Own representation)

As already mentioned, two attribute levels "convenient" and "inconvenient" were assigned for the attributes used in the ACAs. Table 28 list the attribute levels for ACA1: evaluation of CRs.

Table 28: The customer requirements with the two levels "convenient" and "inconvenient" matrix used for ACA1

	Customer Requirements	Convenient Level	Inconvenient level
CR1	Usability	Easy to use	Complex to use
CR2	Display definition	Display easy to see	Display is difficult to see
CR3	Quality of calling	Comfortable calling	Uncomfortable calling
CR4	Additional functions	Many additional functions (e.g. SMS/MMS, games, alarm)	No additional functions (i.e. no SMS/MMS, no games, no alarm)
CR5	Emergency call	With built-in emergency call function	Without built-in emergency call function
CR6	Robustness	Very robust	Little robust
CR7	Battery duration	Long standby battery	Short standby battery
CR8	Comfortability of the mobile phone	Lies comfortably in the hand	Lies uncomfortably in the hand
CR9	Readability of keyboard	Keyboard buttons are easy to read	Keyboard buttons are hard to read
CR10	Price	Low price	High price

(Own representation); Note: that CR5 "emergency call" and CR10 "price" are not included in ACA1 because each has only dependent on one EC and is given then the value 1.

Furthermore, in Table 29, the main matrix used in the ACAs (i.e. ACA2 to ACA10) is listed incorporating the "convenient" and "inconvenient" attribute levels and the CRs influenced by each EC. For example, the EC "menu layers" affects the two CRs: CR1 "usability" and CR7 "battery duration" and so forth. For the numbers of the CRs see Table 28.

For ACA10, the evaluation of ECs, the most important 10 ECs from Pullman's conjointQFD approach are included (refer to Table 26). The EC "display font size" and "strength of signal" were replaced by the ECs "weight" and "volume", respectively.[45] Thus the 10 ECs used in the ACA10 are:

[45] The EC "display font size" and "volume" were among the first 10 ranked ECs in Pullman's conjointQFD approach; however, the EC "weight" and "volume" are considered to be interesting to be included in the ACA10 instead of the aforementioned two ECs.

Table 29: The engineering characteristics and their corresponding levels which construct all the matrices used in the relationship matrix

	Engineering Characteristics (ECs)	Convenient level	Inconvenient level	Influenced CRs
1	**Menu layers**	Max. 3 menu layers to reach function	More than 3 menu layers to reach a function	CR1, CR7
2	**Size of keys**	Big buttons $(1\ cm \times 1cm)$	Small buttons $(0.5cm \times 0.5cm)$	CR1, CR9
3	**Distance between keys**	Big between button distance (>0.5)	No between button distance	CR1, CR9
4	**Display size**	Big display $(8cm \times 10cm)$	Small display $(3cm \times 5cm)$	CR2, CR7
5	**Display font size**	Big font in display (8mm)	Small font in display (4mm)	CR2
6	**Display reflection**	No mirroring display surface	Mirroring display surface	CR2
7	**Display brightness**	Bright display	Dark display	CR2, CR7
8	**Strength of signal**	High sending strength (2 Watt)	Low sending strength(1 Watt)	CR3, CR7
9	**Reception strength**	High receiving strength	Low receiving strength	CR3, CR7
10	**Tone quality**	High tone quality	Low tone quality	CR3
11	**Sound intensity**	High maximum sound intensity	Low maximum sound intensity	CR3, CR7
12	**SMS/MMS**	SMS/MMS functions available	SMS/MMS function not available	CR1, CR4, CR7
13	**Reminder function**	Calendar & alarm function available	Calendar & alarm function unavailable	CR1, CR4, CR7
14	**Installation assistant**	Help by first start-up available	Help by first start-up unavailable	CR1, CR4
15	**Emergency key**	Emergency button available	Emergency button is unavailable	CR1, CR5
16	**Impact strength**	High impact strength	Small impact strength	CR6
17	**Waterproof**	Waterproof	Not waterproof	CR6
18	**Energy consumption**	Low energy consumption	High energy consumption	CR4, CR7
19	**Battery capacity**	High battery capacity (2000 mAh)	Low battery capacity (700 mAh)	CR7
20	**Weight**	Light MP (80 g)	Not light MP (120 g)	CR6, CR8
21	**Volume**	Small mobile phone $(10 \times 5 \times 1)$ in cm	Big mobile phon $(12.5 \times 8 \times 2)$in cm	CR1, CR8
22	**Colour contrast of keys**	High coloured contrast on button	Little coloured contrast on buttons	CR9
23	**Font size of keys**	Big font on buttons (8 mm)	Small font on buttons (3 mm)	CR9
24	**Cost**	Purchase price 100 Euro (no contract)	Purchase price 400 Euro (no contract)	CR10

(Own representation); Legend: cm: centimeter; mm: millimeter; g: gram; mAh: milliampere per hour "battery capacity", "energy consumption", "impact strength", "waterproof", "price", "menu layers", "emergency button", "size of keys", "volume", and "weight". For ACA10, it was necessary to only consider 10 attributes to keep the questionnaire manageable for the target group of elderly people. The next section shows the results of the Baier's conjointQFD approach.

6.3.2 The Results of Baier's ConjointQFD Approach

The questionnaire was conducted for a two-month period. After ending the questionnaire, each adaptive conjoint analysis study was considered alone. Table 30 shows each ACA and the number of elderly participants who took part in each questionnaire. The number of participants are given when the determination coefficient $R^2 \geq 0.55$ and when the determination coefficient $R^2 \geq 0.7$ as well as the mean R^2 at $R^2 \geq 0.55$. For example, the number of respondents for ACA1 is n=40 with a mean of R^2=0.83. The R^2 measures the internal validity of the CA study.

Table 30: All the conjoint studies listed sequentially with the corresponding number of respondents

	CA1	**CA2**	**CA3**	**CA4**	**CA5**	**CA6**	**CA7**	**CA8**	**CA9**	**CA10**
n	40	36	36	36	36	35	35	34	35	35
n $R^2 \geq 0.55$	37	33	33	32	31	32	30	28	29	35
n $R^2 \geq 0.7$	31	30	28	27	27	27	25	27	21	28
Mean R^2	0.83	0.8	0.79	0.79	0.77	0.83	0.76	0.8	0.69	0.85

(Own representation); Legend: n: number of participants; R^2: determination coefficient; CA: conjoint analysis; mean R^2 for $R^2 \geq 0.55$

In the HoQ, the importances of the CRs from the result of ACA1 are entered in the importance column. For each row representing a CR an ACA was conducted to assess the strength of the relation between the ECs and CR concerned (ACA2-ACA9). Each ACA's result reports the importances of the ECs for a certain CR. For each ACA, the relative attribute importances and the normalised part-worths were calculated and the relative importances were entered in the HoQ (see Table 31) for all the results.[46] All the

[46] Only the results directly used for the comparison purposes are presented, the other results not related to the comparisons are left out for clarity and to avoid confusion.

data were calculated on the individual level and then aggregated. For each cell in Table 31 the upper number represents the relative importance of the attribute and the lower number represents its standard deviation. Afterwards, the importances of the ECs were calculated as in the traditional QFD and then entered in the HoQ.

The results of the relative importances of ECs are given in Table 31. The result shows that the "emergency key" is the most important EC by a relative importance of "11%" followed by "weight" with a value of "9.5%" and then "costs" in the third rank with a relative importance of "8.7%". "Volume" comes next in the fourth position with a relative importance of "5.9%", and in the fifth rank comes the EC "size of keys" with a value of "4.9%". It is interesting to note by the assessment of the elderly respondents, the ranking of the following ECs: the EC "SMS/MMS" is ranked in the sixth position with a relative importance of "4.7%". The "reminder function" is ranked in the fifteenth position with a relative importance of "3.3%" and the "installation assistant" is assessed in the eighteenth rank with a value of "3.1%". The "battery capacity" was evaluated by the elderly respondents in the last position with a low relative importance of "1.1%" and the "energy consumption" is rated in the seventeenth rank with a value of "3.1". The rest of the results are shown in Table 31.

The results of Baier's conjointQFD will be used in mainly the comparison in the next section. Furthermore, for the comparison, the ACA10 results are needed.

Table 31: The HoQ results including the results of ACA1-ACA9 (relative importances) according to Baier's approach for mobile phones for elderly people

CRs \ ECs	Importance	Menu layers	Size of keys	Distance between keys	Display size	Display font size	Display reflection	Display brightness	Strength of signal	Reception strength	Tone quality	Sound intensity	SMS/MMS	Reminder function	Installation assistant	Emergency key	Impact strength	Waterproof	Energy consumption	Battery capacity	Weight	Volume	Colour contrast of keys	Font size of keys	Cost
Easy to use	.12 .05	.17 .07	.11 .06	.07 .05									.15 .09	.1 .1	.13 .07	.16 .09						.11 .06			
Good to see and read display	.13 .04				.22 .12	.32 .1	.23 .14	.24 .13																	
Basic functions	.11 .04								.24 .1	.30 .12	.20 .13	.26 .11													
Additional functions	.07 .05												.27 .16	.2 .16	.20 .13				.33 .13						
Emergency call	.09 .05															1 0									
Robustness	.08 .04																.34 .18	.28 .20			.39 .20				
Battery duration	.08 .04	.15 .06			.09 .05			.07 .05	.08 .05	.08 .04		.10 .05	.12 .07	.08 .05					.09 .04	.14 .05					
Comfortably lie in the hand	.11 .05																				.59 .17	.41 .17			
Easy to read keyboard	.12 .04		.29 .11	.12 .11																			.27 .15	.31 .12	
Price	.09 .05																								1 0
Relative importance (Multiplied by 100%)		3.2	4.9	2.4	3.5	4.0	2.9	3.6	3.4	4.0	2.2	3.7	4.7	3.3	3.1	11	2.6	2.1	3.1	1.1	9.5	5.9	3.3	3.8	8.7
Ranks		16	5	21	12	7	19	11	13	8	22	10	6	15	18	1	20	23	17	24	2	4	14	9	3

(Own representation); Note: the relative importances of the ECs are multiplied by 100% in order to make it more readable and for space limitations in the table

As previously mentioned, the results of ACA10 are used to check the validity. The results of the relative importances, standard deviations, and their rankings are shown in Table 32. The results of ACA10 were calculated on the individual level and aggregated.

Table 32: Mean of the relative importances of the ECs, standard deviation, and importance ranking in descendent order for ACA10 in Baier's conjointQFD approach

Engineering Characteristics (ECs)	Mean of individual rel. importances	Standard deviation of individual rel. importances	Rank (in descendent order)
Menu layers	.127	.059	2
Size of keys	.066	.051	9
Emergency key	.125	.073	3
Impact strength	.082	.047	7
Waterproof	.069	.060	8
Energy consumption	.102	.048	5
Battery capacity	.117	.051	4
Weight	.100	.062	6
Volume	.061	.055	10
Cost	.152	.071	1

(Own representation); Legend: rel.: relative

ACA10 results show that "cost" is the EC (attribute) with the highest rank, which is expected in a conjoint analysis study, whereas "volume" settles in the last rank. It is interesting to observe that the elderly people in this study emphasised the "emergency key" as the third most important EC, whereas "weight" was ranked in the sixth position. "Battery capacity" was ranked in the fourth position, and in the eighth position came "waterproof" and closely before it came the "impact strength" in the seventh position.

To this point, the main results of Baier's approach, the HoQ results and the ACA10 results were presented. These results will be used and analysed in the next section in the comparison within the approach and between the approaches.

6.4 Empirical Comparison of the Two ConjointQFD Approaches

6.4.1 Direct Comparison between the Two ConjointQFD Approaches

As illustrated in Figure 19, a direct comparison between the relative importances of the Pullman's and Baier's conjointQFD is made. The relative importances from Pullman's conjointQFD approach are used from Table 26 and for the Baier's conjointQFD from Table 31. Then for the purposes of the comparison, the relative importances of each approach are recalculate in which the most important EC for each approach is given an importance rating of 100 and accordingly the importance of the other ECs is calculated as a percent of that maximum. For example, the EC "waterproof" in Pullman's conjointQFD approach has a relative importance of "23.8". This is "86.86%" of the importance of the most important EC, "battery capacity" with a value of "27.4". The direct comparison is mainly graphically presented for all ECs, see Figure 24, and Table 33 gives a comparison of the first four top ranked ECs and the last three ranked ECs.

Table 33: The top four ranked ECs and the last three ranked ECs of the two conjointQFD methods are listed in (%)

Rank	Pullman's approach	Baier's approach
The first four best ranking of ECs between the two approaches		
1	Battery capacity (100%)	Emergency key (100%)
2	Energy consumption (95.26%)	Weight (86.36%)
3	Waterproof (86.86%)	Price (79.09%)
4	Impact strength (86.86%)	Volume (53.64%)
The last three ranking of ECs between the two approaches		
22	SMS/MMS (3.65%)	Tone quality (20%)
23	Reminder function (3.65%)	Waterproof (19.09%)
24	Sound intensity (1.93%)	Battery capacity (10%)

(Own representation); Note: in Pullman's approach, the 3rd and 4th ranks are equal as well as the 22nd and 23rd ranks

Table 33 shows that the top ranks and the last ranks of the importances of the ECs of the two approaches are not similar. The top four ranked relative importance of the ECs are: "Battery capacity", "energy consumption", "waterproof", and "impact strength" by Pullman's conjointQFD approach; whereas, by the Baier's conjointQFD approach, the top four ranks are as follows: "emergency key", "weight", "price", and "volume", respectively.

A view on the last three ranks in both approaches shows that in Pullman's approach the ECs "SMS/MMS", "reminder function", and "sound intensity" are ranked in the 22nd, 23rd, and last rank, respectively. On the other hand, by the other approach the "tone quality", "waterproof", and "battery capacity" are ranked in the last three positions, respectively.

Figure 24 illustrates a graphical presentation of the comparison between the relative importances between all ECs of both approaches. The graphical view was presented based on the recalculated values of the ECs. Although that most of the importances of the ECs are ranked differently, some importances of the ECs are arbitrary similar. For example, "cost" is ranked in the third rank and in the fifth rank in the Pullman's and Baier's approaches, respectively. "Distance between keys" is ranked in the 20th and 21st rank in the Pullman's and Baier's approaches, respectively.

The differences between the rankings of the importances of ECs between Pullman's and Baier's conjointQFD approaches can be explained by many reasons: (1) the differences in the rankings of the customer requirements between the two approaches, (2) the assessment of the strength of the relationship between the ECs and CRs of the two approaches is based on different viewing aspects. That means that in the Pullman's approach the assessment is based on the engineering prospect (relationship matrix is assessed by the expert team), whereas, by Baier's approach the assessment of the relationship matrix is based on the elderly customer prospect (relationship matrix is assessed by elderly respondents).[47] The differences between the prospect of each method are also indicated by Pullman et al.'s (2002, p. 362). (3) The heterogeneity in the groups who assessed the relationship matrix mainly expert and non-expert in the two approaches, respectively. (4) The internal validities of the 10 ACA-studies are not very high (see Table 30), however, they are not low and are unexpectedly better than expected from the elderly people when considering that the cognitive effort in the Baier's conjointQFD was above average. And (5) the two approaches were not adapted for elderly people which could have increased the difficulty of the two studies taking into consideration that the product is also complex.

[47] It was not attainable to find elderly people who have expert knowledge in the mobile phone as is expected in the Baier's conjointQFD approach.

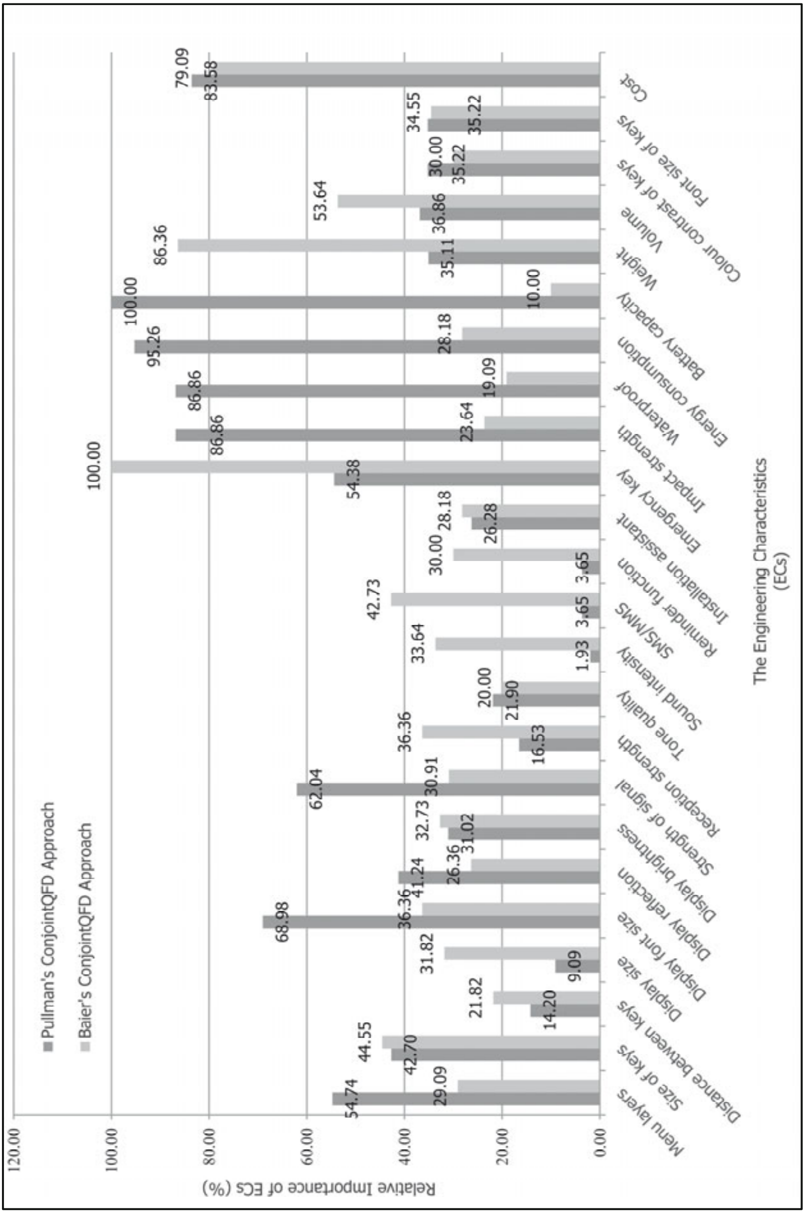

Figure 23: A graphical comparison of the direct results between Pullman's & Baier's approach
(Own representation)

As mentioned above, one of the reasons of the discrepancies in the results is the differences in the Customer requirements, which is directly considered in the calculation of the importances of the ECs. Because of this, a close view of rankings of the primary CRs by the two approaches is given in Table 34.

