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Towards a method for human-centred analysis of external variety

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Abstract

Addressing VUCA challenges in product development, the Human-Centred Analysis of External Variety (HAV) method is introduced. Focusing on the early stages of new product development, HAV provides a structured approach, reducing uncertainty through quick market analysis, customer engagement, and goal setting. HAV is illustrated using a cargo bike product family case study and emphasizes its role in aligning human-centred methods with project goals. The first steps of the HAV method are presented, but also the need for further action towards a validated and elaborated method is discussed.

Keywords: early design phase, variant management, human-centred design, external variety

1. Introduction

In the dynamic landscape of new product development (NPD) and its early phases, projects grapple with volatility, complexity, uncertainty, and ambiguity (VUCA) (Sinha and Sinha, 2020). Sankowski *et al.* (2021) emphasize the complexity inherent in decision-making, understanding dependencies, and prioritizing requirements, including the delicate balance between external and internal goals. Uncertainty and ambiguity surface prominently in knowledge organization and its transformation into product requirements. The study also posits that volatility becomes more perceptible in later development phases, while ambiguity can be mitigated, to some extent, through an enhanced focus on end users or customers.

There are various overarching strategies for overcoming the challenges of the VUCA world. Complexity is primarily understood as multiple and changing relationships between networked elements of a system. Approaches such as variety-oriented design or modularization share the common step of first analysing the existing product complexity within a system (e.g., components or organizational units) and then implementing complexity-reducing measures (Krause and Gebhardt, 2023b). Volatility and uncertainty in NPD are often addressed on the process side by agile process planning. These are characterised by smaller iteration cycles, more detailed project planning and self-organised teamwork (Stare, 2014). Ambiguity in communication within a product development team can also be addressed through agile processes, i.e. through intensive collaboration and frequent dialogue (Stare, 2014).

On the product design side, uncertainty and ambiguity are in turn primarily addressed by innovation approaches. These can be roughly categorised as technology-driven or market-driven innovation. Technology-driven approaches offer great innovation potential, often combined with high risk. Here, for example, trends or new technologies are analysed and their potential for the company's own product or system is examined (Yip and Huang, 2016). Market-driven innovation approaches, on the other hand, offer the advantage of risk reduction, but the resulting innovations are often incremental in nature, according to some critics (Chamberlain, 2010; Chang and Taylor, 2016). A classic procedure within the market-driven innovation approaches is market analysis (Aaker and McLoughlin, 2010). Newer approaches, some of which involve intensive user involvement, also include steps for finding creative solutions and claim to be able to produce disruptive innovations without massively increasing the risk

of failure, e.g. lead-user innovation (Hippel *et al.*, 2011) or design thinking (Friis Dam and Siang, 2021). In principle, market-driven approaches, individual methods and techniques for involving end users and customers as well as the fundamental mindset behind them can be summarised under the collective term human-centred design (DIN EN ISO 9241-210, 2020).

As much as human-centred design is a powerful framework for creating added value for the end user, e.g. in terms of usability or accessibility (DIN EN ISO 9241-210, 2020), or for the company, e.g. in terms of product quality and avoidance of product failures (Paetzold, 2021), the actual implementation can be difficult. On the one hand, it is difficult for product developers or sales engineers to select the appropriate human-centred methods for the development process at hand (Ozcelik *et al.*, 2011) and to define and acquire the right users as representatives for involvement (Yaman *et al.*, 2016). Human-centred methods often fail because the results of the user involvement methods are not properly evaluated or because it is unclear how they can be translated into product requirements (Ozcelik *et al.*, 2011). According to ISO (DIN EN ISO 9241-210, 2020), the selection of human-centred methods and their integration into the product development process should therefore be planned in an upstream step before the start of requirements elicitation and thus before the start of the actual development work.

