EVALUATION OF CONJOINT MEASUREMENTS FOR LIGHTWEIGHT STRUCTURAL PANELS

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ABSTRACT
The aim of this paper is to prove the difference between full factorial and reduced orthogonal designs by using lightweight structural panel prototypes. These prototypes (16 different samples) were developed and built by students during their 3rd semester of the degree program of “Design and Product Management” at Salzburg University of Applied Sciences. Wood processing companies in Salzburg and Southern Germany, as well as industrial designers, were chosen in order to test these prototypes. As a result, it could be proven that reduced research plans cannot be used without a loss of information. This is the outcome of a pre-study about an interdisciplinary student project. The students had to lead the entire process from building prototypes to analysing and interpreting the marketing research results to further implications.

Keywords: design research, experimental design, conjoint measurement, lightweight structural panels, interdisciplinary student project

1 INTRODUCTION

Since the mid-1970s, conjoint analysis has attracted considerable attention as a method for portraying the decisions of consumers realistically as trade-offs among multi-attribute products or services [1]. During the 1990s, the application of conjoint analysis increased even further, spreading to almost every field of study. Today, it provides researchers with substantial insight into the composition of consumer preferences while maintaining a high degree of realism. Conjoint analysis is based on the simple premise that consumers evaluate the value of an object (real or hypothetical) by combining the separate amounts of value provided by each attribute. Eventually, the researchers will define the object or concept with the optimum combination features and show the contribution of each attribute and each level of overall evaluation of each object. [2]. Standard statistics software packages like SPSS use orthogonal designs and thus, reduce the number of possible factor combinations. A substantial amount of information gets lost in this process of reduction. The importance of design research methods and their importance in the New Product Development (NPD) process is discussed in detail hereafter.

2 RESEARCH FOR DESIGN

2.1 Design research

Whether we create various types of furniture, power tools or computers, we need appropriate methods of ensuring that the products satisfy (exceed or even anticipate) the needs and expectations of the consumers. Hauser and Clausing [3] distinguish customer needs arrayed in a hierarchy. They subdivide into primary, secondary and tertiary needs.

Primary needs are described as rather general needs like “good operation and use” or “good appearance”. Secondary needs specify the idea further, e.g. “easy to open and close door” or “clean”. Tertiary needs would according to this be e.g. “easy to close from outside” or “easy to clean”. In case of fulfilment of these needs, design research can also support the establishment of an advantage over competing designs by reflecting changing trends and developments in design, technology and culture [4].

The importance of design becomes obvious when taking a look at recent studies. According to a survey undertaken by the British Design Council in 2002, about 80 percent of companies believe that design increases competitiveness. Furthermore, 83 percent think it helps to increase market share. A study of Norwegian companies found that companies using design have higher levels of innovation activity, generate more revue from innovation and are more profitable overall than companies that do not use design [5].

Nijhuis and Boersema [6] provide two different research models by comparing an adapted strategic model of design with a model of applied research. The similarities are obvious in that both models go through a process of problem identification — a series of steps to understand the problem and provide a useful solution. Each step involves research or a process of knowledge research. Following Press and Cooper, design research is primarily about the process of searching in three areas: searching for understanding, searching for ideas, and searching for solutions [4]. Eventually design research should be understood as a method to support crucial decisions during the NPD process.

2.2 Design and the NPD

Research shows that about 80 percent of new products fail to succeed in the market. Reasons for such a high failure rate are obvious: insufficient market research, wrong market position or price strategy, or market and sales forecasts have been overestimated [7]. Successful new products require companies to understand their consumers, markets, and competitors and to develop products that deliver superior value to customers [7].

Following Jones [8] the NPD process consists of the following sub-processes: organizational management, market research, product lifecycle, product management, project management and product design and development. Market research is here defined as “understanding markets and interpreting product preferences”. Hales [9] stresses that a significant part of design (or decisions influencing design) is affected not by designers, but by other people in the organization, such as engineers, programmers, and managers.