Table 34: The rankings of the primary CRs by Pullman's and Baier's conjointQFD approaches

	Primary Customer Requirements Ranked in Descendent Order	
Rank	**Pullman's Approach**	**Baier's Approach**
1	Usefulness	Basic functions
2	Battery duration	Usefulness
3	Basic functions	Design
4	Robustness	Price
5	Price	Battery duration
6	Design	Robustness
Sample Size	n=17	n=40
Questionnaire Type	Face-to-face interviews	ACA1

(Own representation); Note: "Usefulness" includes CR1-CR2; "basic functions" includes CR3-CR5; "robustness" includes CR6; "battery duration" includes CR7; "design" includes CR8-CR9; and "price" includes CR10 (refer to Table 25)

From Table 34, it is obvious that the CRs are differently rated. By the Baier's conjointQFD approach, the importance of the CRs is evaluated by ACA1 with an internal validity of R^2=0.83 from 40 elderly respondents; whereas, the by Pullman's conjointQFD approach the CRs are collected from face-to-face interviews and then interpreted by the expert team. The differences in the importances of CRs contribute in the differences of the ECs besides the other aforementioned possible reasons.

Further in the next section, the convergent validities will be checked for the "within approaches" and "between approaches", the results can help in further explanation.

6.4.2 Comparison of Validities "Within" and "Between" the Two ConjointQFD Approaches

6.4.2.1 Comparison of the Validity "Within" the Two ConjointQFD Approaches

In this section, the convergent validity "within" the approach itself is assessed. The convergent validity (see Section 3.3.3) is part of the construct validity which tests if the measures of a construct that are expected to correlate in fact do correlate (Straker 2006; Bühner 2006, p. 32). For Pullman's approach/construct, the convergent validity is calculated from the "estimated" EC importances of HoQ (see Table 26) and the observed attribute importances of the ACA study conducted in the Pullman's approach (see Table 23).

Table 35: Summary of the features compared "within" Pullman's approach between the estimated importances of the ECs and observed importances of the attributes (convergent validity)

	Pullman's ConjointQFD Approach		
	Attributes/ECs	**Impact on Preferences in HoQ "Estimated"**	**Relative Importances in ACA "Observed"**
1	**Volume**	10.1	10.75
2	**Display size**	2.5	9.74
3	**Battery capacity**	27.4	13.23
4	**Price**	22.9	14.17
5	**Emergency key**	14.9	9.85
6	**Keyboard**	11.7	10.42
7	**SMS/MMS**	1.0	8.83

(Own representation); Note: The EC/Attribute "SMS/MMS" has a negative value which indicates a reverse correlation; In the ACA study, the "intelligent functions" corresponds to "emergency key" feature and the "additional functions" corresponds to the "SMS/MMS" feature

The common features between ACA and HoQ of the Pullman's approach are used in the convergent validity calculation. In total, seven attributes/ECs are considered in the comparison: "Volume", "display size", "battery capacity", "price", as well as "emergency key", "keyboard", and "SMS/MMS". Table 35 summarises the seven attributes/ECs and their importances in HoQ and ACA.

The convergent validity is calculated using the three known measures, namely, (1) Pearson's (r) coefficient, (2) Kendall-Tau (τ), and (3) Spearman-Rho (ρ).

Table 36 shows the result of the convergent validity "within" Pullman's approach. It verifies a high correlation of Pearson's (r) coefficient with a value of (0.888) ** at a high significant level of $p<0.01$ (two-sided) and also a significant Spearman-Rho (0.821)* at a level of $p<0.05$ (two sided); whereas the Kendall-Tau does not yield any significance. The Pearson's (r) implies the strength of the linear relation between the observed and estimated features, therefore is the most relevant measure in this case. Thus it can be concluded that Pullman's approach verifies a high convergent validity in the example of "mobile phones" for elderly people. Conversely, in the example of the "climbing harness" study from Pullman et al. (2002), the results were not high and also not significant (refer to Tables 4 and 5 in Pullman's et al. 2002, p. 361). Table 36 shows also the main results of Pullman's et al. (2002).

Table 36: Convergent validity “within” Pullman's conjointQFD approach; the correlation calculated in Pullman et al. (2002, p. 361); and the “within” convergent validity by Baier’s conjointQFD approach

	Pearson (r)	**Kendall-Tau (τ)**	**Spearman-Rho (ρ)**
Pullman’s Approach (Mobile Phone for Elderly People)			
HoQ*ACA (Estimated * Observed)	.888** (.008)	.619 (.051)	.821* (.023)
Pullman’s et al. (2002) (Climbing Harness)			
Pullman et al. (2002) “Climbing harness study” (Estimated*Observed)	.320 (.440)	.286 (.322)	.429 (.289)
Baier’s ConjointQFD Approach (Mobile Phone for Elderly People)			
HoQ*ACA10 **(Estimated*Observed)**	.345 (.329)	.111 (.655)	.188 (.603)

(Own representation); Legend: Significant *p<0.05, **p<0.01, *** p<0.001 (two sided); Note: (1) Pullman et al. (2002, p. 361; see Table 4 and Table 5) results are calculated between CA attributes and design features in the parts deployment; (2) the values between brackets in the table represent the significance (p-value); (3) In Baier’s approach, the EC-values used in the calculation are not multiplied with 100% (e.g. for “menu layers” the value used is “0.032”)

In the Pullman et al.’s (2002) study, however, the comparison was assessed between the design features in the parts deployment and the conjoint analysis results; whereas, in this work, the comparison is made between the ECs in the HoQ and the conjoint analysis results.

In Abu-Assab and Baier’s (2010, p. 525) study in the same example of the mobile phones for elderly people, the results of the correlation between the design features in the parts deployment and the conjoint analysis were not high and did not prove to be significant. The low correlation between the design features and conjoint analysis results in Pullman et al.’s (2002) study was justified in that each method (QFD and CA) “look at the new product design problem through very different lenses” (Pullman et al. 2002, p. 362). They also stated that they do not know if these differences between the two methods can be considered typical (2002, p. 363).

The differences between the results of the two methods on the design features level in the two examples (mobile phone for the elderly people and climbing harness) could possibly be due to the fact that on the design features level the customers’ requirements are not present or CRs interpretations are not exact as in the degree they are present in the HoQ since in the parts deployment the technical people are involved in the decisions whereas in the HoQ the customers are directly involved as well as the marketing and sales people in the company. Therefore, it might be an alternative to consider the correlation between the two methods on the HoQ level where the VOC is more present, given the fact that the conjoint analysis method measures the preferences of the customers. In doing so in the example of the mobile phones for elderly people, as shown above, a high and significant correlation was calculated. This implies that it can be that the differences between the two methods are not typical but it depends on the matrix level compared in the QFD.

For the Baier's approach, the convergent validity is assessed from the "estimated" EC importances of HoQ (see Table 31) and the "observed" attribute importances of ACA10 conducted in the Baier's approach (see Table 32). The common features between the HoQ in Table 31 and the ACA10 in Table 32 in Baier's approach are used in the convergent validity calculation. In total, 10 attributes/ECs are used in the comparison: "Menu layers", "size of keys", "emergency key", "impact strength", "waterproof", "energy consumption", "battery capacity", "weight", "volume", and "cost". Table 36 shows the result of the convergent validity "within" Baier's conjointQFD approach. The correlation verifies to be low (0.345) with no significance (p=0.329). The low correlation can be accounted by a number of reasons. First, the ACA10 was sequentially the last conjoint analysis study conducted from the 10 ACA studies. The first 9 ACA studies took an average of 109 minutes for respondents to reach ACA10, which is a considerable burden on the elderly respondents although the internal validity of ACA10 is considerably high with R^2=0.85 however it is not very high. On the other hand, the number of respondents is small with n=35. Besides, one should not forget that in implementing the Baier's approach in the current work, some deviations were made from the original approach, namely that the target group involved did not consist of experts of mobile phones as the expert students in Baier's example. On the contrary, they were elderly people who own a mobile phone. Another point in this case, Baier (1998) reported of a very high internal validity of the study. These reasons have possibly played a role in this case.

It would be interesting to observe the situation when the approaches are adapted to the elderly people (see Chapter 7). In the next section, the "between" approaches convergent validity is handled.

6.4.2.2 Comparison of the Validity "Between" the Two ConjointQFD Approaches

In this section, the convergent validity "between" the Pullman's conjointQFD and the Baier's conjointQFD approaches/constructs are assessed based on the QFD results of the HoQ of both approaches (see Table 26 and 31). In other words, the importances of ECs of the HoQ of Pullman's approach (Table 26) and that of Baier's approach (Table 31) are compared. In this case, all the ECs are used in the comparison, for a list of them see (Table 26 and Table 31).

The results of the convergent validity between Pullman's and Baier's conjointQFD approaches for the mobile phone for elderly people gives a low correlation (Pearson (r) =0.06) with no significance. Many reasons can account for this result as already discussed in the direct comparison between the two approaches (see Section 6.4.1) such as (1) the differences in the importances of the CRs evaluated between the two approaches; (2) The heterogeneity in the groups who evaluated the relationship matrix mainly "expert" and "non-expert" in the two approaches, respectively. (3) The internal validities of the 10 ACA-studies are not very high (see Table 30), however, they are not low and are unexpectedly better than expected from the elderly people when considering that the cognitive effort in the Baier's conjointQFD was above average. Finally, (5) the two approaches were not adapted for elderly people and demanded a high cognitive effort on the elderly respondents. This matter can increase the difficulty of the two studies taking into consideration that the product is also complex.

The results of the comparison between the two approaches mainly "between approaches" as well as the "within" approaches deliver different results. Possible reasons were given in this chapter in the example of the mobile phones for elderly people. However, further research is required that might help in better understanding to the approaches. Thus in the next chapter another example is conducted on the two approaches with adaptations to elderly people as well as a new approach is proposed for the elderly people.

7 Extended Empirical Comparison of the Two ConjointQFD Approaches and the CC-SEQFD New Approach on the Example of the Smart Home for Elderly People – Study 2

7.1 Experimental Design of Study 2

7.1.1 An Overview of Study 2

Study 2 consists of the Pullman's and Baier's conjointQFD approaches and the CC-SEQFD new approach. These approaches are tested on the example of the "smart home" for elderly people. The goal of study 2 is to further investigate these approaches adapted to elderly people and to compare their results directly and indirectly. This study is an extended empirical investigation for study 1 (Chapter 6) with adaptations measures to elderly people as explained in Section 5.3 and Section 5.5. In study 2 conversely to study 1, two levels of adaptations are taken into consideration: by the introduction of a new approach for elderly people and by adaptation measures taken within each approach. Additionally, the examples selected for the study "smart home" is also focused on the elderly and the features are relevant to them.

After this part, Pullman's conjointQFD approach is conducted on the example of the smart home for elderly people as described in Section 5.1.1. However, in this experiment only the conjoint analysis study and the HoQ are implemented. The second approach, Baier's conjointQFD approach is then conducted on the smart home example for elderly according to the three phases explained in Section 5.2.1. Afterwards, the CC-SEQFD new approach is implemented for the first time on the same example and as described in Section 5.3.1. In the last part of the chapter, comparisons of the three approaches are made as follows: (1) direct comparison in which the results of the HoQs of each approach are compared, (2) validity comparison "within" and "between" the approaches, (3) time analysis of the approaches, and (4) comparison between the indirect factors and their analysis. Figure 24 gives an illustration of the experimental design for study 2.

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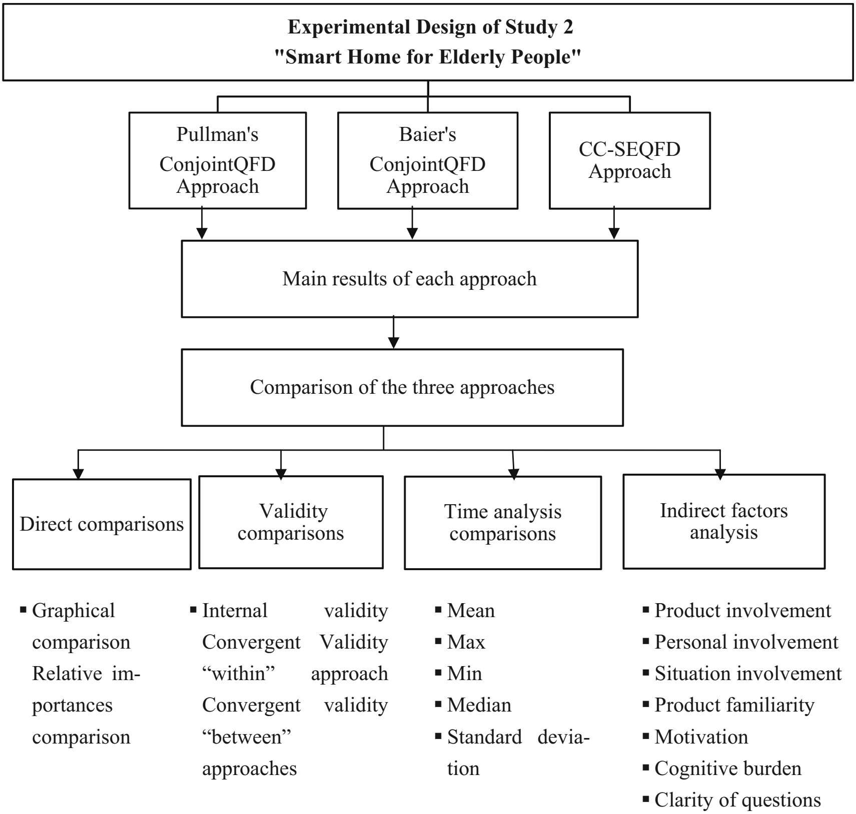

Figure 24: An overview of the design experiment of study 2 on the example of smart home for elderly people (Own representation)

7.1.2 *The Tested Product: Smart Home for Elderly People*

The proportion of elderly people in the population has been continuously increasing in Germany just as in all other industrial countries (see Section 2.1). Most elderly people live and want to continue living in their own homes as long as it is possible for them to live in safe and adequate conditions. This conforms to the social policy to support elderly people to live as long as possible in their own houses (Georgieff 2008, p. 9). The needs of elderly people are divergent depending mainly on their health condition and their living place conditions (see Figure 25).

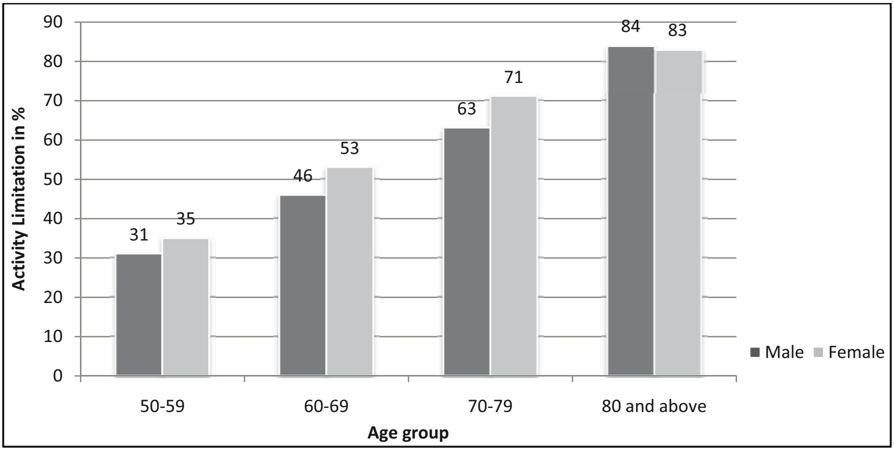

Figure 25: Activity limitations corresponding to age group and gender in Germany in (%) (Own representation adapted from Survey of Health, Ageing and Retirement in Europe 2004)

For example, in their fifties, the limitations on the activity of elderly people vary between 31-35% depending on their gender. In comparison, senior citizens in their eighties experience an activity limitation of 83-84%. This leaves a significant number who need more support than is provided in their houses. At the present, many concepts are being developed to help increase the independence of elderly people in all aspects of their lives (e.g. actively Ageing concept by the World Health Organization WHO 2002) (see Wolter 2007; Malanowski et al. 2008). For some elderly, their dependence could be supplemented with some technical support offered by a smart home instead of having them move into a residential care institution, which results in high costs for the health and social systems and, above all, is against the wish of many elderly, to stay at home. For this main reason, and because of its high potential increasing importance in the lives of elderly people, the product of the smart home seems to be an adequate investigation product for this experiment, especially since the product still lacks the acceptance of the elderly (Abu-Assab and Szuppa 2005; Szuppa 2007; Beer and Szuppa 2005).

Nevertheless, to realise the smart home some minimum technical prerequisites must be available for the concept to work). A recommended computer performance is required, energy storage using Lithium ion accumulators, interconnection between the house and the various machines, and sensors (Georgieff 2008, p. 29). The respondents of the questionnaires were informed of the former presumption in the first stage of the experiment.

A major part of understanding the concept of the smart home is to understand its various application areas. The applications of a smart home are mostly categorised as follows: health and ambulant care, home and maintenance, security and privacy, communication and social network (Georgieff 2008, p. 32). Additionally, energy saving and entertainment are considered important advantages of a smart home. In the present experiment, these aforementioned applications were used in the form of attributes and attribute levels. Each level in this experiment is in itself a product. For each and every attribute two to three different products were selected from a well-known smart home product producer. However, the name of the producer was handled confidentially and the names of the products were changed for the same reason. In the following short depiction of the applications, the main matrix used in the three experiments will be presented in the next section.

7.1.3 The Main Matrix Used in the Three Approaches for the Smart Home for Elderly People

For elderly people, health and ambulant care applications of a smart home cover both prevention and rehabilitation areas in the house (BMBF 2008). Examples for such applications are health care facilities such as remote and self-monitoring as well as remote patient diagnosis which, according to Orwat et al. (2008, p. 6), mostly help the elderly to stay independent in their daily lives. For the smart home experiment, the health factor is substantially basic specifically for the respective target group treated in the work. In this context, two attributes were selected, namely the “emergency alarm at home” and “forwarding emergency alarm”. Each of these attributes has three products covering three price categories (reasonable low price, medium price, and high price) that were selected for each of the two attributes. For the attribute “emergency alarm at home” the levels “emergency button”, “emergency call-set for bathroom”, and a “sophisticated call-set for bathroom” were selected. For the attribute “forwarding emergency alarm” three levels were assigned: “release of alarm”, “connection to private receiver”, and “connection to house emergency call centre”, (see Table 37).

Next the home and maintenance applications flourish from the convergence of technologies, devices, and functions making it one of the most substantial not only in the present time but also in the coming future (see, e.g., Scherer 2009, p. 32). Additionally, the development in the electronic and sensor fields have opened many possibilities and improvement potentials. According to Fellbaum and Hampicke (2002), the smart home is an example for this application field under which “lighting control”, “jalousie control", and "heating control" are implemented and they are used in the current experiment. For the attribute "lighting control", three switchers are selected: the "4-fold button sensor", the "5-canal infrared interface with 3-fold button sensor", and the "120-functions spin regulator". For the jalousie control these three levels are considered, namely "mechanical jalousie switcher", "standard timer service element", and "comfort-timer service element with sun-sensor". Apropos of heating control, three attribute levels were chosen: "room temperature regulator with a dial", "room temperature regulator with a display", and "room temperature with 2-fold touch sensor".