On the other hand, even if human-centred approaches are successfully implemented and evaluated there is no guarantee of corporate success. It is not enough to know which methods are suitable for one's own project boundary conditions, how they are to be applied and how their results analysed, but also the results must be evaluated against of one's own diversification strategy. A strategy must be devised as to how the product family design shall accommodate changing customer requirements. Should the product range be expanded in line with customer requirements or should the product variants offered on the market be scrutinised and optimised in order to produce more cost-effectively? Without a strategic focus, a vicious circle of diversification can arise, in which more and more product variants are created, causing more and more variety-induced complexity and costs on the company side and thus increasingly jeopardising competitiveness (Krause and Gebhardt, 2023a). Therefore, a methodological approach is needed that is suitable for supporting the planning of user involvement that can be placed in the context of early product family development and the associated development strategy.

The aim of this paper is therefore to derive such a methodological approach, to present it using an example and to verify it against the defined requirements. This a prescriptive study according to Design Research Methodology (DRM) (Blessing and Chakrabarti, 2009), including the designated support evaluation and also including a theoretical structural validation according to Validation Square (Pedersen *et al.*, 2000), which will be presented here. For this study a research question can be formulated: *How can a structured and methodical approach look like that can be integrated into the early human-centred product family development phase and support it in analysis, decision-making and further planning?*

The paper outlines the early product family development process (section 2.1) and reviews methods suitable for this phase, that pursue various objectives, such as knowledge organisation, product programme planning or requirements elicitation (section 2.2). Section 3.1 introduces a cargo bike product family as an example, followed by the presentation of the method (section 3.2). Finally, the paper evaluates goal achievement (section 3.2) and discusses future research directions and necessary steps for method validation (section 4).

2. Methods & materials

2.1. Fuzzy front end of new product family development

A general description of the early phase of product development can be found in Cooper (2008). Here, the early phase is everything that takes place before the actual development. It is also called the 'fuzzy front end' due to its vagueness and difficulty in planning. Within the stage gate process, it consists of the stages 'ideation', 'scoping the project' and 'defining the product and building the business case'. It is recommended to implement the voice of customers, e.g. via mock-ups, as early as stage 2 (build the business case) (Cooper, 2008). Pons (2008) describes a project development process of NPD and refers to the first step of product development as 'idea generation', in which customer needs are identified, quality of existing products evaluated and objectives of the new product defined. Both process

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descriptions state that in addition to the objective setting and idea generation, i.e. a decision-making and synthesising, customer/ user involvement should also take place.
Although innovation processes or NPD processes often emphasise the focus on innovation or even disruptive innovations, product development processes do not usually take place in an empty space free of constraints and away from technical specifications; instead, the products developed in these processes are integrated into existing structures and product portfolios and use existing product platforms, production facilities or company expertise. Otto *et al.* (2016) argue that single standalone products hardly exist, posing many constraints on the development projects, making the challenge of complexity greater than of creativity. Product generation development and product family development processes take this fact into account. In product generation development (Albers *et al.*, 2015), expertise or existing solutions from reference systems should be adopted. Product family development embeds the new development in the context of a larger product family (Otto *et al.*, 2016), but places an additional focus on variety within the modular design of the new product family. Again, project objectives (step 2) and analysis of customer needs (step 3) are required before the actual development process can begin with the definition of requirements (Otto *et al.*, 2016). A clear difference to the process descriptions of the general NPD is the focus on the market and the company's own positioning (step 1 and step 2).
In ISO (DIN EN ISO 9241-210, 2020) the design of user experience is defined as an original innovation process. Therefore, a generic human-centred design approach is presented. Planning of the scope and extent of the human-centred design process can be a difficult and critical step, as the scope of user interaction in the future product and thus the extent of the necessary human-centredness is still unknown and often underestimated at the start of the project. Thus, the human-centred design process starts before the definition of requirements or design solutions with the analysis of the context of use. This is an elementary concept of human-centredness and forms the basis for the following steps. The context of use is defined as the specific and combined information about the users, goals, tasks, resources and the environment in which a system, product or service is used. The environment includes both the technical and physical environment as well as the social, cultural and organisational structure within which the human-system interaction is to take place (DIN EN ISO 9241-11, 2018).
Summarising these different perspectives, the early phase of a new product development requires (1) an analysis or overview of the market and the company's own position in it, (2) some form of customer involvement or human-centredness to identify requirements and (3) a decision-making concerning the development goal and the diversification strategy of the product family. With regard to (2), all activities in which information about the context of use is collected from, with or by the user during the product development process are considered as a human-centred activity (Sankowski and Krause, 2023). The new method, called Human-centred Analysis of External Variety (HAV), shall support the planning of the human-centred design process, increase the level of detail in the early phase and thus reduce uncertainty and fuzziness. It shall be able to be integrated into the iterative development process and be iterative itself. Finally, it shall help to organise existing knowledge and information and thus support decision-making. However, it is not our aim to develop a new innovation or creativity method or even a new human-centred design method, as we believe that there are already many established and helpful methods in this area. Instead, it is their selection and planning in relation to the existing product family and the objectives of NPD that shall be supported.