3 MARKET RESEARCH EDUCATION / POSITION IN THE CURRICULUM

An awareness of the different roles and backgrounds involved is what the curriculum of the “Design and Product Management” degree program is based on. All students (no matter on their final decision for marketing or design specialisation) become acquainted with the basics of statistics in their first semester. This course is compulsory for all the students. In the third semester, the students must take a course in “Applied Marketing Research”, focusing on the topics of Marketing and its relation to Market Research and details of the Market Research process. This is trained through a small research project with different industries. In the following semester, students must work with different fields of marketing research, having a special focus on multivariate analysis methods. In the 7th semester (depending on their electives), students will specialise in design research and design management issues which is the main research focus of the degree program.

4 RESEARCH PROJECT

The implementation of theoretical knowledge into practical projects is a major part of the curriculum, e.g. the critical evaluation of standard market research methods was done during a research project that was carried out with students of the fifth semester of the Design and Product Management degree program during the winter semester 2005/06. Within this project, a material innovation (lightweight panels) was judged by different wood processing companies in Salzburg and different Industrial Designers to discover the most promising factor combination for this material. The results of a conjoint measurement with a full factorial design were compared to results acquired by a reduced design. The aim of this study was to use conjoint measurement (these methods were discussed in the statistic lectures in formerly semesters) and to show the sensitivity of the results depending on the sample chosen.

4.1 Background, General Info about lightweight furniture

One recent field of development in furniture industries are lightweight construction materials. The lower weight of furniture should support the easier handling of furniture as well as new possibilities for designing. To be able to build light furniture, lightweight materials must be applied. The development of lightweight materials can be done by different strategies. One very promising strategy is to combine different materials and build new composite materials.

Additionally, to the technical parameters of furniture materials, the suitability of the raw materials is gaining prominence. Examples for sustainable produced lightweight materials are sandwich panels made of wood based materials with a paper honeycomb core layer.

The interest of industries and science into this type of lightweight panel is documented by recent publications in scientific (e.g. Petutschnigg [10]) and popular scientific (e.g. Stosch [11], ZOW [12]) journals, as well as material innovations (e.g. EGGER [13]) of companies.

4.2 Methods and data acquisition

Following terms are defined to simplify the description of the main methods applied.

Stimulus: A prototype of a certain lightweight panel

Factors: The characteristics to describe a stimulus. The factors defined in this study are the thickness (a panel can be 19mm thick or 38 mm thick), the edge (a panel can be without wooden edge or with a wooden edge), the surface (the panel surface can be treated or not) and the Shape (a panel can be curved or plane).

Factor value: The factor value describes for each factor the possible factor stages. In our case every factor is a two-stage factor (two possible values)

Part worth: The part worth shows, if a certain factor influences the preference of the person or not.

Factor combination: One certain stimulus can be described by the values of the factors. E.g. Stimulus one has the factor combination 19mm thick, with wooden edge, with treated surface and a curved shape. This is a certain factor combination.

Interaction: An interaction is given if the part worth of a factor is influenced by another factor. E.g. it can happen that curved panels are only favoured if the panel thickness is 38mm and not 19mm.

The questionnaires were carried out with two different sets of stimuli. One set represented a full factorial design which means that one stimulus must be prepared and evaluated for each possible combination of factor values. To obtain all possible combinations 2.2.2.2 = 2^4 = 16 stimuli are necessary. The second set represents a reduced test design, e.g. an 2^{4-1} test design according to Addelman [14]. In this case only 8 different stimuli have to be produced and evaluated. Yet, the reduction of the test design leads to a mixture of interactions and effects. That means that most interactions cannot be worked out because of lack of information.

An impression of the way that reduction is carried out is given in figures 1 and 2. The spheres symbolize a certain stimuli, and the edges of the cubic symbolize the first three factors. Every factor has two possible values, so a cubic with eight vertices is resulting. The inner cubic symbolizes the fourth factor with value one, and the larger cubic symbolizes the fourth factor with value two.