Moreover, in the household the desire for high safety, security, and privacy is desired (BMBF 2008). Examples of applications are the alarm functions in form of automatic call systems and/or house or building entrance systems such as fingerprint, face-recognition, and so forth (Georgieff 2008, p. 35). In the questionnaires the attributes "window/door alarm", "smoke detector", and "video intercom" were assigned for attributes representing this category. For the attribute "window/door alarm", two levels were assigned: "wireless key for electronic door lock" and "electronic door lock with pin input". Regarding the attribute "smoke detector", two products were adopted: "standard smoke detector" and "wireless smoke detector". Two products were elected to represent the attribute "Video door intercom", namely "video door alarm" and "high-tech video system".

Communication and social networking applications construct an essential part of the autonomy and independence for elderly people helps to keep them in contact with family, friends, and neighbours (Georgieff 2008, p. 36). Nevertheless, this application is not included in the matrix, which is mainly based on physical products. Notwithstanding this fact, this issue should be always considered for a healthy and normal living of the elderly.

As for the energy management application, it contributes in managing energy consumption and hence in saving energy in the automated house by linking various functions (e.g. lighting, jalousie, and heating system) to work together besides benefiting from the natural light to optimise the use of energy at home. For this main attribute, two secondary attributes were used to represent the energy in the matrix: "energy control" and "all-off button". Under the "energy control" attribute, products were chosen, namely the "digital wattmeter" and the "home energy controller". The attribute "all-off button" is determined with two levels: "standard switch" and "antibacterial switch".

Entertainment is represented with one main attribute "audio system" with three-fold levels, "mono-digital radio", "stereo-digital radio", and "intercom amplifier input".

For the purposes of controlling the functions of the smart home from a comfortable centralised point, the attribute “control panel” was selected in three variants: “monochrome control panel”, “coloured control panel”, and “control, infotainment, and entertainment centre”.

Above all these attributes and levels, “price” is herein considered in four subcategories, namely “8000 Euro”, “12000 Euro”, “16000 Euro”, and “20000 Euro”. The consideration of price makes the questionnaires more realistic for the respondents as well as for the results. The categories of the price for the smart home were built from a detailed calculation of each attribute and level involved not only as a final interface but also with the whole back-system that must be built for the corresponding level to be ready to use, including the installation, tax, and the backbone of a smart home. The price was calculated corresponding to the producers’ prices and costs of hiring an installer for each three price-categories, namely “reasonable low price”, “medium price”, and “high price”. In other words, in listing the price, real conditions were taken into consideration for the products to be able to measure realistic data of the whole products used in building the smart home. For this reason, the price was classified into four levels.

In this context, two things are worth mentioning. First, some main categories have more attributes than others depending on the importance of the category especially for elderly people. Moreover, this study of smart homes is distinguished in the way the attributes and levels are chosen. That is to say that the attributes and levels are realistic and directly from the market.

To summarise, the present experiment incorporates a total of 7 primary attributes, 13 secondary attributes and 35 attribute levels (see Table 37 for the entire attribute and attribute levels). All the questionnaires were conducted in German since it was addressed to Germans all over Germany. Afterwards, the questionnaires were translated into English for processing purposes. The levels in the questionnaires were presented with coloured photos to make it easier for the respondents to visualise the products.

The attributes and levels were respectively first gathered from catalogues, books, the internet, and articles about smart homes. The final version is mainly constructed from the expert team’s choices, which includes expert installers of smart homes in the area of research combined with the main product catalogue of the producer of smart home products to make it as close to the real product as possible. This is to ensure that the process would be more understandable and easier to realise since elderly respondents are not familiar with the product.

Table 37: The main matrix incorporating primary, secondary attributes, and their attribute levels for the smart home for the elderly used in study 2

Primary Attribute	Secondary Attributes		Levels	
Safety, security, & privacy	1	Window/door alarm	1	Wireless key for electronic door lock
			2	Electronic door lock with pin input
	2	Smoke detector	3	Standard smoke detector
			4	Wireless smoke detector
	3	Video intercom	5	Video-door alarm
			6	High-tech video system
Home & mainte-nance	4	Jalousie control	7	Mechanical jalousie switcher
			8	Standard timer service element
			9	Comfort-timer service element with sun-sensor
	5	Lighting control	10	4-fold button sensor
			11	5-channel infrared interface with 3-fold button sensor
			12	120-function spin regulator
	6	Heating control	13	Room temperature regulator with a dial
			14	Room temperature regulator with a display
			15	Room temperature with 2-fold touch sensor
Health & ambulant care	7	Emergency alarm at home	16	Emergency button
			17	Emergency call-set for bathrooms
			18	Sophisticated emergency call-set for bathroom
	8	Forwarding emer-gency alarm	19	Release of alarm
			20	Connection to a private receiver
			21	Connection to an emergency call centre
Energy manage-ment	9	Energy control	22	Digital Wattmeter
			23	Home energy controller
	10	All-off button	24	Standard switch
			25	Antibacterial switch
Entertain-ment	11	Audio system	26	Mono-digital radio
			27	Stereo-digital radio
			28	Intercom amplifier input
Control Panel	12	Control panel	29	Monochrome control panel
			30	Coloured control panel
			31	Control, infotainment, and entertainment centre
Price	13	Price	32	8000 Euro
			33	12000 Euro
			34	16000 Euro
			35	20000 Euro

(Own representation)

Additionally, the product is complex and has a high degree of innovation. In study 2, the aforementioned matrix is used in the three approaches.

7.1.4 The Sample

The three methods were separately carried out, forming three independent samples. In order to exclusively investigate the differences as well as the similarities between the three approaches, it is essential to make sure that no differences are caused from the independent samples so that these effects (if any) can also be considered in analysing the results. For this reason, a between-subject-design with three independent samples (Pullman's approach: n=73; Baier's approach: n=34; CC-SEQFD: n=60) are tested according to their structural equality using the Chi-square homogeneity test. Taking into consideration the target group and the effort needed (cognitive burden, duration, etc.) in running the questionnaires, it was more suitable to go for the between-subject-design to avoid the learn effect (Agarwal and Green 1991, p. 145) as well as the sequence effect, and above all that elderly would not be overwhelmed with more than one questionnaire. As for the respondents, they were selected according to quota sampling based on the main characteristic of "age" (50 and above).

The quota sampling was implemented in Pullman's conjointQFD approach by using a filter question before the beginning of the questionnaire, in the Baier's conjointQFD approach, a password and a filter question were used to control the age, and in the CC-SEQFD questionnaire the respondents were asked directly before conducting the face-to-face interviews about their ages. The first two experiments were run online and open to respondents from all over Germany. The new approach CC-SEQFD was a written questionnaire and was conducted in a region in Germany. However, respondents were also from different federal states from Germany (see Table 38 for details).

The three questionnaires were conducted between August and November 2010. A total of n=232 respondents answered the questionnaires. However, after filtering them only n=167 respondents were considered in the calculations. The individual samples are as follows (sample sizes after filtering given in parentheses): Pullman's conjointQFD approach: n=123 (73); Baier's conjointQFD approach: n=49 (34); CC-SEQFD new approach: n=60 (60). Table 38 illustrates a detailed overview of the socio-demographical analysis of the three samples based on "age", "gender", "education", "household income", "federal state", "occupation", and "marital status" of the respondents. Having a between-subject-design, it is necessary to check the homogeneity of the independent groups to check how comparable the samples are. Again for this purpose, Chi-square homogeneity test was conducted based on the socio-demographical data available from the questionnaires.

Table 38: Summary of the socio-demographical frequency distribution presented for the three approaches for elderly people used in study 2

Characteristics		Pullman's ConjointQFD		Baier's[48] ConjointQFD		CC-SEQFD New	
		abs.	in %	abs.	in %	abs.	in %
		n=73	n=100%	n=34	n=100%	n=60	n=100%
Age	50-59	43	56.16	22	64.71	42	70
	60-69	25	31.51	9	26.47	13	21.7
	70-79	5	6.85	2	5.88	5	8.3
Gender	Male	43	58.9	14	41	38	63.3
	Female	30	41.1	20	59	22	36.7
Education	Secondary school	2	2.74	2	5.9	7	11.67
	Secondary school (O-level)	8	10.96	-	-	12	20
	School Leaving Exam (A-level)	11	15.07	5	14.7	6	10
	Occupation/ Apprenticeship	5	6.85	5	14.7	10	16.67
	Degree (University, college)	45	61.64	19	5	25	41.67
Household Income	< 500 Euro	2	2.74	3	8.8	1	1.67
	500-1.499 Euro	9	12.33	7	20.6	21	35
	1.500-2.499 Euro	18	24.66	12	35.3	27	45
	2.500-3.499 Euro	12	16.44	10	29.4	8	13.3
	> 3.500 Euro	25	34.25	2	5.9	3	5
Federal State	Berlin	14	19.18	16	47.1	9	15
	Brandenburg	30	41.1	16	47.1	43	71.67
	East Germany	6	8.22	0	0	3	5
	West Germany	23	31.5	2	5.88	5	8.33
Job	Worker	2	2.74	1	2.9	9	15
	Employee	24	32.88	13	38.2	27	45
	Public official	4	5.48	1	2.9	7	11.67

48 The number of respondents is based on the first questionnaire (ACA1) in the Baier's conjointQFD approach.

Table 38: Summary of the socio-demographical frequency distribution presented for the three approaches for elderly people used in study 2 /(cont.)

Characteristics		Pullman's ConjointQFD		Baier's[48] ConjointQFD		CC-SEQFD New	
		abs.	in %	abs.	in %	abs.	in %
		n=73	n=100%	n=34	n=100%	n=60	n=100%
	Self-employee	13	17.81	4	11.8	3	5
	Pensioner	25	34.25	11	32.35	13	21.67
	Housewife/Houseman	3	4.11	3	8.8	0	0
	Others	2	2.74	0	0	1	1.67
Marital Status	Single	3	4.11	3	8.8	5	8.33
	Married	58	79.45	25	73.5	50	83.33
	Divorced	5	6.85	3	8.8	2	3.33
	Widowed	4	5.48	8	8.8	3	5
	Others	3	4.11	0	0	0	0

(Own presentation); Legend: Abs. = Absolute

Table 39 summarises the results of the Chi-square test, showing as expected that the age (quota method characteristic) is homogeneous. Besides "age", the characteristics "gender", "education", and "marital status" showed no significant difference between the groups.

Table 39: The results of homogeneity of the three independent samples using the Chi-square test for the three approaches for elderly people in study 2

Socio-demographical characteristics	Differences between the three approaches
Age	NS
Gender	NS
Education	NS
Household Income	S
Federal State	S
Job	S
Marital Status	NS

(Own representation); Legend: NS: Not Significant; S: Significant

On the other hand, the characteristics "household income", "federal state", and "job" show some significant difference among the three groups. For example, for the household income, categories "500-1499 Euro" and "1500-2499 Euro", the sample of Pullman's approach is similar to the sample of Baier's approach. However both differ from the sample of the new approach for those categories. In another example for this characteristic, the sample of Pullman's approach is closer to the sample of the new approach in the categories "<500 Euro" and "2500-3499 Euro" but different from the sample of Baier's approach. As for the "federal state" characteristic, generally, the sample of Baier's approach is similar to the new approach but both differ from the sample of Pullman's approach. Nonetheless, in the characteristic "job", the samples of Pullman's and Baier's approach conform closely in comparison to the third sample. Despite the significant differences between the three independent samples in those three aforementioned categories, it is shown, however, that there are still some similarities between the samples but not for the three samples. This incongruity in those categories should be taken into consideration in analysing the results.

7.2 The Pullman's ConjointQFD Approach

7.2.1 Constructing and Running the Adaptive Conjoint Analysis

As described in Section 5.1.1, this approach integrated two methods: ACA and HoQ. For the purposes of the experiment, an expert team was formed for the experiment. The team consists of an elderly expert installer for smart homes (certified), three students who are familiar with the product, and the author. There was also the opportunity to consult other expert in the area when needed.

First, many attributes were identified for the product smart home which are considered important through the use of the internet, journals, articles, newspapers, catalogues, and trade fairs (e.g. CeBit, e-home, and IFA). Thereupon, the expert team reduced the number of attributes to eight for the conjoint analysis experiment so that it would be feasible for the target group of elderly people to partake in it. Figure 26 shows a snapshot of the ACA questionnaire.

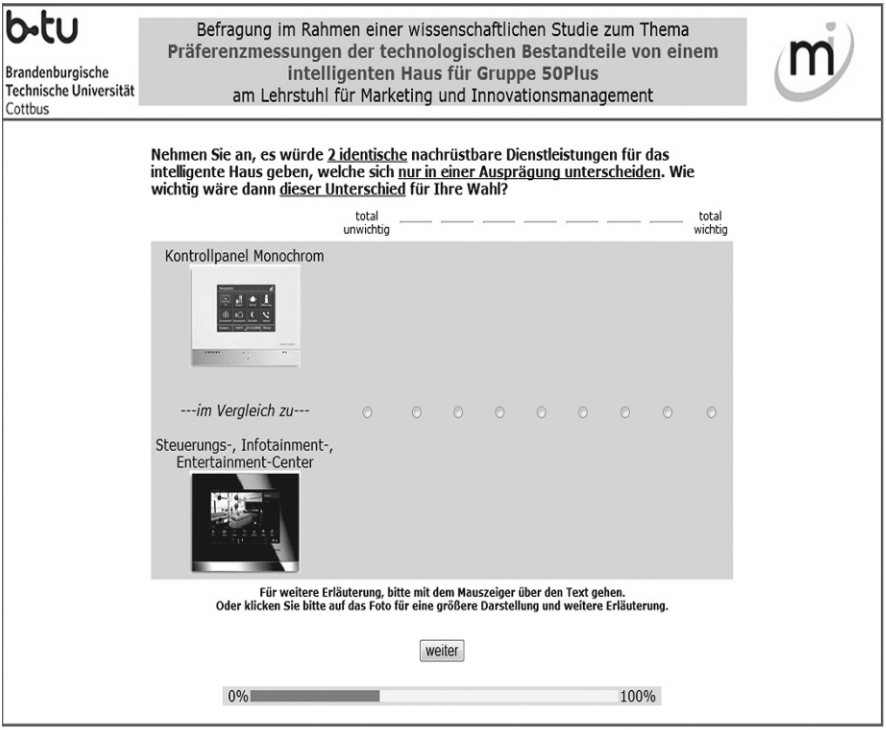

Figure 26: Snapshot of one of the questions in the ACA interview. (Own representation)

In building the questionnaire, it was necessarily to take some adaptation measures to make it easier for elderly people to take part in it in order to obtain better results. An ACA online-interview was used from the Sawtooth Software/SSI Web (Windows Version 2.0.1b). Elderly respondents of the online interviews were given support in using the computer during doing the questionnaire (if they want). All elderly respondents of this questionnaire did not use any support in the online questionnaire. Other adaptations issues, the language. The questionnaire's language was German since the respondents were German. To lighten the cognitive burden as well as to increase the interest of the elderly respondents to avoid premature uncompleted participations. For example, a video is made especially for this questionnaire to replace the long text description of the conjoint matrix (see Figure 27).

Figure 27: Adaptations to elders: a video was made for the online ACA questionnaire (Video is available under the website http://www.youtube.com/watch?v=AWiUasRxziY&feature=player_embedded)

Colours, font, and font size were regarded to suit the elderly people. Special attention was paid to escape the trap of long questionnaires for elderly people as much as possible and to the degree that applied to the approach. Moreover, information was given in different forms throughout the questionnaire. They were given general information about the product in the video to make the product more familiar for the target group especially that the product is also complex. In the questionnaire, information about the attributes and levels was available by the mouse-over option.

The online questionnaire/interview included: (1) Introduction and a filter question, (2) information part, in which the elderly respondents were given some information about the purpose of the interviews followed by some questions related to issues like the technological affinity of elderly respondents, their pre-knowledge of the product in question, and the video was also offered in this part. Afterwards, (3) The conjoint part including the calibration question (see Section 3.2.2.2), followed by (4) the holdout question which consisted of five profiles, each composed of six attribute levels, then (5) the socio-demographical questions. Finally, (6) respondents were offered to participate in the raffle (a Sony Reader eBook, see Figure 28) and an acknowledgement for all participants.

Figure 28: The prize was a Sony eBook

A pre-test was conducted on 7 elderly respondents. Then around 350 people were contacted to participate in the questionnaire either personally, per emails, or posters, or flyers, and in elderly forums. In total 123 took part in the questionnaire, from which only 73 respondents were accepted. However, only n=43 corresponding to $R^2 \geq 0.7$ (average $R^2 = 0.805$) were further included in the calculations.

The relative importances of the attributes were calculated on the individual level and then aggregated. Each attribute has three levels; however, the price has four levels. The price was given four different levels so that the differences between the choices would be reasonable.

The main matrix used in the ACA is displayed in Table 40 as well as the main results of the average normalised part-worths calculated on the individual level and their corresponding standard deviations. The results are multiplied by 100% so that it would be easier to read. The relative importances of the attributes are shown in Table 41.

The results show that "price" is the most important attribute for the smart home considered by elderly people, followed by the "forwarding emergency alarm". Then "jalousie control" ranked third in importance in agreement to the expert team's expectation since "jalousie control" is regarded as a security application.

Table 40: Average normalized part-worths of the levels and their average standard deviation calculated on the individual level, n=43

Attribute	Levels	Mean of normalised part-worths (%)	Mean standard deviation of normalised part-worths (%)
Control panel	Monochrome control panel	3.2	4.9
	Coloured control panel	**7.4**	5.8
	Control, infotainment. and entertainment centre	5.7	6.4
Light control	4-fold button sensor	4.2	5.7
	5-channel infrared interface with 3-fold button sensor	4.7	4.5
	120 function spin regulator	**5.2**	6.5
Jalousie control	Mechanical jalousie switcher	2.7	5.4
	Standard timer service element	5.8	4.7
	Comfort-timer service element with sun-sensor	**9.1**	7.0
Heating control	Room temperature regulator with a dial	1.7	4.2
	Room temperature regulator with a display	8.2	8.7
	Room temperature with 2-fold touch sensor	**8.5**	8.9
Emergency alarm at home	Emergency button	3.1	6.5
	Emergency call-set for bathrooms	5.4	5.3
	Sophisticated emergency call-set for bathrooms	8.2	7.4
Forwarding emergency alarm	Release an alarm	1.2	2.8
	Connection to a private receiver	13.2	16.2
	Connection to an emergency call centre	**15.6**	15.1
Audio system	Mono-digital radio	1.3	2.5
	Stereo-digital radio	**6.9**	5.4
	Intercom amplifier input	4.8	5.3
Price	**8000 Euro**	**16.6**	16.5
	12000 Euro	11.2	9.0
	16000 Euro	6.5	8.2
	20000 Euro	1.8	3.5

(Own presentation)

Table 41: Mean relative importance of attributes calculated on the individual level, n=43 presented in (%)

Attributes (descending order)	Relative Importance (%)	Standard Deviation (%)
Price	18.59	18.6
Forwarding emergency call	17.96	14.8
Jalousie control	11.90	5.8
Heating control	11.45	8.1
Emergency alarm at home	11.10	6.8
Control panel	10.73	5.5
Light control	9.47	5.8
Audio system	8.79	5.4

(Own presentation)

As for the entertainment component "audio system" is least preferred by the respondents and also the "light control" factor was second least preferred.The respondents in this questionnaire were oriented to the comfortable aspects of the products involved in the levels although they preferred the most convenient price, namely "8000 Euro". For example, for the attribute "control panel", they choose the third level, the "120 function spin regulator", which as the other third levels, has a tendency towards comfort. Likewise in the attribute "jalousie control" the preference was mostly for the "comfort-timer service element with sun sensor". In the same sense, the attributes "heating control", "emergency alarm at home", and "forwarding emergency alarm" they mostly preferred "room temperature with 2-fold touch sensor", "sophisticated emergency call-set for bathrooms", and "connection to an emergency call centre" respectively. However, in the case of "control panel" and "audio system", respondents chose the "coloured control panel" and "stereo-digital radio" respectively. The products chosen were not convenient to the price preferred.