2.2. Methods for the early phase

This section presents existing methods that are suitable for supporting the early development phase. Here the focus lies on methods that help to organise knowledge and information, collect information or requirements from, with or by users and support product programme or product family planning.
A very basic technique for organising existing knowledge or information that is independent of any area of application is the creation of a graph, e.g. in the form of a mind map (Lima, 2014). This is a tree structure that continually branches out information and organises it hierarchically. A similar way to map information is in the form of a concept map (Lanzing, 1998), which also explicitly provides cross-connections between the individual nodes and attaches labels to these connections. Due to their general validity, these two can be found as the conceptual basis of many other specialised analysis and design methods.

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The Boston Consulting Group's growth-share matrix (Stern, 2006) is more specific and also suitable for early product development. In this matrix, the company's own products are distributed on axes relating to market share and market growth. In addition, the relative turnover can be represented by the diameter of a circle. The matrix is often divided into quadrants that are labelled as "Poor Dogs", "Question Marks", "Stars", and "Cash Cows". Companies can use this overview to plan and decide which products they should continue to offer, discontinue or develop further. The matrix can therefore be used to identify an initial rough direction of development.

In Design Driven Portfolio Management (Petersen *et al.*, 2011), a model is created that supports the management of portfolio projects according to design aspects, whereby the programme hierarchy is compared with the two parameters of execution risk and market risk. In addition, the estimated turnover, the current development phase and an estimate of the necessary investments, so-called design quality criteria, are provided as further variables. These represent potential risks in development, such as budget overruns or quality problems. The procedure is intended to derive a design philosophy and support its implementation. It combines the topics of NPD and product programme planning.

Jonas (2013) presented a method is that supports the revision of a product programme. The existing product range is mapped in the form of a program structuring model (Jonas, 2013) for analysis and visual overview. This depicts the individual products in the product range, their hierarchy and economic parameters. The approach further considers the integration of the results into the further product family design. Possible carry-over candidates for reuse within the product programme are identified. The method thus provides support for the strategic planning of modular product programmes.

'Design-for-variety' approaches are also often used in context of product programme planning and product family design. The aim is to keep the variety resulting from various customer requirements, i.e. external variety, under control or to implement it with as little internal variety as possible (Krause and Gebhardt, 2023b). The approaches assigned to this topic always start with an analysis of the existing variety of the existing product family and the identification of the goals that the company has set for it. A special tool in this context is the Tree of external Variety (TeV) (Kipp, 2013). It is a hierarchical tree structure that breaks down the variety of products perceived by customers. TeV is therefore in turn a product programme visualisation formulated at the level of customer-relevant product features.