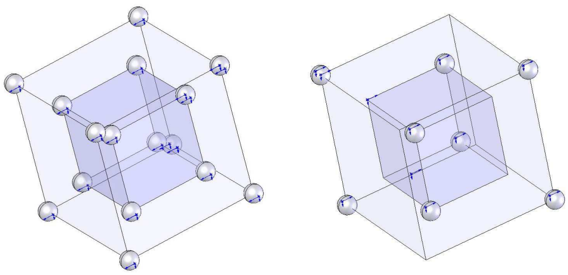

Figure 1 and 2: Sketch for the full factorial plan (left) and the reduced plan (right)

The stimuli were prepared by the students at Salzburg University of Applied Sciences, and 16 persons were questioned to rank the samples according to their preference. The participants for this study were leading employees of furniture producing companies with more than 25 employees (11 interviews) and industrial designers (4 interviews). At the furniture producing companies, both the decision makers for product development and the decision makers for material purchasing were interviewed.

Figure 3 and 4: View on some stimuli (left) and image while conducting an interview (right)

4.3 Analysis

The data of 12 questionings were useful for data analysis (6 per set of stimuli). In table 1 the part worths as result of the conjoint measurement are shown for each person. Furthermore table 1 shows whether the person used the full factorial set of stimuli or not and if the person is an industrial designer or not.

person	Edge		Thick		Surface		Shape		set	Desi
	with-out	with	19 mm	38 mm	un-treated	treated	plane	curved		
1	1,00	-1,00	2,00	-2,00	0,00	0,00	0,50	-0,50	full	Yes
stand.	28,57		57,14		0,00		14,29			
2	-0,50	0,50	-1,00	1,00	0,00	0,00	2,00	-2,00	full	Yes
stand.	14,29		28,57		0,00		57,14			
3	-2,00	2,00	1,00	-1,00	0,00	0,00	0,50	-0,50	full	Yes
stand.	57,14		28,57		0,00		14,29			
5	-0,25	0,25	-0,25	0,25	-0,50	0,50	-2,00	2,00	full	No
stand.	8,33		8,33		16,67		66,7			
6	0,25	-0,25	0,50	-0,50	0,75	-0,75	2,00	-2,00	full	No
stand.	7,14		14,29		21,43		57,14			
7	0,50	-0,50	2,00	-2,00	0,00	0,00	-0,50	0,50	full	No
stand.	16,67		66,67		0,00		16,67			
9	0,00	0,00	-0,50	0,50	1,00	-1,00	2,00	-2,00	red.	No
stand.	0,00		14,29		28,57		57,14			
10	-2,00	2,00	1,00	-1,00	0,00	0,00	0,00	0,00	red.	No
stand.	66,67		33,33		0,00		0,00			
11	-0,25	0,25	-0,50	0,50	-0,25	0,25	2,00	-2,00	red.	No
stand.	8,33		16,67		8,33		66,67			
13	0,25	-0,25	-0,25	0,25	1,50	-1,50	0,00	0,00	red.	No
stand.	12,50		12,50		75,00		0,00			
14	0,25	-0,25	-0,25	0,25	-1,00	1,00	2,00	-2,00	red.	No
stand.	7,14		7,14		28,57		57,14			
15	-0,75	0,75	-0,75	0,75	0,00	0,00	2,00	-2,00	red.	No
stand.	21,43		21,43		0,00		57,14			

Table 1: Results of the Conjoint Measurement

These results show that the part worth values are scattering in a wide range for all factor values. For this reason no clear statement about the preference of certain factor combinations is possible. The results show, that their might be a difference between the preference values depending on the set of stimuli (full factorial or reduced) and the profession (industrial designer or not). But the data is not sufficient to do support probable statistical testing methods. For this reason more data is necessary to get better results.

5 CONCLUSIONS

Summing up, it can be stated that state of the art methods can further be specified to reach more satisfying results for design research. In any case it was an interesting and challenging project and only a first step. A more comprehensive empirical study and more specifications of design research methods will follow. In any case, this project shows the ideal combination of technical skill development (constructing and building prototypes) and the usage of state of the art design/market research tool. In this way, the students could profit in two ways at once. As a recommendation for other educators, the authors would suggest a critical evaluation of state of the art market research methods. Any design curriculum should involve the critical testing of these state of the art market research methods and should try to identify an interface to resembling disciplines and theories. Overall, the project was very exciting and informative for the students.

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