7.2.2 The Results of Pullman's ConjointQFD Approach

The second part of Pullman's approach is the application of the HoQ. In this part, the same expert team was in charge as in ACA. The steps are followed as in Section 5.1.1.2.

Table 42: The HoQ according to Pullman's conjointQFD approach for the smart home – Study 2

HoQ based on Pullman's approach (normalised)			Importance	Engineering Characteristics (ECs)												
				Window/ door alarm	Smoke detector	Video intercom	Jalousie control	Light control	Energy control	Emergency alarm at home	Forwarding Emergency alarm	Heating control	Control panel	All-off button	Audio system	Price
Customer Requirements (CRs)	1	I would like to feel safe at home	.094	.25 (9)	.25 (9)	.25 (9)	.03 (1)	.03 (1)		.03 (1)	.08 (3)			.08 (3)		
	2	I would like to have absence simulation	.083				.43 (9)	.43 (9)					.14 (3)			
	3	That calling help quickly is possible	.13		.27 (9)					.27 (9)	.27 (9)		.09 (3)	.09 (3)		
	4	That I can save energy at home	.085				.08 (3)	.25 (9)	.25 (9)			.25 (9)	.08 (3)	.08 (3)		
	5	A button to shut down lights, etc.	.071					.25 (3)						.75 (9)		
	6	That I can control the jalousie	.056				.60 (9)		.20 (3)				.20 (3)			
	7	That I can control the heating easily	.056					.38 (9)	.13 (3)			.38 (9)	.13 (3)			
	8	That I can control the lights easily	.046				.14 (3)	.43 (9)	.14 (3)				.14 (3)	.14 (3)		
	9	It would be good to have music available	.053										.25 (3)		.75 (9)	
	10	Convenient price	.328													1.0 (9)
Absolute Importance (normalised)				.024	.059	.024	.085	.012	.046	.038	.043	.042	.069	.087	.04	.328
Ranking				12	6	12	4	2	7	11	8	9	5	3	10	1

(Own representation)

The interviews were divided into phases in order to gather the demands and needs of the respondents. This action was considered necessary because the product's degree of novelty was rather high and unknown to many. On the other hand, it was hard to find people who were familiar with the product in the area of research. First, in the face-to-face interviews, respondents were shown a diagram of a smart home and given a general explanation along with the definition of the product. Then they were asked about the things that they like most about their homes and likewise about the things that they didn't like or found inconvenient in their homes. They were also asked about their affinity to technology and how acceptable the idea of more technology at home was for them. Next they were shown a 3 minute video about the smart home (especially if they were found not to have enough information about the product). Finally, they were asked to list the things that they liked about the smart home, things that they didn't like about it, as well as their wishes and if some of the inconvenient conditions in their current homes could be replaced or enhanced by the product. Afterwards, the interviews were processed by three members and categorised as shown in Table 44 under the CRs.

A second group of thirty respondents was asked to rank the secondary (i.e. the statement shown in Table 42) and the primary CRs "safety and security", "comfort", "health and ambulant care", energy management", "entertainment", and "price" each on a scale from 1 to 6. The secondary CRs were rescaled so that the sums of secondary CRs equalled their primary CR. This was done for all the secondary CRs. Then each secondary need was multiplied with the weight factor of its primary need to keep the right weights of the secondary needs in comparison to their primary needs.

It should be noted that in this experiment, no bench marking part was done since it was absolutely inconvenient due to the product complexity and novelty degree; on the other hand, the respondents were not in a position to do this as the product is not easy to compare.

In the next phase, the expert team identified one or more engineering characteristics (measureable as much as possible) that corresponded to each secondary customer requirement and then assessed the strength of the relationship between each CR and EC on a scale of 1-3-9. It should be noted that Pullman et al. (2002, p. 359) used the scale -5 to +5 to signify the strength of the relation between CRs and ECs. However, in this experiment the scale 1-3-9 is used to avoid the problematic issue of negative signs in the QFD matrix. The results of the CRs, their importance, ECs and the strength of the relationship matrix, importance of ECs, and ranking of the importance of ECs are illustrated in Table 42.

In this experiment, the attributes and levels implemented in the conjoint experiment were deployed in the HoQ to avoid longevity of the experiment; whereas in the original method the attributes and levels of the conjoint experiment were considered in the deployment matrix. The HoQ shown in Table 42 is the sought result of Pullman's approach which will be later compared to the other methods.

Next the Baier's conjointQFD approach for elderly people on the example of the smart home is implemented.

7.3 The Baier's ConjointQFD Approach

7.3.1 Constructing and Running the Adaptive Conjoint Analysis

Baier's conjointQFD approach integrates conjoint analysis into QFD to determine (1) the importance of the CRs and (2) the corresponding strength relationship between ECs and CRs merely using the customer preferences (refer to Section 5.2.1). Conjoint analysis and, respectively, ACA are applied in the integration process. Each CR with a minimum of two corresponding ECs forms a conjoint study. The results of the conjoint studies "importances of attributes" are taken into the HoQ matrix instead of the values normally estimated by the expert team. Subsequently, the importances of the ECs are calculated as usual by the QFD method.

Regarding the present approach, two issues which inherently differ from Baier (1998) experiment are: (1) The smart home possesses a high degree of novelty and complexity and consequently (2) elderly people are not experts in the field. On the contrary to the examples of the PC for students (see Baier 1998, p. 80; Baier and Brusch 2005, p. 191), of luxury purses for men (see Baier and Brusch 2005, p. 194), and football shoes for free-time athletes (Baier and Brusch 2009, p. 240). These two issues should be considered when analysing the results.

The same adaptation measures to elderly people used by the Pullman's conjointQFD approach for smart home were also implemented in this experiment.

The ACA questionnaire consisted of the following phases: (1) Introduction, (2) information about the product and filter question, (3) socio-demographical elicitation, (4) estimation of CRs (ACA1), (5) evaluation of the relationship matrix (ACA2-ACA10), (6) Holdout questions (ACA11), and finally (7) Raffle and acknowledgement.

It started with an introduction of the questionnaire in which a link for all the eleven ACA interviews was available on the first page for later accessibility of the right interview. Each respondent was assigned a password that helped to link the elderly respondents to the 11 parts making the questionnaire. Additionally, a filter question was also used to make sure that all respondents were 50 and above.

In step 2, information was given about the product and the main purpose of the questionnaire. However, in the current questionnaire, the critical point was the long duration of the interviews (average time of an interview=73 minutes). Because of this, the text and questions were reduced as much as possible to the extent that it would be acceptable in order to lighten the task of the elderly respondents while avoiding lowering the acceptable information required. Information about attributes and attribute levels were available by mouse-over.

In step 3, the socio-demographical questions were asked (See Section 7.1.4). In step 4, the first conjoint study (ACA1) was conducted in which the importances of the CRs were evaluated. The conjoint matrix implemented for ACA1 consists of CRs (attributes) with "convenient" and "inconvenient" levels, as shown in Table 43. In addition, a holdout question was also given consisting of 5 profile/stimuli with 6 attribute levels within each stimuli based on a pre-determined orthogonal design. At this point, it is worth indicating that the same CRs and ECs used in Pullman's approach were also used in Baier's approach for the comparison purposes.

In step 5, nine conjoint studies (ACA2-ACA10) were conducted to evaluate the importances of the relationship between ECs and CRs. ACA2-ACA10 evaluated the importance of each CR1-CR9. "Price" was not evaluated by a conjoint analysis study because it has only one level. Table 44 illustrates the "convenient" and "inconvenient" levels of the attributes/ECs with the corresponding CRs used in the ACA2-ACA10 and ACA11.

In step 6, an additional conjoint study (ACA11) was conducted with the purpose of assessing directly the ECs by the elderly respondents. ACA11 is not needed for the estimation of the importances and part-worths of the attributes and levels respectively, but to assess the validity of the measurement. ECs were the attributes in ACA11 and the levels were represented by the "convenient" and "inconvenient" levels. All the conjoint studies were conducted using the ACA SSI/Web version 5.4 and accordingly were based on an orthogonal design. Each attribute and level preference was rated on a 9-point rating scale in which 1 was the lower limit and 9 was the upper limit (e.g. 1=totally unimportant and 9=totally important). An additional holdout question was included for ACA11 which consisted of five stimuli; each includes five attribute levels. In this question, the elderly respondents were asked to assess their purchase intentions for each stimulus (which presents a whole product) on a scale from 0 (i will not buy it) to 100 (I will buy it).

Table 43: Customer important characteristics

Customer Requirements	**CRs (in attribute form)**	**Inconvenient Level**	**Convenient Level**
"Safe at home"	Security	Minimum	Optimal
"Absence simulation"	Absence simulation	Not available	Available
"Calling for a quick help"	Emergency alarm	Not feasible	Feasible
"Save energy at home"	Saving energy	Little energy saving	A lot of energy saving
"A shut down button"	All-off button	Not available	Available
"Automatic control of jalousie"	Jalousie control	Not feasible	Feasible
"Automatic heating control"	Heating control	Not feasible	Feasible
"Automatic light con-trol"	Light control	Not feasible	Feasible
"Music available around"	Music at home	Not available in all rooms	Available in all rooms
"Convenient price"	Convenient price	High price	Low price

(Own representation)

Then in step 7, the respondents were thanked for their help and their endurance to keep up until the last question and they were offered to participate in the raffle.

In total, 49 respondents participated in the current questionnaire. The questionnaires (i.e. from ACA1 to ACA11) were conducted online in face-to-face interviews to make sure that respondents complete all questions. This additional effort was taken because of the long duration of the questionnaire (average time of questionnaire is 73 minutes and Max. 166 minute). The respondents were not interrupted during doing the questionnaire. However, they were helped when they did not understand a question or idea.

Figure 29: An example of the questionnaire showing a pair question (Own representation)

Moreover, the interviewer tried to give a general idea about the smart home and the way the questionnaire is built before beginning of the interview. Figure 29 depicts one of the questions of the ACA-questionnaire.

Table 44: Engineering characteristics with convenient and inconvenient levels and the CRs that affect each EC

	Engineering Characteristics (Attributes)	**Levels (convenient and inconvenient)**	**ECs Affected by CRs**
EC1	Window/door alarm	Wireless key for electronic door lock/ Electronic door lock with pin input	CR1, CR3
EC2	Smoke detector	Standard smoke detector/ Wireless smoke detector	CR1, CR3
EC3	Video intercom	Video-door alarm/ High-tech video system	CR1, CR3
EC4	Jalousie control*	Mechanical jalousie switcher/ Standard timer service element/ Comfort-timer service element with sun-sensor	CR1, CR2, CR4, CR6, CR8
EC5	Light control*	4-fold button sensor/ 5-channel infrared interface with 3-fold button sensor/ 120-function spin regulator	CR1, CR2, CR4, CR5, CR7, CR8
EC6	Energy control*	Digital wattmeter/ Home energy controller	CR4, CR6, CR7, CR8
EC7	Emergency alarm at home*	Emergency button/ Emergency call-set for bathrooms/ Sophisticated emergency call-set for bathroom	CR1, CR3
EC8	Forwarding emergency alarm *	Release of alarm/ Connection to a private receiver/ Connection to an emergency call centre	CR1, CR3
EC9	Heating control*	Room temperature regulator with a dial/ Room temperature regulator with a display/ Room temperature with 2-fold touch sensor	CR4, CR7
EC10	Control panel*	Monochrome control panel/ Coloured control panel/ Control, infotainment, and entertainment centre	CR2, CR3, CR4, CR6, CR7, CR8, CR9
EC11	All-off button*	Standard switch/ Antibacterial switch	CR1, CR3, CR4, CR5, CR8
EC12	Audio system*	Mono-digital radio/ Stereo-digital radio/ Intercom amplifier input	CR9
EC13	Price*	8000 Euro/ 12000 Euro/ 16000 Euro/ 20000 Euro	CR10

(Own representation); Legend: *: means they were used further

7.3.2 The Results of Baier's ConjointQFD Approach

The questionnaire was conducted for 40 days from October 2010 till November 2010. After ending the questionnaire, each ACA was considered alone in the calculations. Table 45 shows each ACA and the number of elderly respondents who took part in each questionnaire. The number of respondents who were included in the calculations are n=35 corresponding to an average R^2=0.82. The determination coefficient (R^2) is a measure of the internal validity of the goodness of the data. Low number of elderly participants can be accounted for many reasons: (1) lengthy questionnaire, (2) unfamiliarity of the product by the elderly (novelty of the product) as well as (3) the complexity of the product for the elderly people and the high cognitive burden required, and (4) somehow short questionnaire time (40 days). However, the decision to do face-to-face interviews seems to be a convenient choice to secure enough respondents for the questionnaire.

Table 45: The number of respondents and correlation coefficient for ACA1-ACA11

	CA1	**CA2**	**CA 3**	**CA4**	**CA5**	**CA6**	**CA7**	**CA8**	**CA9**	**CA10**	**CA11**
n	40	38	34	35	34	33	35	35	35	33	35
R^2	0.82	0.72	0.79	0.78	0.79	0.86	0.9	0.9	0.83	0.87	0.74

(Own representation); Legend: n=number of respondents; R^2=Determination coefficient; R^2 is calculated for all R^2); Note: (1) ACA is written CA for space limitation in the table; (2) Mean n = 35 (2); Mean R^2=0.82

Table 46 provides a summary of the whole results of the HoQ. It shows the results of the calculation of all mean relative importances of ACA1-ACA10 calculated on the individual level. The upper numbers represent the relative importance of ECs corresponding to the given CRs. And the lower number in brackets represents the standard deviation calculated on the individual level. For example, the customer requirement for "security" (CR1) is presented by mean of "0.144" and standard deviation of "0.054" calculated on the individual level.

For the CRs, the most important CR is the "convenient price" with a value of "0.147". The second most important CR is "security" with "0.144", both CRs "saving energy" and "automatic heating control" share the third ranking, each with a value of "0.126", for the rest of the CR rankings refer to the HoQ Table.

For the results of the relative importances of the ECs, "light control" is ranked as the most important EC with a value of "0.157", in the second position is the "control panel" with a relative importance of "0.151", then comes "price" with relative importance of "0.147". Interesting for the elderly respondents are the ranking of the following ECs: the EC "emergency alarm at home" comes in the ninth position with a relative value of "0.044", in the seventh place comes the "forwarding emergency alarm" with a relative value of "0.056", and "all-off button" with a value of "0.065" in the sixth position. "Energy control" comes in the fifth position with an importance of "0.105". It is obvious that the energy issue is an important aspect of the smart home product which is valued by the elderly people. For the rest of the results refer to the HoQ in Table 46.

The results of the Baier's conjointQFD approach will be later compared and analysed.

Table 46: The HoQ according to Baier's ConjointQFD approach for the smart home Study 2

HoQ based on Baier's approach (normalised)	Importances	Window/door alarm	Smoke detector	Video intercom	Jalousie control	Light control	Energy control	Emergency alarm at home	Forwarding emergency alarm	Heating control	Control panel	All-off button	Audio system	Price
		Engineering Characteristics (ECs)												
Customer Requirements (CRs)														
I would like to feel secure at home	.144 (.054)	.112 (.07)	.109 (.07)	.107 (.07)	.155 (.08)	.124 (.06)		.133 (.07)	.166 (.09)			.093 (.07)		
I would like to have absence simulation	.079 (.066)				.367 (.16)	.308 (.12)					.325 (.14)			
That calling help quickly is possible	.124 (.052)		.218 (.09)					.192 (.07)	.262 (.11)		.223 (.11)	.105 (.09)		
That I can save energy at home	.126 (.053)				.20 (.09)	.163 (.08)	.197 (.07)			.168 (.07)	.176 (.07)	.096 (.07)		
A button to shut down lights, etc.	.066 (.047)					.682 (.19)						.318 (.19)		
That I can control the jalousie	.071 (.045)				.355 (.17)		.345 (.148)				.300 (.155)			
That I can control the heating	.126 (.058)					.279 (.10)	.293 (.13)			.304 (.13)		.124 (.10)		
That I can control the lights	.058 (.044)				.244 (.13)	.196 (.07)	.236 (.08)				.216 (.08)	.106 (.06)		
It is good to have music available around	.059 (.040)										.437 (.24)		.563 (.24)	
Convenient price	.147 (.054)													1.00 (0.0)
Relative Importance (normalised)		.0167 (.01)	.041 (.015)	.0170 (.009)	.111 (.021)	.157 (.027)	.105 (.031)	.044 (.014)	.056 (.018)	.055 (.014)	.151 (.035)	.065 (.03)	.034 (.01)	.147 (0.0)
Ranking		13	10	12	4	1	5	9	7	8	2	6	11	3

(Own representation)

7.4 The Conjunctive-Compensatory Self-Explicated QFD New Approach

7.4.1 Constructing and Running the Conjunctive-Compensatory Self-Explicated New Approach

The main focus of the current research is to tailor the research methods to elderly people; in other words to make the necessary changes to the method either on the level of structure and/or design in order to make it easier for the target group, for example by (1) lowering the cognitive effort, (2) reducing the duration of the survey, (3) making it clear (e.g. choices of colour, design, etc.), (4) making it easier to read, and (5) making it more interesting and so forth.

The experience with Pullman's and Baier's conjointQFD approaches on the two products the "mobile phones" and the "smart home" for elderly people has identified some difficulties for the elderly in taking the online questionnaires. For example, some of the setbacks of the aforementioned methods were, again, the long duration of the questionnaire, the cognitive effort required from the elderly, and thus the low number of participants compared to the effort invested to win a participant for the questionnaire.[49] So it was not enough to make some changes regarding the external design of the survey (e.g. suitable colours, videos, more help possibilities, more information and so forth) but there is also a need to make changes within the methods combined in the two approaches, therefore a new combination with the QFD is tested in this experiment.

The conjunctive-compensatory SE method is combined to the QFD and tested in this section on the example of smart home for elderly people, as described in Section 3.1.2.2 and in Section 5.3.1. In the new approach, the CC-SE method is applied to evaluate the entire HoQ matrix as ACA by Baier's conjointQFD approach (i.e. for identifying and rating of CRs and for evaluating the relationship matrix). The same CRs and ECs described for the smart home in Pullman's and Baier's approaches are also used in the new approach for the comparison purposes (see Table 46). Accordingly, the approach was constructed as described in Section 5.3.1, Figure 17 in three main phases. For the purposes of collecting the data a written questionnaire was developed, incorporating 17 pages divided into 7 parts described in the following steps:

(1) Introduction, information about the product, and the raffle (eBook),

[49] Other factors played a role for low participants (e.g. degree of interest of the survey, area of running the survey, the suitable motivation for participants, etc.).