Apart from the product family-oriented approaches, there are also those at the product design level. In the early design process these are methods and approaches that are intended for the collection, evaluation and classification of customer requirements and desired product characteristics. The best known and most established of these are Quality Function Deployment (QFD), Kano Method and Conjoint Analysis. QFD is used to systematically focus on the customer as part of product planning (Hering, 2022). The method combines two dimensions: Firstly, the internal product view, in which a definition of the required internal product features is created from the customer's perspective and compared with the customer's requirements; and secondly, the market view, in which customer requirements and their weighting are recorded and compared with competitors (Hering, 2022). QFD thus has a strong focus on the customer's requirements, but usually takes place without direct customer involvement.

The Kano method is based on the Kano model and complements it with a quantitative approach for identifying and classifying the attributes described in the Kano model, i.e. threshold, performance and excitement attributes (Sauerwein *et al.*, 1996). This evaluation is carried out using a special questionnaire technique in the form of a so-called Kano questionnaire (Sauerwein *et al.*, 1996). The advantage lies in the high number of product characteristics that can be queried with regard to their value for the customer. However, the evaluation is always carried out by individually comparing the fulfilment with the non-fulfilment of one characteristic. This is the main difference to conjoint analysis, which evaluates a set of features from the customer's perspective and thus draws conclusions about the value of the individual product features (Baier and Brusch, 2021). The evaluation is therefore often considered to be closer to reality, as the product as a whole is evaluated by the customer. However, this questioning technique leads to a rather small number of comparable attributes and characteristics.

In both, Kano method and conjoint analysis, the collection of customer-relevant product characteristics is not directly specified, but is a prerequisite. This means that human-centred methods are needed in the preparation phase to elicit characteristics and requirements. The portfolio of existing human-centred methods and techniques is very large (Glende, 2010). It ranges from document analyses, ethnographic

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surveys, observation and questionnaires to interviews and their various adaptations, such as focus group interviews, expert interviews and in-depth interviews, to name but a few.
Summarising the brief overview of existing methods for information analysis, process planning and decision-making in early product (family) development, there are already many methods that support individual aspects and challenges in this area and also some approaches that address multiple views equally. However, there is no single or combined approach that answers the research question and fulfils the requirements from 2.1. Product developers with appropriate experience in product family planning or development and human-centred design methods are probably able to select and combine suitable methods from the existing method landscape for the respective development process or adapt them accordingly. All others shall be assisted by the HAV method which was presented in section 3. In developing the method, we have orientated and, where possible, reused or further developed suitable building blocks of other approaches for the new HAV method.

3. Results and discussion

To present the HAV method, a simplified case study is presented and the steps of HAV are explained using an example. To make the decisions and processes clearer for the reader, we want to give a brief description of the company and the external situation.

3.1. A case study of cargo bikes

The company presented is a medium-sized bicycle company that produces in Germany and whose main sales market is also primarily in Germany and in Europe. The coronavirus pandemic has led to a significant increase in sales figures in this market segment, allowing production facilities to be expanded and storage space to be increased. The larger capacities are to be used both to meet the increased demand and to consolidate the position of the still relatively young company on the market by expanding the product range into further market niches. The external variety of the existing product family is thus to be expanded in a strategic manner, taking user needs into account.
The range includes urban bikes with and without electric motors, which are well suited to urban areas and are therefore particularly popular with commuters and leisure cyclists, as well as trekking bikes with and without electric motors, which are also suitable for longer distances. The range also includes cargo bikes with an electric motor in the Long John, backpacker bike and bakery bike models. On the Long John models, the load is positioned between the front wheel and the rider. Backpacker bikes have a longer wheelbase and an extended frame on the rear wheel. On a bakery bike, the load is placed in front of the handlebars and on the rear pannier rack.

