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Virtual Reality based Conjoint Analysis for Early Customer Integration in Industrial Product Development

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Abstract

Disruptive innovations of products and production systems have the potential to provide a leap in value for existing and new customers. However, companies in industrial markets face two major problems when bringing innovations to markets. First, companies often lack systematic customer integration in the product development process. Second, disruptive innovations break with existing technologies and are therefore regularly beyond the scope of customers' imagination due to its complexity and level of novelty. Hence, when customers evaluate new product concepts, they often cannot fully capture its benefits. By addressing these two problems, companies can promote the efficiency of the product development process and thereby the success of disruptive innovations.

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1. Introduction

Already in 1961, Schumpeter stated that innovations are a key for a company's long-term success [1]. Since then, innovations have become one main source for companies to sustain competitive in their markets and are essential for their survival [2–5]. Further, companies need to build new products that perfectly meet customers' requirements [6,7]. Therefore, several methods have emerged to integrate customers at an early stage of the development process. Examples include empathic designs [8,9], creativity techniques [10] or quality function deployment [11,12]. The number of innovations across industries increases whilst the time span under which innovations are launched is shrinking. This puts managers under pressure to pursue an efficient product development process while keeping resource spending at the minimum. In meta-studies, the failure rate of new product development ranges between 20% and 96% [13]. This rate can be reduced by integrating customers in an early stage of the product development [2,5].

However, companies in industrial markets face two major problems when bringing innovations to markets. First, companies often lack systematic customer integration in the product development process [14]. Second, disruptive innovations break with existing technologies and are therefore regularly beyond the scope of customers' imagination due to its complexity and level of novelty. Hence, when customers evaluate new product concepts, they often cannot fully capture its benefits. The need to "revitalize themselves through new products" [15] have let companies explore new ways in the product development process. One promising new path for early customer integration is the use of virtual prototypes in the development process of disruptive innovations [16]. Evaluating highly complex innovations in B2B markets help to generate a clear picture of consumer preferences. Virtual prototypes can be developed earlier, more quickly and more cost effectively than real prototypes [15]. In addition, virtual

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representations of highly complex products facilitate the information transfer by visually presenting the features and benefits of the new products to potential clients.

Against this background, this paper aims to develop a systematic procedure for early customer integration by means of *efficiently* generated virtual prototypes. We developed a method and a software tool enabling companies to integrate customers at an early stage of product development with the help of virtual prototypes to facilitate customers' imagination of disruptive innovations. Combining the knowledge of business scientists and engineers, a multi-stage limit conjoint analysis with an embedded virtual reality (VR) application helps overcoming the two mentioned problems, as will be shown in this paper.

To this end, the paper is divided into two main parts. First, the developed statistical method and the underlying procedure of early customer integration are described. Second, the technical implementation is discussed by focusing on *efficient* modeling and automated generation of multiple VR stimuli to present innovative product features.

2. Early Customer Integration in industrial product development with MELIMCA

At early stages of a new product development (e.g. idea generation and concept phase [17]), companies often cannot estimate the impact of alternative product attributes and levels on customers´ purchase decision [3]. However, new product ideas should be derived based on target customers attribute and level requirements [18,19]. Therefore, companies need to determine relevant attributes and levels from a customer's perspective [20]. This information serves as a foundation to conduct concept tests and develop consumer oriented products [21]. Preference measurement techniques thereby yield a detailed analysis regarding the impact of different product attributes and their relative importance on the purchase decision. Although there is a variety of preference measurement techniques [22], the conjoint analysis is the most used method [23,24].

Conjoint analysis can be used for analyzing consumer preferences in both, business-to-consumer (B2C) markets and business-to-business (B2B) markets. One of the main differences between B2C and B2B markets is that in a B2B-setting, the buying decision is taken by a group of people rather than by individuals [25]. This group can be defined as the *buying center* [18,26]. In B2B literature, several models have discussed the group decision making process, whereby most of these models assume two consecutive steps in the decision making process [27,28]. In the first step, each individual builds his own preference regarding the decision. In the second step, these individuals form a collective decision based on individual preferences [29]. This collective decision varies depending on the influence and bargaining power of buying center members [30]. Therefore, when integrating B2B-customers in the product innovation process, both steps need to be considered separately. Against this background, Voeth and Hahn have modified the conjoint analysis in a way that allows for estimating individual preferences in a first stage estimating the influence (e.g. bargaining power) of each buying center participant on the group decision in a second stage [31]. Finally, both stages can be combined to simulate the final decision of the group. This method is defined as **multiple stage limit conjoint analysis** (MELIMCA) and represents a systematic approach to integrate customers at an early stage in the product development process. In the following sections, all three stages of the MELIMCA will be discussed in more detail.

2.1. First Stage: Measurement of Individual Preferences

In a first step, individual customer preferences need to be measured. This can be achieved with the help of a traditional conjoint analysis (TCA) [32,33]. Even though there are several more advanced types of conjoint analysis available, the TCA is used for this study because it requires a limited number of stimuli, which means at the same time, lower efforts for the costly generation of VR stimuli. In a TCA, respondents rank, rate or trade-off a number of different product profiles (stimuli), whereby each stimulus consists of a number of different attributes and levels [34]. However, the TCA is often criticized as being unrealistic because the choice task only generates preference data without incorporating a respondent's purchase decision [34]. This often leads to the non-realistic assumption that each respondent will buy any of the presented product alternative [34]. Voeth and Hahn have addressed this issue by means of **limit conjoint analysis** (LCA) [35]. The limit conjoint analysis is an extended version of the traditional conjoint analysis, and has its roots in the group-psychology work of Thibaut and Kelley [36]. In an LCA respondents not only rate or rank their order of preference, but also specify to which ranking position they would still buy the presented product alternative [29]. Visually, respondents are requested to place a **limit-card** after the last stimulus they would consider worth buying. This procedure helps to differentiate acceptable and non-acceptable combinations of several levels of product attributes (e.g. product alternatives) in two groups [34] as shown in Fig. 1.

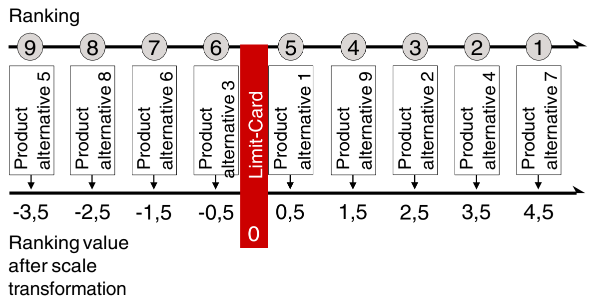

Fig. 1. Limit-Card.

In the example (see Fig. 1), the respondent has placed the limit-card between product alternative three and five to declare that he or she would only purchase five of the nine given product alternatives (e.g. product 7, 4, 2, 9 and 1).