(2) Description of the main attributes and attribute levels,
(3) Description of the steps of the CC-SE method graphically and in text
(4) Socio-demographical questions
(5) Rating of the CRs on a rating scale of 1-10
(6) Rating the relationship matrix using CC-SE questions (SE1-SE9)
(7) Additional CC-SE (SE10) to evaluate directly the all the ECs used for the validity issues and not for the HoQ.
(8) Acknowledgement

In step 1, an introduction to the questionnaire was presented in which it was clearly stated which target group was intended for the survey in addition to some general information about the investigated product. The purpose of the interview and the main task of the interviewees were stated. At the end of the page, participants were given the choice to take part in the raffle (the same eBook was offered for the three questionnaires).

In step 2, elderly participants were given a coloured printout with the main attributes and attribute levels of the questionnaire and were asked to take a couple of minutes to study the table (Figure 31 depicts part of the printout). Then in step 3, the participants were shown a written description of the four steps of the conjunctive-compensatory self-explicated method in one page and a graphical description with an explanation of those steps on the other (see Figure 30 for the graphical description).

In step 4, the socio-demographical questions were presented, the respondents were asked to state their age, gender, state of residence, educational level, job, income, and marital status.

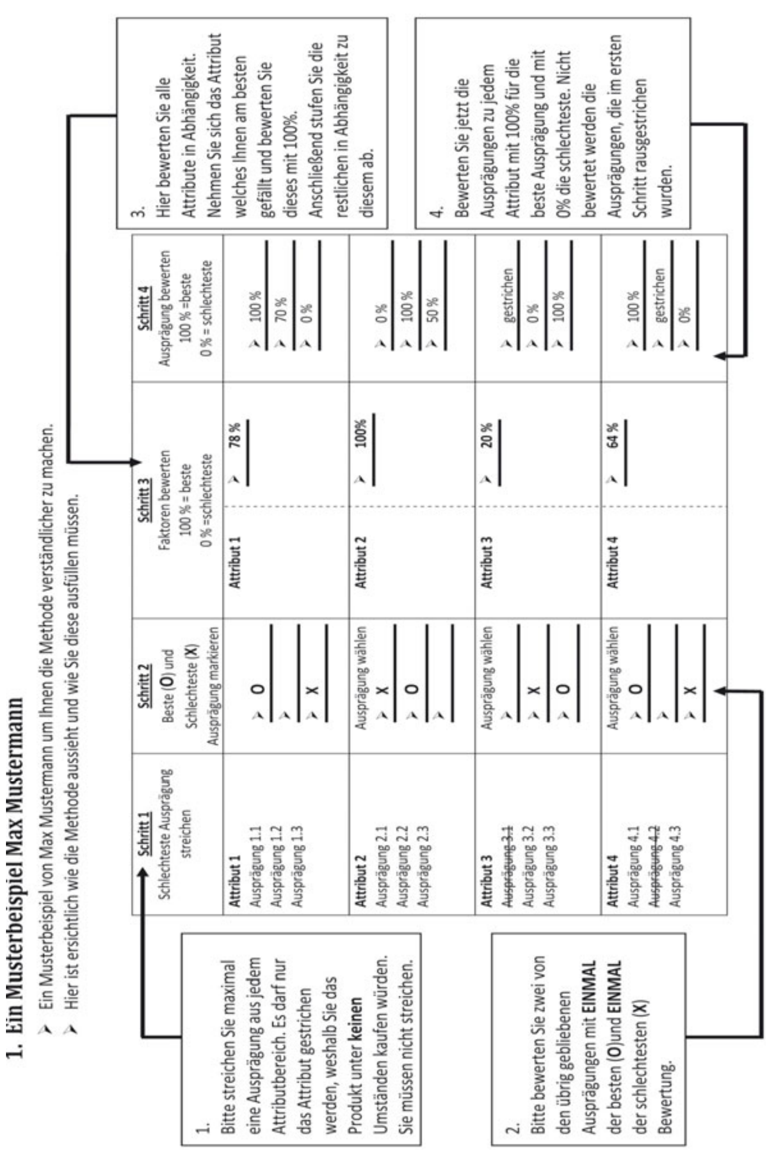

Figure 30: The graphical presentation with description of the four steps of conjunct-tive- compensatory self-explicated questionnaire
(Own representation)

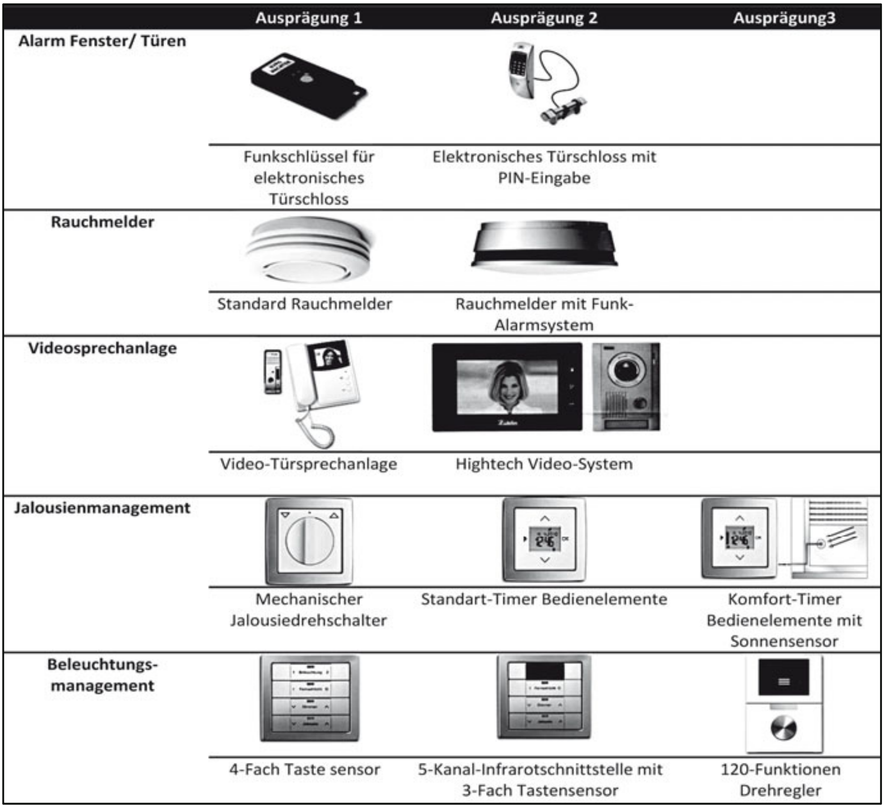

Figure 31: A part of the two-page matrix that incorporates the attributes and attribute levels for the self-explicated questionnaire in the German language

In step 5, the first part of the house of quality, "customer requirements" were taken from the previous methods and were evaluated in the new method using a scale of 1-10.

In the rating scale, 1 means "totally unimportant" and 10 means "totally important". The subjects were asked to rate each of the primary needs and then the secondary ones. 60 respondents rated 6 primary and 10 secondary needs. For example, the primary CR "security" was rated as the most important CR, followed by "price" and "efficiency".

In step 6, the CC-SE questions were asked in order to evaluate the relationship matrix in the HoQ. The SEs from SE1-SE9 assessed the strength of the correlation between each CR and its corresponding ECs based on the expert team decision of the HoQ in Table 42. That means that for each of CR a corresponding CC-SE questionnaire is constructed with the ECs representing the attributes of the matrix and the attribute levels are introduced with “convenient” and “inconvenient” levels. In total, 9 CC-SEs are designed for the 10 CRs. The “price” correlate with one EC and thus is directly evaluated with 1.

For example, the CR “I would like to feel safe at home” (i.e. security) was influenced by 8 ECs: “window/door alarm”, “smoke detector”, “video intercom”, “jalousie control”, “light control”, “emergency alarm at home”, “forwarding emergency alarm”, “all-off button”. The respondents were asked in step one of the CC-SE study to identify the attribute levels that were “totally unacceptable” to them, then in step 2, to determine the most and the least preferred levels without including the deleted unacceptable levels (if any). In the third step, the respondents were asked to identify the critical attribute and set its importance to 100, then rate the other attributes based on the critical one. The critical attribute was used as an anchor in this step. Finally, in step 4 of the CC-SE study, the interviewees were asked to rate the acceptable levels by assigning 100 for the most preferred level within each attribute and 0 for the least preferred level (for details of the CC-SE method see Section 3.1.2.2). Figure 31 shows a snapshot of the CC-SE for CR “jalousie control”.

In step 7, an additional SE part was conducted with the respondents to estimate directly the importances of all the ECs of the smart home. The main purpose of the additional SE method was to check the validity and it wasn’t used for the estimation of the attributes and attribute levels. Finally, in step 8, at the end of the questionnaire, respondents were thanked for taking part in the survey.

The current questionnaire was chosen to be conducted in face-to-face interviews because in the pre-test phase, it was determined that the respondents needed help in understanding the steps in spite of all the descriptions being provided and all the simplifications of the questionnaire. For example, Dorsch and Teas (1992, p. 41) conducted a conjunctive-compensatory self-explicated survey in which the answers were gathered in group interviews. The author’s aim was to lower the cognitive effort required in running the survey.

By running the written questionnaire, 60 respondents took part in the face-to-face interviews. The questionnaire was written in German. The demographical analysis shows that most of the elderly respondents are from Brandenburg (72%), Berlin (15%), and the rest (13%) from the other federal states. The face-to-face interviews were conducted in the university area which can explain this point; therefore the principle of choice was rather haphazardly than randomly chosen. Consequently, the sample is not representative for the structure of the population (see Bortz and Döring 2006, p. 394). All respondents were 50 and above. 70% were between the ages of 50 to 59; whereas 22% were between the ages of 60 and 69 and only 8% were between the ages of 70 and 79.

b. Bitte bewerten Sie den Komfort Ihres Smart Homes

1. Bewertung der Jalousiesteuerung

Step 1	**Step 2**	**Step 3**	**Step 4**
Schlechteste Ausprägung streichen	Beste (**O**) und Schlechteste (**X**) Ausprägung markieren	Faktoren bewerten 100 = beste 0 =schlechteste	Ausprägung bewer-ten 100 =beste 0 = schlechteste
Jalousiemanagement Mechanischer Jalousie-drehschalter • Standard-Timer Be-dienelemente • Komfort-Timer Be-dienelemente mit Sonnensensor	1. ____ 2. ____ 3. ____	**Rauchmelder** ➤ ____	1. ____ 2. ____ 3. ____
Energiekontrolle • Digital-Leistungsmesser • Home Energy Cont-roller	1. ____ 2. ____	**Energiekontrolle** ➤ ____	1. ____ 2. ____
Kontrollpanel Kontrollpanel Monoch-rom • Farb-Kontrollpanel • Steuerungs-, Info-tainment-, Entertain-ment-Center	1. ____ 2. ____ 3. ____	**Kontrollpanel** ➤ ____	1. ____ 2. ____ 3. ____

Figure 32: A section of the SE questionnaire for the attribute/CR "jalousie control" in the German language

The questionnaire took place in the time from end of October to the 10th of November 2010 (two weeks). This seems to be quite a good number of participants in comparison to the overall time of running the survey compared to the number of participants in the two previous questionnaires. The mean time of the face-to-face interviews was around 20-25 minutes.

7.4.2 The Results of the CC-SEQFD New Approach

In the first stage, the attributes and attribute levels for the conjunctive stage of the SE were calculated by counting the number of “unacceptable attribute levels” and transferring them to “% of considering the level to be unacceptable”. Then the averages (in %) of the unacceptable attribute levels were calculated by summing the unacceptable counts within an attribute and dividing them by the number of levels -1 for each attribute. This value represents the average importance of the attribute in the conjunctive stage. Eventually, the importance of each attribute was normalised, in this case by dividing the above calculated value by the sum of all the importances and then multiplying by "100%" as calculated by Srinivasan (1988) (for an example, see Table 47).

Table 47: Results for the conjunctive and compensatory stages for the CR2 "absence simulation" on the aggregated level

CR2	Conjunctive Stage			Compensatory Stage		
Absence simulation (n=60)	**(A) %**	**(B) Average**	**(C) Imp.**	**(D) Mean PW**	**(E) Range**	**(F) Imp.**
Jalousie control		5.00	**35.29**		28.19	**48.70**
Mechanical jalousie (l1)	5.00			21.64		
Standard timer service (l2)	1.67			39.03		
Comfort-timer service (l3)	3.33			49.83		
light control		5.00	**35.29**		5.64	**9.74**
4-fold button sensor (l1)	5.00			40.79		
5-channel infrared interface (l2)	0.00			38.30		
120-function spin (l3)	5.00			35.15		
Control Panel		4.17	**29.41**		24.06	**41.57**
Monochrome (l1)	1.67			17.83		
Coloured (l2)	1.67			41.89		
Control. infotainment (l3)	5.00			39.68		

(Own representation); Legend: (A): % considering the level to be "unacceptable"; (B): Average % "unacceptable"; (C): Average importance = (B) and normalised to add up to 100; (D): Mean part-worth; (E): Range of (D) over levels; (F): Average importance = (E) and normalised to add up to 100; l: for level

For the compensatory stage, the attribute level desirability ratings were calculated from the answers which were collected as follows: For each attribute, the most preferred level was equal to a "100 point" desirability rating conversely the least preferred level but "still acceptable" was equal to "0 point" desirability rating. The remaining attributes (if any) are then rated between the two points of desirability ratings by respondents. In other words, the part-worths for each elderly respondent were obtained by multiplying the given desirability rate by the given attribute importance divided by 100.

Next, to calculate the average attribute importance, the range was first figured out by subtracting the maximum part-worth from the minimum part-worth within an attribute and for each attribute. Then the range was multiplied by 100 over the sum of ranges of all attributes. The results for the all the respondents were then calculated for all CRs. For example, Table 47 depicts the results of the CR2 "absence simulation" for the conjunctive and compensatory stages. Those calculations were conducted for all elderly respondents (n=60) along all CRs on the aggregated level for the conjunctive stage and on the aggregated and individual levels for the compensatory stage, respectively.

In building the QFD matrix, shown in Table 48 for the conjunctive-SE stage, the average importance of each EC's "attributes" influencing each CR was calculated as in Table 47 and then entered into the HoQ. For example, the average importance of the attribute "jalousie control" influencing CR2 is "35.29", the one for the attribute "light control" influencing CR2 is "35.29", and the one for the attribute "control panel" influencing CR2 is "29.41".

These were then all entered in the row of CR2 "absence simulation" under the EC columns "jalousie control", "light control", and "control panel" respectively for the conjunctive-SE stage in percentage format and so forth for all CRs. Nevertheless, for the attribute "convenient price" there was no need for an SE study since it was presented with 1 EC. Afterwards, the average importances of all the ECs (i.e. standard results of a QFD) were calculated as conventional; the EC values influencing each CR were added together after having been multiplied by the weights (importances) of the corresponding CRs. The last row in the matrix provided the rank of each EC's importances in descending order.

Analogously, the average importances of the attributes for the compensatory-SE stage on the aggregated level are computed (as shown in Table 47, column (F)), and then entered in the HoQ (Table 48), in this example, in line "CR3" for the corresponding three attributes and so forth from CR1 to CR10.

Three HoQ were calculated in the new approach for the conjunctive-SE stage calculated on the aggregated level (see Table 48), the HoQ for the compensatory-SE stage calculated on the aggregated level (see Table 49), and the compensatory-SE stage calculated on the individual level (see Table 50) for the smart home.

Table 48: The HoQ using the conjunctive-SE stage of the CC-SEQFD new approach for smart home

Customer Requirements (CRs)	HoQ based on the conjunctive-SE (normalised)	Weights	1 Window/ door alarm	2 Smoke detector	3 Video intercom	4 Jalousie control	5 Light control	6 Energy control	7 Emergency alarm at home	8 Forwarding emergency alarm	9 Heating control	10 Control panel	11 All-off button	12 Audio system	13 Price
1	I would like to feel safe at home	.142	.16	.05	.05	.11	.13		.16	.13			.21		
2	I would like to have absence simulation	.092				.35	.35					.29			
3	That calling help quickly is possible	.116		.09					.22	.22		.22	.26		
4	That I can save energy at home	.130				.21	.15	.12			.15	.15	.24		
5	A button to shut down lights, etc.	.096					.54						.46		
6	That I can control the jalousie	.080				.38		.38				.25			
7	That I can control the heating easily	.089					.28	.11			.33	0.28			
8	That I can control the lights easily	.080				.25	.21	.07				.18	.29		
9	It would be good to have music available	.046										.45		.55	
10	Convenient price	.129													1.0
	Absolute Importance		.022	.018	.007	.124	.194	.031	.048	.044	.049	.151	.158	.025	.129
	Ranking		11	12	13	5	1	6	8	9	7	3	2	10	4

Engineering Characteristics (ECs): columns 1–13.