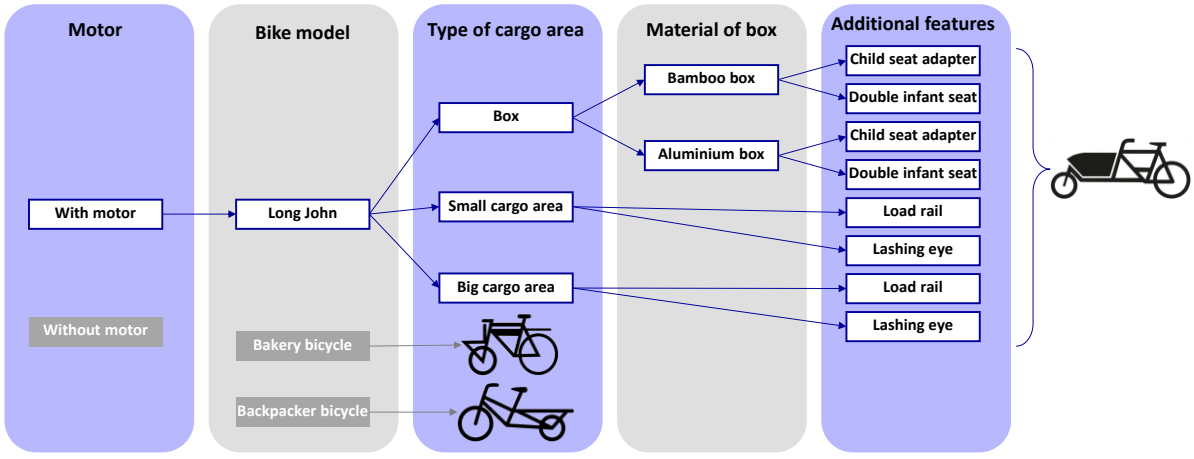

Figure 1. Excerpt from tree of external variety for a cargo bike product family

Figure 1 shows a section of the external variety of the existing product family in the form of a tree of external variety. The branch with the variety of Long John cargo bikes is shown in complete form, while the branches for the other types and normal bikes with and without a motor are not shown. The tree of external variety shows the different versions offered by the company for each customer-relevant characteristic or feature,

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such as bike model, and which are perceptible to the customer. The tree is to be read from left to right and branches out successively until all product variants of a product family result at the end.

3.2. Human-centered analysis of external variety

After this overview of the current status of the company and the product family to be analysed as well as the initial decision to focus on a specific product type, the HAV method can be applied. If it is also necessary to provide methodological support for this initial step, which precedes the HAV method, the market share and growth matrix, for example, is suitable here.

1. External variety through keywords: The first step of the HAV method involves a simplified and quick market overview, which should be formulated from the customer's perspective. If extensive market research data is available or a complete market overview is required, this data can be processed here as an alternative. For example, a data mining approach can be used to extract information out of product reviews, blogs, or websites. The aim of the first step is to obtain an overview of the functions and features offered on the market and thus the product characteristics that can be perceived by the customer. For this purpose, keyword-based features and characteristics relevant to purchasing are collected for both the company's own products and those of competitors. If a tree of external variety has already been set up for one's own product family, the characteristics can be taken from here. In our case, these include e.g. 'aluminium box', 'child seat adapter', 'big cargo area' and 'motor'. For the competitors, the features and characteristics relevant to purchasing can be taken from product brochures and online shops. For example, descriptions such as "ideal for dog lovers" or "available in many colours" can be found there; such expressions can be simplified to 'dog box' and 'customisable design'. This creates a collection of keywords for the variety perceived by the customer in the market. A distinction can be made between the company's own and competitors' keywords for external variety using solid and dashed lines (Figure 2, step 1). The collection of purchase-relevant features and characteristics in the form of keywords is continued until no more new keywords are found or until the portfolios of the most important competitors have been checked.

2. Prevalence on the market: In the second step, the keywords found in the first step can be given a qualitative prevalence indication: often, occasionally and rarely (Figure 2, step 2). This information can again be obtained from a comprehensive market analysis or estimated on the basis of the keyword search performed in the first step of HAV, i.e. by counting the number of products on the market with the same product features. The information provided in step 2 is therefore not a benchmark against competitors, but an overview of what is available on the market and how often it is offered.

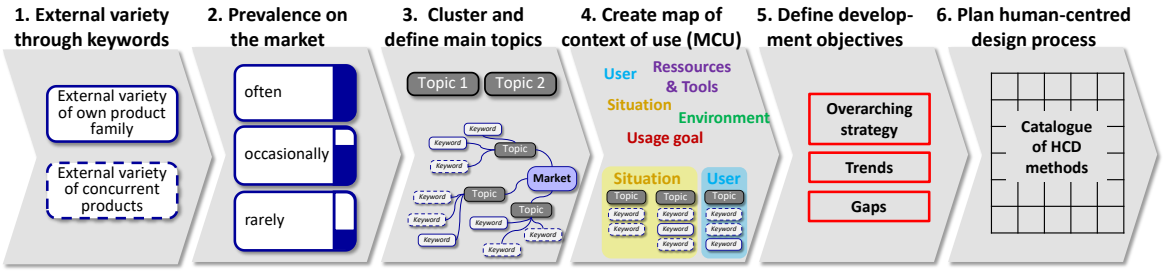

Figure 2. Steps of human-centred analysis for external variety method

3. Cluster and define main topics: In steps 3 and 4, a twofold clustering takes place. In the first, the keywords found are clustered into main topics. These are derived as superordinate properties from the keywords themselves. For example, the keywords 'box with door', 'box with ramp' and 'eyelets for cords' can be grouped into a cluster and named 'transport of dogs'. This first clustering process can be done in the form of a mind map (Figure 2, step 3).

4. Create map of context of use (MCU): In the second clustering, the categories are predefined. These are the elements of the context of use: the user(s), the purpose of use, necessary resources and tools as well as the environment and situation in which the product is used. This second clustering creates a so-called map of context of use (MCU) for the product group or market segment to be analysed. The general elements of the context of use help to recognise where exactly the different contexts of use and thus the variety in the products of the product segment come from. For example, whether this comes more from the diversity of the users or from the diversity of the different environments in which the product is

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used. Depending on the case, it is therefore possible that several main topics and associated keywords are assigned to one and the same context of use element, while other elements are not assigned at all. In our example, we sort both 'transport of dogs' and 'transport of children' to the context of use element 'situation'. In contrast, we have not used the 'Resources & tools' element in the MCU for cargo bikes. However, this should not lead to the conclusion that this element is not relevant in the present case, but merely that no diversity drivers could be identified that could be assigned to this element. For the sake of clarity, we recommend switching to a hierarchical tree structure at this point.

5. Define development objectives: Once the MCU has been fully clustered and sorted, it can be used to identify gaps in relation to competitors, locate trends or also form or scrutinise own development objectives. If there are already many solutions and they are widely available on the market for one context of use element, there may be a gap in the product range of the company's own product family that should be closed. If there are only a few solutions available in another part of the MCU, there may be potential to take on a pioneering role with the design of new and user-friendly solutions. This and other potentials are collected and discussed here. Promising potentials shall be substantiated or questioned in the following step 6 with data from the human-centred study.

Figure 3 shows the finished MCU for the example of the cargo bikes product family, in which the overarching development goal or strategy 'Urban and digital space' has been displayed in red. When analysing the MCU and comparing it with the company's own goals, gaps were identified in the company's own product family compared to the competition in the areas of 'Range' and 'Transportation of dogs'. The company does not yet have its own solutions in these areas. Further potential for the company's own product family is seen in the area of 'Business'. The large number of solutions and their prevalence in the market indicates a correspondingly large market for this product solutions. This area shall also be further expanded and this market niche addressed more strongly. In contrast, potential for new and innovative solutions is seen in the area of 'Security'. There are isolated solutions in this area and further potential is seen through the use of digital solutions.