(Own representation)

Table 49: The HoQ according to the compensatory-SE stage of the CC-SEQFD new approach for smart home (aggregated level)

	HoQ based on the compensatory SE–aggregated (normalised)	Weights	Engineering Characteristics (ECs): Widow/ door alarm	Smoke detector	Video intercom	Jalousie control	Light control	Energy control	Emergency alarm home	Forwarding emergency alarm	Heating control	Control panel	All-off button	Audio system	Price
Customer Requirements (CRs) 1	I would like to feel safe at home	.142	.07	.26	.04	.16	.10		.10	.24			.03		
2	I would like to have absence simulation	.092				.49	.10					.42			
3	That calling help quickly is possible	.116		.41					.09	.019		.19	.13		
4	That I can save energy at home	.130				.11	.08	.47			.12	.16	.06		
5	A button to shut down lights, etc.	.096					.47						.53		
6	That I can control the jalousie	.080				.34		.40				.25			
7	That I can control the heating easily	.089					.13	.39			.22	.26			
8	That I can control the lights easily	.080				.20	.10	.43				.24	.03		
9	It would be good to have music available around	.046										.31		.69	
10	Convenient price	.129													1.0
	Absolute Importance		.010	.085	.00	.126	.130	.13	.024	.056	.03	.15	.079	.032	.12
	Ranking		12	6	13	5	3	2	11	8	9	1	7	10	4

(Own representation)

Table 50: The HoQ according to the compensatory-SE stage of the CC-SEQFD new approach for smart home (individual level)

		HoQ based on the Compensatory-SE (Individual level) (Values are normalized)	Importances	Window/ door alarm	Smoke detector	Video intercom	Jalousie control	Light control	Energy control	Emergency alarm at home	Forwarding emergency alarm	Heating control	Control panel	All-off button	Audio system	Price
Customer Requirements (CRs)	1	I would like to feel safe at home	.142	17 (.8)	19.1 (6.4)	9.28 (5.0)	11.30 (4.3)	11.3 (4.5)		10.9 (5.4)	12.5 (6.4)			9.0 (4.7)		
	2	I would like to have absence simulation	.092				35.1 (15.2)	35.8 (11.8)					29.0 (17.2)			
	3	That a calling help quickly is possible	.116		27.3 (9.5)					20.5 (7.9)	23.4 (9.1)		15.3 (7.7)	13.7 (8.1)		
	4	That I can save energy at home	.130				11.5 (7.8)	17.2 (4.5)	22.7 (5.3)			21.2 (4.5)	14.4 (7.3)	13.0 (6.9)		
	5	A button to shut down lights, etc.	.096					38.3 (24.0)						61.7 (24.0)		
	6	That I can control the jalousie	.080				45.2 (18.5)		26.4 (13.4)				28.4 (14.8)			
	7	That I can control the heating easily	.089					11.6 (8.4)	25.8 (10.1)			40.5 (12.1)	22.2 (10.4)			
	8	That I can control the lights easily	.080				15.6 (10.3)	30.9 (12)	18.8 (8.7)				18.1 (7.1)	16.6 (9.3)		
	9	It would be good to have music available around	.046										35.2 (21.4)		64.8 (21.4)	
	10	Convenient price	.129													100 0
Absolute Importance				.023 (.009)	.059 (.018)	.013 (.007)	.112 (.030)	.143 (.030)	.089 (.021)	.039 (.015)	.045 (.018)	.064 (.013)	.136 (.051)	.118 (.035)	.030 (.098)	.129 (0.0)
Ranking				12	8	13	5	1	6	10	9	7	2	4	11	3

(Own representation)

Table 51: The last step is shown in the calculation of the average importances and standard deviation for CR4 "energy control" on the individual level of the compensatory-SE stage, see this line input in Table 50

CR4 "Energy Control"						
Average Importances of Attributes						
Respondents	**Jalousie Control**	**Light Control**	**Energy Control**	**Heating Control**	**Control Panel**	**All-off Button**
1	5.19	7.79	20.78	25.97	16.88	23.38
2	9.09	13.64	22.73	20.45	18.18	15.91
3	2.78	22.22	25.00	27.78	2.78	19.44
4	6.67	16.67	33.33	30.00	10.00	3.33
5	9.30	16.28	23.26	16.28	20.93	13.95
6	5.00	17.50	25.00	20.00	15.00	17.50
7	5.13	20.51	25.64	20.51	10.26	17.95
8	2.63	23.68	26.32	23.68	7.89	15.79
9	10.64	17.02	19.15	21.28	17.02	14.89
10	10.66	14.93	21.32	21.11	14.93	17.06
11	14.00	16.00	20.00	18.00	16.00	16.00
12	19.47	19.47	20.49	20.29	20.29	0.00
13	17.95	17.77	17.77	17.77	14.36	14.36
14	20.00	17.50	25.00	20.00	0.00	17.50
15	4.36	17.43	21.79	21.57	15.25	19.61
16	5.26	21.05	26.32	21.05	7.89	18.42
17	5.41	21.62	27.03	21.62	8.11	16.22
---------------------A break is made here for space limitation-----------------------						
45	7.35	14.71	29.41	23.53	22.06	2.94
46	7.69	7.69	38.46	38.46	7.69	0.00
47	9.52	16.67	23.81	21.43	9.52	19.05
48	6.45	12.90	32.26	19.35	29.03	0.00
49	8.33	16.67	20.83	18.75	16.67	18.75
50	8.11	10.81	27.03	18.92	16.22	18.92
51	14.00	14.00	20.00	18.00	18.00	16.00
52	16.00	12.00	20.00	18.00	16.00	18.00
53	15.69	11.76	19.61	19.61	15.69	17.65
54	20.00	20.00	14.29	28.57	14.29	2.86
55	18.87	13.21	18.87	18.87	11.32	18.87
56	19.61	10.89	21.79	21.57	17.43	8.71
57	20.49	20.29	20.29	14.34	16.39	8.20
58	22.37	22.15	22.15	11.19	22.15	0.00
59	13.73	17.65	19.61	17.65	15.69	15.69
60	8.70	13.04	17.39	13.04	43.48	4.35
Average Imp.	11.52	17.20	22.72	21.20	14.35	13.00
Standard deviation	7.78	4.46	5.26	4.50	7.31	6.88

(Own representation)

The third HoQ; namely compensatory-SE stage based on the individual level is based on the calculations of the average importances on the individual level of the attributes corresponding to how CR1 to CR10 are figured out in a similar way, but individually for each respondent. A snapshot of such a computation is illustrated in Table 51 for the CR4 “energy control” which is influenced by 6 ECs, namely “jalousie control”, “light control”, “energy control”, “heating control”, “control panel”, and “all-off button”. In this table, the last step of the calculation is demonstrated and the average importance and the standard deviations are entered in the HoQ for the compensatory-SE stage calculated on the individual levels (Table 50) for the CR4. This procedure is then carried out for all the CRs to fill the relationship matrix of the HoQ. The importances of ECs presented within the matrix are the average of the individual EC importances calculated for 60 elderly respondents. The last row presented the descending order of the ranks of these importances.

The last SE (SE10) study incorporated all the ECs to be used only for the validity issues. At this point, it is interesting to check the relation (if any) between the importances resulting from both the conjunctive-stage and compensatory-stage for the same attributes and CRs. Table 52 listed the results of three different correlations between the two stage results for the 10 self-explicated studies comprised in the new approach.

Table 52: The various correlations between the attributes of the conjunctive and compensatory stages for each SE of the 10 SE studies (n=60)

	SE1	**SE2**	**SE3**	**SE4**	**SE5**	**SE6**	**SE7**	**SE8**	**SE9**	**SE10**
Pearson (r)	-0.44	-0.34	-0.93	1	-0.64	-1**	0.91	-0.81	-0.92	-0.315
Kendall-Tau	-0.49	0	-0.60	1**	-0.75*	-1**	0.82	-0.55	-0.80	-0.041
Spearman-Rho	-0.52	0	-0.67	1**	-0.82*	-1**	0.87	-0.63	-0.9*	-0.098

(Own representation); Note (*): The correlation is on 0.05 significant (i.e., significant); (**): The correlation is on 0.01 significant (i.e. very significant)

The “Pearson’s (r)” correlation coefficient reflects the degree of the linear relationship (not the slope) between the conjuncture and compensatory SE stages. The results of the “r” varied within the 10 studies from a weak relation (e.g. in SE1, SE2, SE10) to a very significant relation (e.g. SE6). In this respect, the Kendall-tau ranking coefficient is also of interest, since the approach outputs rank the same attributes and levels. The latter measures the association between the conjunctive and compensatory SE stages. The results shown in Table 52 indicate that Kendall-tau observations are more discordant than concordant (7 negative observations vs. 2 positive observations and a zero). Some have a strong positive association (e.g. SE4, SE7) while many have a strong negative relation (e.g. SE6, SE9, SE3) and SE2 shows no relation. The Spearman-rho in general shows a good monotonic relationship between the two observations.

7.5 Empirical Comparison of the Three Approaches

7.5.1 Direct Comparison of the Three Approaches

In this section, a direct comparison of the results of the three approaches will be presented. The relative importances of ECs in the HoQ are mainly compared. Figure 33 depicts the normalized relative importance of ECs calculated in the main 3 HoQs: (1) Pullman's conjointQFD approach for smart home for elderly people (refer to Table 42), (2) Baier's conjointQFD approach for smart home for elderly people (refer to Table 46), and (3) Compensatory-SE stage calculated on the individual level (refer to Table 50).

Figure 33 shows that the results of the direct comparison between the aforementioned approaches are close to each other (similar). For a more precise view, Table 53 compares the first four top relative importances of ECs from all five HoQs as well as the last three relative importances of ECs from the five methods. For brevity, the five approaches are sometimes used in the short naming format as follows:

(1) Pullman's conjointQFD approach: M1
(2) Baier's conjointQFD approach: M2
(3) Conjunctive-SE stage of the CC-SEQFD new approach: M3-1
(4) Compensatory-SE stage of the CC-SEQFD new approach calculated on the aggregated level: M3-2
(5) Compensatory-SE stage of the CC-SEQFD new approach calculated on the individual level: M3-3

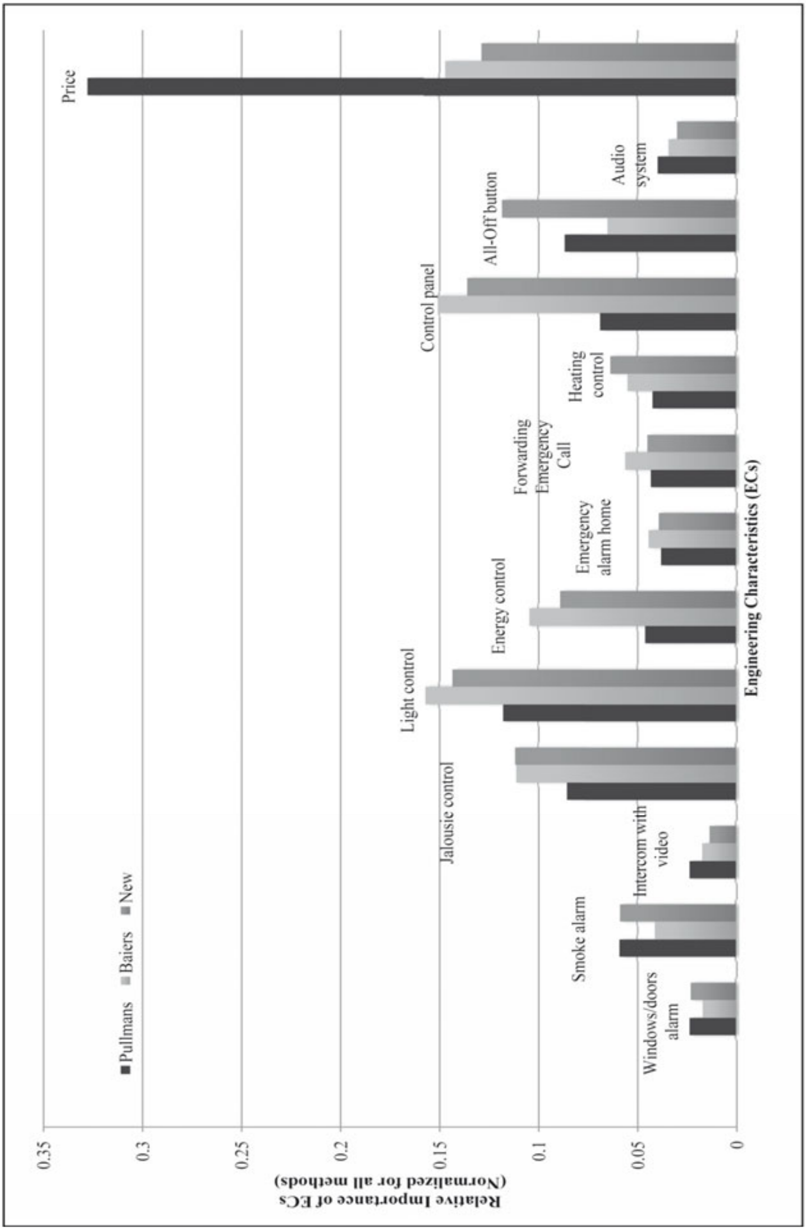

Figure 33: A direct comparison of the direct results among the three approaches (Own representation); Note: The values are not shown on the graphics for clarity, for values refer to Table 42; 46; and 50

Table 53: Presentation of the first four and respectively the last three normalized relative importances in the ranking of ECs for all approaches

	M1	M2	M3-1	M3-2	M3-3
Rank	Pullman (traditional approach)	Baier (individual level)	New Conjunctive (aggregated level)	New Compensatory (aggregated level)	New Compensatory (individual level)
The first four best ranking ECs among all approaches (↑)					
1	Price (0.328)	Light control (0.157)	Light control (0.194)	Control panel (0.157)	Light control (0.143)
2	Light control (0.118)	Control panel (0.151)	All-off button (0.158)	Energy control (0.1312)	Control panel (0.136)
3	All-off button (0.087)	Price (0.147)	Control panel (0.151)	Light control (0.1305)	Price (0.129)
4	Jalousie control (0.085)	Jalousie control (0.111)	Price (0129)	Price (0.1289)	All-off button (0.118)
The last three ranking ECs among all approaches (Total 13 ECs) (↓)					
11	Emergency alarm at home (0.038)	Audio system (0.034)	Window/ door alarm (0.022)	Emergency alarm at home (0.024)	Audio system (0.030)
12	Window/ door alarm (0.024)	Intercom with video (0.017)	Smoke detector (0.018)	Window/ door alarm (0.010)	Window/ door alarm (0.023)
13	Intercom with video (0.024)	Windows/ doors alarm (0.017)	Intercom with video (0.007)	Intercom with video (0.005)	Intercom with video (0.013)

(Own representation)

As can be seen in Table 53, similar results were accrued from the various approaches especially on the first four rankings and last three rankings. For example, "light control" comes in first rank in three approaches (M2, M3-1, and M3-3); whereas it comes in the second rank by the M1 and in the third position in the M3-2. It is interesting to note that the first three rankings in Baier's and the new approach (both are computed on the individual level) are the same: "light control", "control panel", and "price". Also the same three last ranks "audio system", "window/door alarm", and "intercom with video" (considering that the last two ranked almost the same under method 2). Conversely, "energy control" from the upper table and "smoke detector" from the lower table are the only two ECs that are listed under only one method, namely the compensatory new approach (M3-2) and the conjunctive new approach (M3-1) respectively. Additionally, "price" (0.328) is indeed by far evaluated in the M1. Regarding the ranking of the rest of the ECs by all approaches, that is to say by the ECs in-between relative importances, no trend can be delineated in the way the ECs were ranked in this range by all approaches. Moreover, few ECs along the approaches were ranked the same in this range.

At this point, the ranking of “price” under the three main approaches is a debatable issue, especially in the conjunctive and compensatory self-explicated stages (M3-1, M3-2, and M3-3). In the preference analysis literature one of the drawbacks of the self-explicated method is the manner the respondents deal with price. It is often indicated that they devalue the attribute “price” because of social image as well as to avoid embarrassment in the issue. For a more precise view on this controversy, the price ranking among the primary CRs is additionally presented and compared with a particular attention by the self-explicated ranking of the price.

Table 54: Comparison of the primary CRs ranking by all methods with particular attention on the price ranking by the new approach

	Primary Customer Requirements Ranked in Descending Order		
Rank	Pullman* (As traditional)	Baier* (Individual level)	New* Approach
1	Price (0.195)	Price (0.147)	Security (0.190)
2	Security (0.186)	Security (0.144)	Price (0.185)
3	Emergency (0.184)	Efficiency (0.126)	Efficiency (0.184)
4	Efficiency (0.180)	Comfort (0.126)	Emergency (0.174)
5	Comfort (0.135)	Emergency (0.124)	Comfort (0.15)
6	Entertainment (0.120)	Entertainment (0.059)	Entertainment (0.117)
Sample size	n=30	n=39	n=60
Questionnaire type	Direct questionnaire (likewise Pullman)	ACA1	Direct questionnaire (part of SE)

(Own representation); Note (*): All importances are normalized

Table 55: Correlation coefficients for primary CRs importances for 3 approaches

	Correlation Coefficients for Primary CRs Importances for 3 Approaches		
	Pearson (r)	**Kendall-Tau (τ)**	**Spearman-Rho (ρ)**
Pullman & Baier	.832* (.040)	.966** (.007)	.986** (.000)
Pullman & New	.971** (.001)	1.000**	1.000**
Baier & New	.927** (.008)	.966** (.007)	.986** (.000)

(Own representation); Note (*): correlation is significant at the 0.05 level (two-sided); (**): correlation is significant on the (0.01) level (two-sided)

The primary CRs (see Table 54) show almost similar rankings among the 3 methods (see also the correlations between them in Table 55). It is worth noting that each normalised importance value of CRs resulted from three different questionnaires. In the M1 as well as M3 direct questionnaire was conducted to evaluate the importances of CRs. In M2, the importances of CRs are the results of ACA1. In the SE method, "price" ranked second, whereas in Pullman's and Baier's approaches, it was ranked first. Another ranking for "price" is available from the SE questionnaire (SE10) showing that in the conjunctive-SE stage, "price" ranked in the fourth position. On the contrary, in the same part of the SE10 under the compensatory-SE stage, "price" ranked first. Despite "price" coming in first under the SE method, second, and in fourth in others, the author does not infer a devaluation of "price" in the SE questionnaire in this case. In addition, it became clear in the face-to-face interviews that "price" plays a substantial role for the respondents. A very possible explanation to this issue is the product involved "smart home" is very expensive and complex. Therefore, the social factor contention (e.g. avoid embarrassment) disappears; rather it would be unusual not to consider the price in this case.

Another interesting concern is the ranking of the last two ECs by the 3 approaches (see Table 54) additionally by almost all part questionnaires, there is a total consensus on ranking them last namely: "windows/doors alarm" and "Intercom with video" although they rank "Security" high. Contingent reasons for this could be that the products for those two ECs are small and easy to buy without linking them to the product smart home; nevertheless, technically, they are used for building a smart home. Moreover, from the field experience, for example "smoke detectors or alarms" can be bought for a convenient price; however, many companies beware the buyers of a possible fake alarm every now and then. The "smoke detector" beeps when the batteries are empty but then "who remembers that the beep source is from the smoke detector". In other words, this means for the elderly people, one thing: these products make problems so they try to avoid them.

Next section, the convergent validities will be investigated for the three approaches.

7.5.2 Comparison of Validities "Within" and "Between" the Three Approaches

7.5.2.1 Comparison of Validity "Within" the Three Approach

In the previous section, the three approaches were compared directly between each other. Thereupon the results in general were significant. In this section, another comparison seems to be worthwhile and feasible: the comparison of results within the same approach between the observed and estimated ECs for each approach. Such a comparison is a typical test of convergent validity.

For Pullman's approach, the observed values are the relative importances of the 8 attributes of the conjoint analysis (ACA) conducted in the approach (See Section 7.2.1, Table 40). Those attributes were included in the study and were all considered in building the QFD. Subsequently, the same eight estimated ECs are compared. The result of the correlation between the observed and estimated attributes/ECs is shown in Table 56.

Table 56: Correlations within Pullman's approach on the aggregated and individual levels (Study 2)

	Pearson (r)	Kendall-Tau (τ)	Spearman-Rho (ρ)
O*E (Aggregated level) n=43, R^2>0.70	.570 (.140)	.286 (.322)	.381 (.352)
O*E (Individual level) n=12, R^2>0.90	.505 (.202)	.286 (.322)	.381 (.322)
O*E (Aggregated level) n=12, R^2>0.90	**.827* (.011)**	**.571* (.048)**	**.762* (.028)**

(Own representation); Legend: O: Observed; E: Estimated; Note (*): correlation is significant at the 0.05 level (two-sided)

The first test was conducted on the sample of n=43 where the determination correlation coefficient R^2>0.70 (measures internal validity of ACA).

The result of the convergent validity for Pullman's approach shows no significance on all three correlation coefficients Pearson (r), Kendall-Tau, and Spearman-Rho when calculated on R^2>0.70.