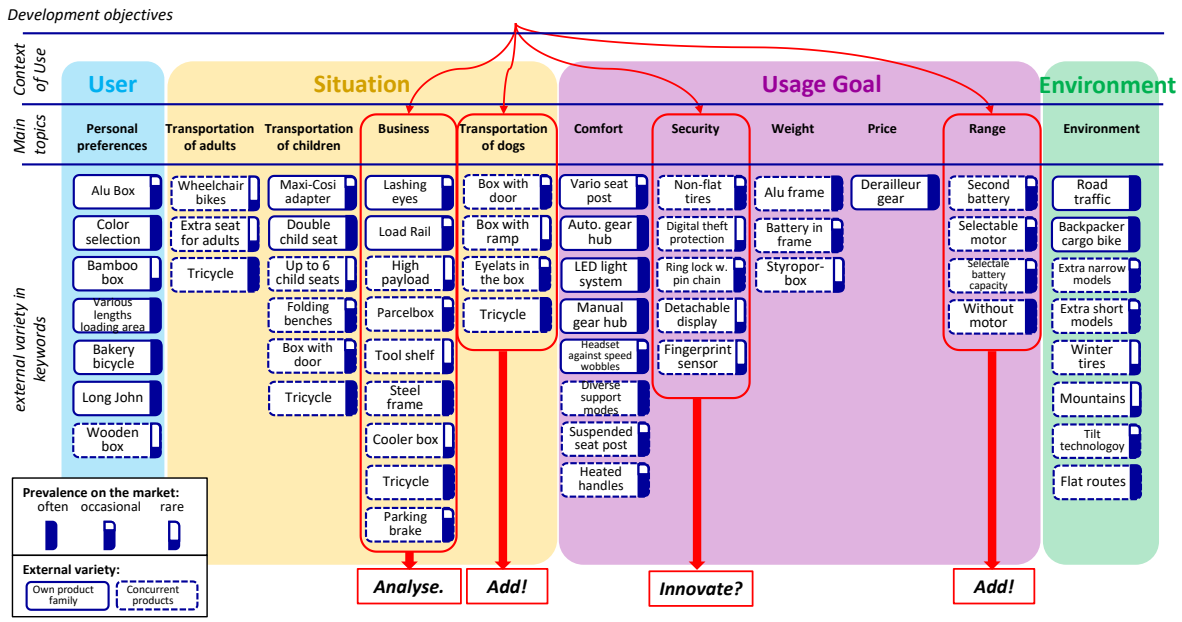

Figure 3. Resulting MCU for the cargo bike case

6. Plan human-centred design process: With this result, the human-centred development process can now be planned and suitable methods selected. The effort and scope of the human-centred process as well as the degree of user or customer involvement should match the categories from step 5. The riskier the potential new development, the more resources and time should be planned for the human-centred design process and the closer and more intensive the user-designer interaction should be. Various overviews or selection catalogues of human-centred methods can be consulted in the state of research, e.g. (Glende, 2010; Overvik Olsen and Welo, 2011) as well as an ISO standard (ISO/TR 16982, 2002). Here objectives, boundary conditions and, in some cases, procedural instructions for various methods can be found. For the topics and customer-

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relevant characteristics marked with 'Add!' in Figure 3, rather cost-efficient methods should be favoured. Carrying out a cost-benefit assessment can also help to determine whether and to what extent the use of human-centred methods is necessary and helpful. This is also related to the development effort or risk for the new product features. Those with low development effort and low cost and resource input can probably be developed without further human-centred analysis. Alternatively, analysis methods with little or no direct user involvement, such as QFD, can be used to prepare for development. If the existence of requirements is to be checked after all, questionnaires, for example, can be considered as a relatively cost-efficient method. Kano surveys or conjoint analysis, on the other hand, are more expensive and time-consuming in terms of participant acquisition, implementation and evaluation, but also more accurate and reliable.

Human-centred analysis methods should also be planned as preliminary work for the development of those topics and customer-relevant features marked with 'Analyse.'. In this case, however, gathering of qualitative data could be helpful, i.e. help to understand the "What?", not only the "How much?". Focus group interviews with representatives of the user group, can be considered for this purpose.