Further it was tested if the results would be improved if only R^2>0.90 were used from the observed data. Consequently, the 43 respondents were filtered according to the new criterion R^2>0.90. Only 12 elderly respondents were found to have this high R^2. Afterwards, the correlations were individually computed and again the results of the correlations did not prove to be significant, but few of the twelve respondents did indeed attain significant values. For example, one respondent from the 12 respondents proved to have a significant correlation with the three coefficients: .785* (.021), .643*(.026), and .786* (.021) respectively. Another respondent attained a Pearson (r) of .958** (.000). Then the "mean" of the ECs' importances from the 12 respondents with high R^2 was tested against the estimated values and unexpectedly, it proved to be significant with all correlations (.827*; .571*; and .762*) (see Table 56). In summary, the convergent validity when R^2>0.70 is equal to (.570) but not significant. However, with a high R^2, a significant result was observed on the aggregated level and not on the individual level. The small sample size (in this case, e.g., n=12) inhibits a possible generalisation of the convergent validity of Pullman's approach.

As for Baier's conjointQFD approach, the elderly respondents in the ten ACAs were checked exactly and only the respondents answering all ten ACAs were considered in the calculations for the estimated observations. Subsequently, from a total of n=49 only n=29 were eligible to take part in the test of the convergent validity. This action was necessary since Baier's approach is calculated on the individual level and each ACA for each respondent represents a row in the QFD. This means a respondent who did not complete at least one ACA but completed the other nine is not eligible for the test. For each respondent, a QFD was built and the ECs were calculated. Each QFD result represents the estimated values. On the other hand, the observed values were attained from the additional ACA11 for n=29. Afterwards, the three correlations were tested on the individual level and the results are then illustrated in Table 57. The correlations were low and not significant on the individual level (n=29, average R^2=0.782) and respectively on the mean of the individual values, the results were as follows: (.194), (.210), and (.419).

Table 57: Correlations "within" Baier's conjointQFD approach on the aggregated and individual level (Study 2)

	Pearson (r)	**Kendall-Tau (τ)**	**Spearman-Rho (ρ)**
O*E (Aggregated level) n=29, R^2=0.782	.194 (.592)	.210 (.412)	.419 (.229)
O*E (Individual level) n=29, mean R^2=0.782	.168 (.642)	.135 (.590)	.322 (.364)
O*E (Aggregated level) n=9, R^2>0.90	.444 (.198)	.138 (.587)	.263 (.463)

(Own representation); Legend: O: Observed; E: Estimated

Although the results of the mean are not significant, they are better than the ones calculated on the individual level. Again, it was further tested under the criterion that R2>0.90. Only 9 respondents from n=29 met the criterion. The convergent validity on the aggregated level for the high R2 was tested and resulted in .444 (.198), .138 (.587), and .263 (.463) respectively. Few of the respondents on the individual level verify to be significant, though they have a high determination coefficient. The approach did not show high convergent validity. Conversely, the PC experiment (Baier 1998) verifies a high convergent validity for the method. Many reasons account for these differences in the results. For example, in the PC example, the sample number is larger (n=40) than in this example (n=29 and n=9). Moreover, the PC experiment was conducted under the condition that the respondents were considered experts in the product field, contrary to the example in this experiment, the elderly people were not all familiar with the product, and it was not expected to find elderly people on the street who were experts in the product. Baier (1998, p. 84) emphasises that the determination coefficient verifies to be high for the respondents. In this case, the coefficient was acceptably good for n=29, mean R2=0.782. However, only n=9 were above 0.90. As concluded from Pullman's experiment, the higher R2, the more likely it was to get significant results. Another important issue is the complexity of the product; a smart home is too complex. Many other reasons (e.g. long duration of the experiment, cognitive factor, entertainment factor, sample homogeneity) could account for the differences, too.

For the CC-SEQFD new approach, the observed data were taken from the additional SE questionnaire (SE10) which asked the elderly respondents about all their preferences for all ECs; whereas the estimated data is taken from the relative importances resulted from the QFDs. That means from the conjunctive-SE stage and the compensatory-SE stage on the aggregated and individual levels with n=60.

Table 58: The results of the correlations for the new method stages: M3-1, M3-2; and M3-3

	Pearson (r)	**Kendall-Tau (τ)**	**Spearman-Rho (ρ)**
O*E (M3-1) (Aggregated level)	.293 (.322)	.180 (.415)	.202 (.507)
O*E (M3-2) (Aggregated level)	.499 (.083)	.385 (.067)	.544 (.055)
O*E (M3-3) (Aggregated level)	.107 (.727)	.154 (.464)	.187 (.541)
O*E (M3-3) (Individual level)	.181 (.499)	.141 (.50)	.202 (.492)

(Own representation); Legend: O: Observed; E: Estimated; Note: n=60

Table 58 demonstrates the main results which clearly return low correlations and respectively low convergent validities for the three stages, although that the compensatory SE (M3-2) shows better correlations than the other two with no significant. Once more, in the estimation of the convergent validity on the aggregated approaches signifies better values than those calculated on the individual levels. It should be noted that SE10 has a low internal validity which possibly affects the convergent validity of the approach.

7.5.2.2 Comparison of the Validity "Between" the Three Approaches

In this section, the convergent validities of the results among the three approaches are assessed. For this purpose, the results of the ECs are compared between each approach using the correlation coefficients Pearson (r), Kendall-Tau, and Spearman-Rho.

Table 59: Correlation matrix among the three methods using the Pearson (r), Kendall-Tau, and Spearman-Rho

	Pearson (r)	**Kendall-Tau (τ)**	**Spearman-Rho (ρ)**
M1*M2	**.630*** (.021)	.714** (.001)	.862** (.000)
M1*M3-1	.529 (.006)	.581** (.006)	.770** (.002)
M1*M3-2	.516 (.071)	.763** (.000)	.862** (.000)
M1*<u>M3-3</u>	**.605*** (.029)	**.787**** (.000)	**.922**** (.000)
M2*M3-1	.812** (.001)	.710** (.001)	.858** (.000)
M2*M3-2	**.928**** (.000)	.817** (.000)	.918** (.000)
M2*<u>M3-3</u>	**.927**** (.000)	**.865**** (.000)	**.955**** (.000)
M3-1*M3-2	.711** (.006)	.514* (.018)	.662* (.014)
M3-1*<u>M3-3</u>	**.914**** (.000)	**.744**** (.000)	**.879**** (.000)
M3-2*<u>M3-3</u>	**.910**** (.000)	**.785**** (.000)	**.911**** (,000)

(Own representation); Note (*): correlation is significant at the 0.05 level (two-sided); (**): correlation is significant on the (0.01) level (two-sided); (***): correlation is significant on the (0.001) level (two-sided)

All the ECs for the three approaches: Pullman's conjointQFD, Baier's conjointQFD, and CC-SE new approaches considered on the different stages level; namely the conjunctive-SE stage (aggregated level), the compensatory-SE stage (aggregated level), and the compensatory-SE stage (individual level) have the same 13 ECs (for the ECs see, e.g., Table 50). The normalised relative importances of the 13 ECs were tested in pairwise for the three correlations Pearson's (r), Kendall-Tau, and Spearman-Rho. The results of the convergent validity for the approaches are given in Table 59. The results in almost all cases are significant. From all the tested correlations, the interesting ones are the correlations between Pullman's approach (M1), Baier's approach (M2), and the new approach rather than those between the stages of the new approach. The most important finding is that Baier's conjointQFD approach proves to be the most significant approach given the linear relation to Pullman's approach detected with the Pearson's (r) coefficient (.630*) just ahead of the compensatory-SE stage (individual level), (M3-3) which proves to be significant with an r=.605* to Pullman's approach. Interestingly, however, the aggregated new approaches (M3-1) and (M3-2) proved not to be significant on the linear coefficient test. In this sense, the approaches with the individual levels (M2 and M3-3) verify to have a good correlation with the M1. On the other convergent validity tests assessed by the non-parametric coefficient Kendall-Tau and Spearman-Rho, the compensatory-SE (individual level) new method compared to Pullman's approach shows to have the highest values of (.787** and .922**), respectively with a good clearance before all others. Though all methods manifest high correlations and association with significant to the first method (see Table 59).

Afterwards, Baier's approach (M2) was compared to the variants of the new approach; all results have high coefficients and signified "very significant" correlations (Table 59). Notwithstanding that the aggregated-compensatory SE stage of the new approach (M3-2) shows the highest "very significant" result by Pearson (r) =.928**, though the individual-compensatory-SE stage of the new approach (M3-3) could be considered to have the same "very significant" Pearson's (r) correlation (.927**) given its 0.001 difference. On the other coefficients, the individual-compensatory-SE stage of the new approach has by far the highest "very significant" value with .865** and .955** respectively. On this level, it should not be underestimated that all results are "very significant" as well.

In the lower part of Table 59, the correlations are tested within the new approach variants. Again the most "very significant" results were attained by the comparison of the individual-compensatory SE new approach with the other two variants with the three correlations coefficient showing good clearance from the others.

In summary, both Baier's approach and the individual-compensatory-SE stage of the new approach prove to be better when tested against Pullman's approach and when tested against each other. In fact, they corroborate the most significant results on the various correlations. This implies that the approaches calculated on the individual levels (M2 and M3-3) prove a better significant and accordingly, this can be a reason for the researcher to take the burden of calculating the values on the individual level.

In the next section, further comparisons of the approaches are conducted on the contingent indirect factors (see Ernst 2001) and new inferences are made.

7.5.3 Comparison of the Time Analysis and Contingent Indirect Factors Influencing the Results of the Three Approaches

7.5.3.1 Time Analysis Comparison of the Three Approaches

The main comparisons of the data were done in the previous sections. In this section, however, some other criteria are examined that influence the goodness of the results. The criteria will be overviewed, but there will not be a thorough comparison of details among the approaches because of the low resonance from respondents and to maintain a general clarity in the entire analysis.

In the first part, a time analysis is presented in which the three questionnaires' durations per respondent were collected and compared. Table 60 gives a summary of the main results. For the Pullman's conjointQFD approach, the average time was 27 minutes 45 seconds and the average age was 59 years. The youngest was 50 years old and the eldest 78 in the same approach. The longest questionnaire lasted 1 hour, 22 minutes, and 40 seconds for a 76 year old respondent with an R^2=0.846. The online questionnaire was not conducted from computer labour; thus one cannot determine if the elderly-respondent worked without breaks on the questionnaire. On the other hand, the quickest time was 6 minutes and 78 seconds recorded by a 59 year old participant with a very high determination coefficient (R^2=0.92).

Table 60: Time analysis among the three approaches

	Pullman's Approach (n=73) R^2>700		**Baier's Approach** (n=34)) R^2>700		**New Approach** (n=60)	
Descriptive Statistics for Duration of Experiment Smart Home	**Time** (min)	**Age** (years)	**Time** (min)	**Age** (years)	**Time** (min)	**Age** (years)
Mean	27.45	59	72.45	58.35	~29	>50
Max	**82.40**	67	**166**	73	**60**	>50
Min	**6.78**	59	**35**	50	**15**	>50
Median	23.3	59.1	77	57.50	25	>50
Standard deviation	16.22	7.40	38.56	5.80	**n. a.**	**n. a.**

(Own representation); Legend: Max: Maximum; Min: Minimum; n.a.: not available

As for the Baier's conjointQFD approach, the mean time was around 72 minutes to complete all eleven parts of the questionnaires and the average age was 58 years. It is interesting to observe that it took a 73 year old participant the longest time to complete the questionnaire with 2 hours 46 minutes. Notwithstanding the long time, the participant achieved a high correlation in all the ACAs (see Table 61). Again, one cannot determine whether the participant continuously worked on the questionnaire. On the other hand, the quickest questionnaire took exactly 35 minutes from a 50 year old participant.

In fact it is interesting to notice that this participant completed all the ACAs with high correlations (see Table 61). In this table, the 11determination coefficients are available for the longest and quickest questionnaires. Both participants' results show a high internal validity.

Table 61: The determination coefficient (R2) for the two respondents with the maximum and minimum time in the second approach

	Determination Coefficient (R^2)										
Time (min)	**CA1**	**CA2**	**CA3**	**CA4**	**CA5**	**CA6**	**CA7**	**CA8**	**CA9**	**CA10**	**CA11**
R1 (Max)	.728	.996	.824	.938	.965	.977	.965	.965	.989	.898	.932
R2 (Min)	.956	.931	.905	.841	.901	.994	.803	.803	.839	.721	.941

(Own representation); Legend: R1: Respondent 1 with the longest duration time for the questionnaire; R2: Respondent 2 with shortest duration time for the questionnaire

For the CC-SE new approach, it should be taken into consideration that it was a written questionnaire conducted in face-to-face interviews with no stop-watch but rather measured according to the interviewer's estimation of each interview given the total time of interviews at that day. For this reason, the standard deviation computation and age for the questionnaire were not available. For example, the average time of interviews was around 29 minutes. The longest interview lasted one hour; by contrast, the quickest interview lasted around 15 minutes. Consequently, the duration of the third approach proved to be shorter than the Baier's approach and almost like the Pullman's approach, as shown in Table 60. However, the Pullman's approach consisted of one conjoint study; whereas the CC-SE new approach consisted of 11 CC-SE parts. In other words, with respect to time, the new approach succeeded in lowering the overall questionnaire duration which was one intention of the suggested approach in order to make it easier for the elderly respondents.

Three weeks after the end of all questionnaires in December 2010, a written questionnaire was sent to all elderly respondents[50] to answer questions concerning the influence factors on them during answering the main questionnaires. Elderly respondents were asked after 3 weeks because they would be more objective and more reasonable in their answers rather than if they were asked directly after the questionnaire since they were expected to be tired which could lead to subjective responses to the questions and in order not to make the main questionnaire longer.

7.5.3.2 Contingent Indirect Factors Analysis of the Three Approaches

In the additional questionnaire, the elderly respondents were asked about 8 different factors that could possibly have affected the value of their results (Ernst 2001, pp. 149-152). Table 62 lists the 8 factors and item representing the factor, and the Likert scale used. In the first factor "product involvement", the elderly respondents were asked about their interest in the product of smart homes using a five-point Likert scale where numbers and wordings were used; the scale varied from (1) "not interesting at all" to (5) "very interesting".

Table 62: The influencing factors considered, their main issues, and corresponding scale used based on Ernst (2001, pp. 145-152)

Factors	**Points considered**	**Likert Scale (Two ends)**
Product involvement	The degree of interest for the product smart home	(1) "not interesting at all" to (5) "very interesting"
Personal involvement	The degree of importance of having a smart home	(1) "not at all" to (5) "very much"
Situation involvement	The likelihood of buying smart home products	(1) "strongly disagree" to (5) "strongly agree"
Motivation for taking part	The degree of fun/amusement by answering the questionnaire	(1) "no fun at all" to (5) "makes a lot of fun"
Degree of interest	The degree of tediousness/interest by answering the questionnaire	(1) "tedious/boring" to (5) "interesting"
Cognitive burden	The degree of difficulty of the questionnaire	(1) "very difficult" to (5) "totally not difficult"
Clarity	The degree of clarity of the questionnaire	(1) "very unclear" to (5) "very clear"

(Own representation)

The results demonstrated that respondents corresponding to Pullman's approach were more interested in the product than those from the other two approaches (mode: 4; 3; 3,

[50] This additional questionnaire was sent to all the respondents who wrote their addresses or emails in the three approaches investigated in study 2.

respectively) based on the mode analysis which corresponds to the answers (see Table 63). It is worth noting that the mean (standard deviation) and mode were calculated for the contingent indirect factors. However, the comparison among the approaches was based mainly on the mode since it seemed to present the answers more accurately for some questions than the mean.

The second factor "personal involvement" was interpreted as the extent of the importance of the product "smart home" to the elderly respondents. The results show that the product was not rated as important for the elderly respondents in all three approaches, though in Baier's approach, the respondents were more neutral towards the product (Baier's approach: mean=3.14 and mode=3) (refer to Table 63).

The third factor, "situation involvement", tested the likelihood of buying a smart home or part of the product. The results indicate that the elderly respondents in Baier's approach were more likely to buy a product with a mean=3.57 and mode=4 than respondents from the other two approaches. Indeed, the two groups from Pullman's approach and the new approach were totally unlikely to acquire it with a mean=2.21; 2.14 and mode=1; 1, respectively.

The factor "motivation" considered two points. In the first point, it asked the respondents about their degree of "fun" or "amusement" when they answered the prior questionnaire. The results showed a degree of variation in the answers. The respondents in Pullman's approach had "fun" in doing the questionnaire (mean=3.36; mode=4), while respondents from Baier's approach were "not amused" due to the lengthy duration of the questionnaire (mean=2.19 and mode=2). For the new approach, the respondents' results were equally divided between "not amused" and "neutral" (mean= 2.5; mode= 2 & 3).

In the second point for the "motivation" factor, the elderly respondents were asked about their "degree of interest" in taking the main questionnaire using the scale from "very tedious" to "interesting". The results were to some degree surprising in that the three approaches seemed to have the same interest effect on respondents. Baier's approach and the new approach had a mode=3 which meant "neutral", whereas for Pullman's approach it was equally divided between 3 and 5, which meant "neutral" and "interesting".

The factor "cognitive burden" was interpreted by the degree of difficulty of the prior questionnaire for the respondents. The results surprisingly indicated that the respondents of Baier's and the new approaches have a mode=3 which means "neutral" whereas the respondents of Pullman's approach did not find it to be difficult with a mode=4.

Table 63: Mean (standard deviation) and mode are listed for the factors with contingent influence on the quality of the results for the three approaches

	Pullman's Approach (n=14)		Baier's Approach (n=21)		New Approach (n=14)	
Factors	**Mean**	**Mode**	**Mean**	**Mode**	**Mean**	**Mode**
Product involvement	3.14 (.91)	4	2.81 (.66)	3	3.36 (1.04)	3
Personal involvement	2.5 (.98)	2	3.14 (.64)	3	2.93 (1.28)	2
Situation involvement	2.21 (1.21)	1	3.57 (.90)	4	2.14 (1.19)	1
Motivation for taking part	3.36 (.89)	4	2.19 (.79)	2	2.50 (.50)	2 & 3
Degree of interest	3.86 (.99)	3 & 5	2.57 (.73)	3	2.36 (.72)	3
Cognitive burden	3.64 (.81)	4	3.19 (.66)	3	2.86 (.64)	3
Clarity	3.50 (.82)	4	3.29 (.76)	4	2.86 (.74)	3

(Own representation); Note: (1) the results are based mainly on the mode

Finally, the factor "clarity" is handled which corresponds to how well the questionnaire was understood by the elderly respondents. The results show that in Pullman's and Baier's approaches, the respondents evaluated the two questionnaires to be "clear" with a mode=4. On the other hand, for the new approach, respondents were "neutral" in their answers with mode=3.

Furthermore, they were directly asked about the "familiarity" of the product for them. The results show a clear discrepancy in the groups' familiarities with the product as shown in Table 64. At the time, the respondents of Pullman's approach revealed that they had "no familiarity" at all (yes=0, no=14); the respondents of Baier's approach appear to be mostly familiar with the product (yes=17, no=4); whereas the respondents of the new approach can also be considered to be unfamiliar with the product (yes=2, no=12).

Table 64: The answers for the question of "familiarity" of the product for elderly respondents

	Pullman's Approach	**Baier's Approach**	**New Approach**
Yes	0	17	2
No	14	4	12

(Own representation)

To sum up, for the respondents of Pullman's approach, it showed out that they had an "interest" in the product. However, they did not find it important to have or to buy it. On the other hand, it was a pleasant questionnaire which did not require a lot of cognitive effort from them and it was structured in a clear way. Against this positive evaluation, the method which generally accounts for the traditional QFD is considered to be attainable and amusing for the elderly respondents (e.g. video was a good idea). Despite this, the convergent validity results in the current example were not high or significant in general, but one should not forget the degree of complexity of the involved product.

In Baier's approach, despite most of the respondents being "neutrally" interested in the product and its degree of importance, most estimated that the likelihood to buy or build a smart home or purchase parts of it as possible. As for the questionnaire, most of the respondents were not amused while answering it but surprisingly it was mostly neutrally evaluated in its demand on the cognitive capacity. This can mean that the adaptation measures made for elderly people for the approach were necessary and subsequently helped in reducing the cognitive burden and proved the delivered good results ("between" convergent validity between the approaches) for the complex product. The Baier's approach for elderly people was also evaluated positively in the clarity of the questionnaire. This result is interesting, because for a long questionnaire (mean time= 73 minute) to be found understandable and clear by most respondents for a complex product means that the adaptation was helpful.

As for the new approach, most of the respondents were neutrally interested in the product and they were not convinced of its importance nor were they expecting to buy it or part products of it. In evaluating the questionnaire, most respondents were equally divided between the evaluations of "not amusing" and "neutral". Moreover, the questionnaire was neutrally evaluated between "being tedious" and "neutrally interesting". Likewise, the cognitive burden was "neutrally" evaluated and for the "clarity" as well. Given the aforementioned results, it can be concluded that the new approach has shown potential and successes in many points, e.g., in the interview time reduction and the convergent validity results, which were very significant, while on the other hand there is still room for improvement, e.g., on the external presentation and in the clarity of presenting the steps or using an online questionnaire instead of a written one were many new presentation possibilities are accessible.

7.5.4 Analysis of the Comparison of Validity Results of the Approaches

In the current work, the comparisons of the results were tested based on two levels "between" and "within" the approaches. (1) The convergent validity was used in the comparison "between" the approaches and showed a high correlation with high to very high significance levels; whereas (2) the results "within" the approaches measured by the convergent validity did not show, generally speaking, any significance. However, a special case in Pullman's approach was recorded in which the correlation showed significance for the elderly respondents (n=12) when calculated at a high internal validity (R^2>0.90). The insignificance of the convergent validity "within" the approaches can be accounted to many reasons such:

(1) the difference in prospect between QFD and conjoint analysis,
(2) the internal validity of the conjoint and CC-SE methods
(3) the degree of the product complexity and sequence of the questionnaires,
(4) the degree of adaptation of the questionnaire to elderly people, and
(5) the indirect factors, especially the "cognitive factor", "situation involvement", "product involvement", and "familiarity" of the product

Regarding the difference in the view between QFD and conjoint analysis, in the present case the convergent validity was calculated between the estimated importances (QFD) and the observed (conjoint analysis) result. Although each method is concerned with the voice of customer in regard of the product prospect, the voice of customer is part of a process to calculate the importances of the engineering characteristics in the QFD method. On the other hand, in the conjoint analysis, the customer answers are estimated into utilities and part-worths. In other words, the QFD interpreted what managers think customers want and conjoint analysis directly reflects customer wants (see discussion in Pullman et al. 2002, p. 362). Conversely, the results of Study 1 on the example of mobile phones showed a good convergent validity with significant between the two methods QFD and ACA. In study 2, the results of the "within" approach comparison was generally not significant. Because of the diversity of the results, more research should be done.

Another possible cause can be the degree of complexity of the product (i.e. ten or more attributes and many levels) for the respondents. This issue can be overwhelming for elderly people, leading them to use simplification techniques in answering the pair questions in adaptive conjoint studies and this, in return, influences the internal validity and consequently the results. Because of the complexity of the product the questionnaire requires more time, which makes the sequence of the questionnaires somehow a critical issue for elderly people, especially when the complete questionnaires are answered without taking breaks.

In study 2, the degree of adaptation of the questionnaire to elderly people was in focus. Many measures were taken into consideration to make it easier and more comfortable for the elderly people to take the questionnaire of each approach. The good results for the "between" convergent validity can be a good indication of the effect of the adaptation used in the questionnaires for elderly people. However, the results of the indirect factors and time analysis show clearly that the adaptation measures used on the elderly people has helped in reducing the complexity of the product and made the questionnaires a little bit easier. For example, Pullman's and Baier's approaches were considered to be clear by the respondents. It was noticeable that Baier's approach was considered "neutral" in the demand of "cognitive effort", which can be taken as a positive indication of the effect and importance of adapting the questionnaire to elderly people. On the other hand, the indirect results specially indicate that the new approach still has potential to improve in the adaptation of the questionnaire to elderly people, since its results tend toward "neutrality". For the antecedent issue, the author took the standard presentation of the conjunctive-compensatory self-explicated questionnaire from Srinivasan (1988) which obviously can and should be simplified for the elderly people.

The indirect factors' results of study 2, especially the "cognitive burden" represented by the "difficulty" of the questionnaire, the factor "situation involvement" expressed in the "likelihood of buying" the product, the "product involvement" represented by the "degree of interest in the product", and the "familiarity of the product" among other factors indicate that the adaptation of the questionnaire could be improved. Accordingly better comparison results can be expected.

7.6 Summary and Final Remarks

The goal of this chapter was to test the three approaches (Pullman's conjointQFD approach, Baier's conjointQFD approach, and the CC-SEQFD new approach) in two issues (1) "between" approaches convergent validity and (2) "within" approaches convergent validity taking into consideration adaptation options for the elderly people on the example of the smart home.

A number of adaptations for elderly people were taken into consideration in all the questionnaires were it was useful and possible to implement them. For instance, elderly people were offered to be interviewed in the department's computer lab to receive the help needed when using the computers and when having any questions. More specific measures were adapted to the questionnaire, such as using a video to present all the characteristics involved in the study, which made the questionnaire more enjoyable and elderly people were then given the possibility to get more information instead of receiving written instructions that would have been left unread. Colours and font sizes of the text in the questions were adjusted to be easy to see and read. Moreover, prompt information on each attribute and level involved in the questionnaire was offered by the mouseover effect. Finally, the questionnaire language was also chosen to be German. Special consideration was taken in formulating clear and short questions as well as to reduce the number of questions as possible. Graphics were used to give a clear illustration of the attribute and/or level in order to make the question as clear and understandable as possible. Adaptations were made when possible.

Furthermore, the approaches were compared for their "between" convergent validity. The results conform to have high values for Pearson's (r) coefficient with high significance for Baier's approach to Pullman's approach followed by the new approach calculated on the individual level. On the other hand, the new approach calculated on the individual level verifies a higher Kendall-Tau and Spearman-Rho over all other approaches.

For the "within" convergent validity of each approach, the results did not prove to be significant. Only in special cases or on the level of individual respondents did it conform to be significant within the approaches. It is interesting to indicate that all the special cases which proved to be significant have a very high determination coefficient R^2. However, many reasons can account for the insignificance of the convergent validity (for details see discussion in Section 7.5.3). For example, the product complexity is high which can magnify the differences between the customer needs (observed importances) and what managers think will best satisfy customer needs (estimated importances). Another possible reason is the sequence of the questionnaires. For example, in Baier's approach the R^2 for ACA11=0.74 (the 2nd lowest determination coefficient) and for the new approach the R^2 for SE10=-0.098 (the lowest determination coefficient of all SEs). Those two values form the observed importances in calculating the convergent validity. Neither has a high internal validity (R^2) and accordingly directly affects the convergent validity among many (see Section 7.5.3).

From the indirect factors influencing the results, it can be concluded that Pullman's approach regarding the factors related to the design of the questionnaire, such as "amusement while answering", "tediousness/interest", "degree of difficulty", and "clarity" of the questionnaire, were positively evaluated (above "neutral") while in Baier's approach, it was seen as clear and the elderly respondents were involved in the process since they had the highest likelihood to buy the product. The new approach was mainly evaluated “neutrally” on the factors related to the questionnaire design. This means that the CC-SEQFD approach has potential to be improved regarding the design of the questionnaire. The adaptation measures can improve the internal validity and hence the other measures.

In total, the conjunctive-compensatory self-explicated method calculated on the individual level of the new approach shows good tendency in the convergent validity in the study, which, when cost and time are considered, gives it an advantage over the other two approaches. However, more studies are needed to check the new approach.

8 Summary and Outlook

8.1 Overview and Summary of the Work

The point of departure of the present work is elderly people. In the last decade, the proportion of elderly people in the overall population has remarkably increased in all industrialised countries including Germany (the present country focus). Thus the importance of the group that elderly people form is continuously increasing, especially on the economic level, as they shape a present and future purchasing power. The companies are thus compelled to adjust to the changing needs and requirements of elderly consumers if they want to survive and have chances in present and future markets. Market research methods are a substantial tool for companies to listen to their consumers and produce products that consumers want and need. Accordingly, those methods need to be adapted to elderly consumers to enhance their effectiveness in collecting the required data and hence produce products that elderly people need and want to buy.

Consequently, this work investigates the question of adapting research methods to elderly people by proposing a new combination of conjunctive-compensatory self-explicated method and the QFD method. It investigates two combinations of conjoint analysis and QFD methods within the example of two complex technological products. To achieve the abovementioned goals, a theoretical description of the methods and the target group is carried out, to be followed by a description of the main approaches used in this work, namely Pullman's conjointQFD, Baier's conjointQFD, and the CC-SEQFD new approach. Finally, two empirical studies are explained and analysed.

After offering an introduction to the problem and an overview of the work in Chapter 1, the target group of elderly people in Germany is analysed in Chapter 2. The **main emphasis lays on the demographical development** until 2060 and the socio-economic situation of elderly people in Germany.

In Chapter 3, the preference analysis methods are analysed. The **main focus lays on the two main methods, namely on self-explicated and conjoint analysis**. More specifically, descriptions of the procedures of the conjunctive-compensatory self-explicated method and the adaptive conjoint analysis are presented. Finally, a comparison of advantages and disadvantages based on empirical studies and an assessment of the methods takes place.

The second method used in this work, QFD is analysed in Chapter 4. The basics of QFD including its history, main definitions, and main matrix, the "house of quality", are pre-

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sented. **Special attention is given to the advantages and disadvantages of the method and solutions to some of the QFD problems are presented**. At the end of the chapter, an overview of the solutions considering the integration of preference analysis into QFD is given, based on an in-depth review of researchers who used those combinations.

As **the attention is given to** the integration of preference analysis methods into QFD, three approaches, namely **Pullman's conjointQFD approach, Baier's conjointQFD approach, and the CC-SEQFD new approach**, are described in Chapter 5.

To achieve an empirical comparison, **Pullman's and Baier's approaches for elderly people were applied to the case study example of mobile phones (study 1)**. The results are analysed in Chapter 6 on three levels of comparison: (1) direct comparison between the results of the two approaches, (2) comparison "within" the approach using the convergent validity, and (3) comparison "between" the approaches using the convergent validity.

The second empirical study, conducted on the example of "smart home" for elderly people (study 2), is described in Chapter 7. In this chapter, the **CC-SEQFD new approach is compared to Pullman's and Baier's approaches** in which adjustment measures on the conjoint analysis and conjunctive-compensatory self-explicated methods for the elderly people were considered. Finally, direct and indirect comparisons took place. The direct comparisons are similar to the comparisons made in the previous chapter, where (1) the results of the three approaches were directly compared; (2) validity comparisons between the three approaches were conducted. Additionally, (3) and indirect comparison were made including a time analysis comparison and the contingent indirect factors comparison.

8.2 Summary of the Main Results

In the present work, two empirical studies (study 1 and study 2) on the customer requirements of elderly people were conducted using up to three different approaches of how to integrate preference analysis into QFD. In study 1 on the mobile phones for elderly people, Pullman's conjointQFD and Baier's conjointQFD approaches were conducted as a pre-test to the main experiment (study 2). The different approaches lead to different results of the mobile phone study. On the comparison "between" Pullman's and Baier's approaches, the "between" convergent validity or "cross" convergent validity shows a low convergent validity with no significant. On the other hand, the comparison of the “within” convergent validity of the approaches shows a high convergent validity with significant for Pullman’s approach, conversely to Baier’s approach. The differences in the results “between” and “within” comparisons can be possibly explained as follows:

- The sample sizes are too small for Pullman’s and Baier’s approaches (n=35; n=39, after filtering, respectively).
- The samples’ degrees of homogeneity cannot be totally excluded from affecting the results.
- The internal validity of the conjoint analysis in Baier’s approach was not high.
- Baier’s approach requires more cognitive effort than Pullman’s approach.
- The elderly people cannot be considered experts in the use of mobile phones.
- The results of the CRs of both approaches were differently ranked, which directly affects the impact of importance of the ECs in the HoQ, and consequently their rankings.
- No adaptations measures for elderly people were considered in study 1.

Study 2 on smart homes for elderly people was used to test Pullman’s conjointQFD, Baier’s conjointQFD, and the CC-SEQFD new approaches with many adjustments made to cope the questionnaires for the elderly people. All approaches have shown high convergent validities with significance between the approaches. Baier’s approach showed the highest convergent validity followed by the suggested new approach calculated on the individual level, namely the conjunctive-compensatory SE method. Regarding the “within” the approaches convergent validity, Pullman’s approach scored a higher value than Baier’s approach and the CC-SEQFD new approach; however, all “within” the approaches validities did not show any significant. The differences in the results “between” and “within” approaches comparisons can be possibly explained as follows:

- The sample sizes are too small for Pullman’s, Baier’s, and the new approach (n=73; n=34; n=39, respectively).
- The samples’ degrees of homogeneity cannot be totally excluded from affecting the results. The samples are homogeneous in the categories of “age”, “gender”, “education”, and “marital status”, conversely, they are inhomogeneous in the rest of the characteristics.
- The internal validity of the conjoint analysis in the Baier’s approach was good but not too high; whereas the internal validity of the new approach was not high.

- Baier's approach requires more cognitive effort than Pullman's approach. However, more adjustments were made on all the approaches to adapt them for elderly people.
- The product "smart home" is complex and unfamiliar for many of the elderly people respondents.
- The indirect contingent factors as well as duration of the questionnaires.

To summarise, the **main result** that can be drawn from the empirical part is that the CC-SEQFD new approach can be used for elderly people and that CC-SE can be a good substitute for conjoint analysis, especially when cost and time are critical. Another corollary from the indirect contingent factors is that adaptations of the conjoint analysis and CC-SE methods help to simplify the methods for elderly people. Table 65 summarises all the main results of study 1 and study 2.

Table 65: A summary of all the results of study 1 and study 2 for elderly people

		Pearson's (r)	Kendall-Tau	Spearman-Rho
Mobile Phone for elderly people	**"Between" Approaches Convergent Validity**			
	Pullman's*Baier's	.134 (0.531)	-.26 (0.862)	-.047 (0.829)
	"Within" Approaches Convergent Validity			
	Pullman's approach HoQ*ACA	.900** (.006)	.619 (.051)	.821* (.023)
	Baier's approach HoQ*ACA10	.345 (.329)	.111 (.655)	.188 (.603)
	"Between" Approaches Convergent Validity			
Smart home for elderly people	**M1*M2**	.630* (.021)	.714** (.001)	.862** (.000)
	M1*M3-1	.529 (.006)	.581** (.006)	.770** (.002)
	M1*M3-2	.516 (.071)	.763** (.000)	.862** (.000)
	M1*M3-3	.605* (.029)	.787** (.000)	.922** (.000)
	M2*M3-1	.812** (.001)	.710** (.001)	.858** (.000)
	M2*M3-2	.928** (.000)	.817** (.000)	.918** (.000)
	M2*M3-3	.927** (.000)	.865** (.000)	.955** (.000)
	M3-1*M3-2	.711** (.006)	.514* (.018)	.662* (.014)
	M3-1*M3-3	.914** (.000)	.744** (.000)	.879** (.000)
	M3-2*M3-3	.910** (.000)	.785** (.000)	.911** (.000)
	"Within" Convergent Validity			
	Pullman's approach (Aggregated level) n=43, R^2>.700	.570 (.140)	.286 (.322)	.381 (.352)
	Pullman's approach (Aggregated level) n=12, R^2>.900	.827* (.011)	.571* (.048)	.762* (.028)
	Baier's approach (Aggregated level) n=29, R^2 = .782	.194 (.592)	.210 (.412)	.419 (.229)
	Baier's approach (Aggregated level) n=9, R^2 >.900	.444 (.198)	.138 (.587)	.263 (.463)
	O*E (M3-1) (Aggregated level)	.293 (.322)	.180 (.415)	.202 (.507)
	O*E (M3-2)	.499	.385	.544

Table 65: A summary of all the results of study 1 and study 2 for elderly people

		Pearson's (r)	Kendall-Tau	Spearman-Rho
	(Aggregated level)	(.083)	(.067)	(.055)
	O*E (M3-3) (Aggregated level)	.107 (.727)	.154 (.464)	.187 (.541)
	O*E (M3-3) (Individual level)	.181 (.499)	.141 (.50)	.202 (.492)

(Own representation); Note (*): correlation is significant at the 0.05 level (two-sided); (**): correlation is significant on the (0.01) level (two-sided); (***): correlation is significant on the (0.001) level (two-sided)

8.3 Discussion and Implications for Future Research

The current results of the work can be critically considered. On the one hand, the differences of the results of the validity between the approaches as well as the small sizes of the samples in the two studies, and the complexity of the technological products implemented in the work. Thus one is limited in generalising results. However, the following points can be gained:

- Adaptation measures in the research methods (CA, CC-SE, and QFD) for elderly people helps in attaining better results.
- The New approach is promising when "between" convergent validity is considered as well as duration of the questionnaire and in the indirect factors.

The complexity of the products and methods imposes a big burden effort on the elderly respondents in doing the questionnaires as well as on the researcher in designing, conducting, and analysing the results.

Some issues that can be improved in future research are:

- More adaptations in designing the interviews should be considered.
- Updated versions of the self-explicated and the adaptive self-explicated (ace) method (Netzer and Srinivasan 2011) are expected to overcome some deficiencies of the CC-SE method. The main advantages of this suggestion are the use of the web-based data collection and the adaptive option which would be more comfortable and time saving in general for all groups and specifically for elderly people.
- Incentives should be introduced to attach more interest on doing a questionnaire.
- The homogeneity of the sample should be considered from the beginning of the survey (if possible).

- Different products (also not complex) should be investigated on the new approach.

Finally, market research is confronted with many challenges in the present and future. The new technologies and the change they bring in the handling of the market research as well as the focusing on the different target groups. The elderly people are an interesting and challenging target group for the market research field and they should be considered more thoroughly by adapting the existing methods and by developing new ways that would help to identify their needs and produce the right product for them.

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