Finally, for those topics and customer-relevant features marked with 'Innovate?', an outcome-open innovation process with more intense user involvement is recommended to reduce the risk of product failure. In addition to qualitative analysis methods, approaches and methods with a strong creative character are suitable for this purpose. For example, a development process based on the design thinking approach seems predestined here, but individual methods with intensive user involvement such as the persona scenario method, customer journey maps, user tests, rapid prototyping and sketching can also be helpful here.

3.3. Discussion

The results from this paper serve both to present the HAV method and to take a first step towards validation of the method. It is necessary to underline that, according to the Validation Square (Pedersen et al., 2000), method validation has only reached the first stage, the structural validity. It is achieved when proof of internal consistency has been provided on a theoretical level and proof that the example problem is similar to the real problem has been provided on an empirical level. Internal consistency means that the individual steps within the method build on each other logically. This means that the method is practicable and leads to a defined result. The step-by-step presentation of the HAV using an example case demonstrates on a theoretical and empirical level that the method is functional and internally consistent with regard to its objective. The last step, however, requires further elaboration and individual breakdown per human-centred method, which degree of human-centredness or degree of interaction it enables and, even more importantly, how well it can be used to address which uncertainties and ambiguities in product development processes and at what risk.

According to DRM, the first step in the validation, i.e. support evaluation, of a method takes place as part of the prescriptive study and serves to prove that the method fulfils the requirements (Blessing and Chakrabarti, 2009). The requirements we have defined result from the research question and further explanations in section 2.1. The degree of fulfilment of the requirements is explained in Table 1.

Table 1. Initial verification of HAV method on the basis of fulfilled requirements

1	Structured and methodical approach → ***Fulfilled*** by the presentation of method using in a case study
2	Suitable for early product development phase → ***Fulfilled***, as little to no information is required to implement the method; The information collected during implementation is freely accessible.
3	Suitable for product family design → ***partially fulfilled***: External variety is considered and analysed. However, there is no subsequent integration of the results into the product family design. It is therefore not possible at this stage, without further development, to assess how well the process will fit into the following product family development process. → ***only partially fulfilled***
4	Considers human-centred goals and methods → ***Fulfilled***. Human-centred aspects are included by sorting keywords according to the context of use elements and by integrating human-centred methods.
5	Supports analysis of as-is situation and increase level of detail in the early phase → ***Fulfilled***, in steps 1 - 4 through the simplified market analysis and through analysing the external variety on the market
6	Supports decision-making in development goals → ***Fulfilled*** in step 5
7	Supports planning of further development process → ***partially fulfilled:*** Requirements and categories regarding the method selection have been listed, but the human-centred methods have not yet been fully assigned to these categories. → ***only partially fulfilled***
8	Supports iterative working → ***not tested***; The iterative approach would be particularly helpful for planning and selecting further human-centred methods in later steps of development. However, this was not tested in this study.

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4. Conclusion and future work

This paper has addressed the question of how a methodical approach can be designed to support analysis, planning and decision-making in the early human-centred product family development phase. For this purpose, descriptions of the early product family development phase and the methods relevant here were used to derive a method for human-centred analysis of external variety (HAV). It was then presented using a product family of cargo bikes, thus providing initial proof of its functionality and internal consistency.
However, further studies and evaluation steps are still required to validate according to DRM. The subsequent studies on the HAV method should aim for an application evaluation. This includes empirical proof of both the applicability and the effect on its target variables. In our case, this would be empirical evidence that the HAV actually supports analysis, decision-making and process planning. This could be done, for example, through an experiment with participants from the academic context.
Furthermore, a categorised overview of human-centred methods that is specifically geared towards the results of the MCU is still needed. A further investigation and classification of human-centred design methods with regard to their suitable and cost-effective use is necessary.

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