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A METHOD FOR SYSTEMATIC ELABORATION OF RESEARCH PHENOMENA IN DESIGN RESEARCH

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Abstract

The mission of design research is to discover and investigate not or partially known phenomena, and to formulate statements concerning their manifestations and relationships with other phenomena. Identification of phenomena happens in the fuzzy front end of research projects and the early explorative phases of research cycles. In spite of their determining nature, defining and processing research phenomena happen in an intuitive manner, often resulting in complications in the conduct of research. This paper proposes a method for a systematized handling of research phenomena in design research. Systematization is done in the framework of defining a research model and devising a research design based on it. The proposed method places a phenomenon in a local world, and specifies the involved things, attributes, effects and relations. Decomposition of a complex phenomenon to constituent phenomena is facilitated by a combinatorial mechanism. The paper demonstrates the applicability of the method in a concrete case. Further research concentrates on obtaining empirical evidence concerning the use and effect of the proposed method in multi-year PhD projects.

Keywords: Research methodologies and methods, Information management, Uncertainty, Design research, Phenomenon

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1 INTRODUCTION

The mission of design research is to discover and study unknown physically-based phenomena and conceived technologically-induced phenomena, and to formulate statements concerning their manifestations, uniformities, irregularities, and relationships with other phenomena (Bayazit, 2004). This knowledge supports: (i) increasing the overall awareness of the nature, approaches, manifestations, methods, norms and values of design, (ii) extending the knowledge platform of designing by exploring facts, laws, principles, theories, (iii) supporting creative human activities and processes by novel design methodologies, computer-aided tools, creative techniques, and best practices, and (iv) enhancing problem solving intelligence related to theoretical and practical concerns and contexts by informing, modelling, simulating, collaboration, and advising. Though it plays a crucial role in the development of research models and research designs in the fuzzy front end of research projects and in safeguarding a proper scope and focus in the early explorative phases of research cycles, the ways of a systematic handling of research phenomena in design research are not fully understood and often overlooked (Faste and Faste, 2012).

Since it is a common mistake made by researchers that they begin their investigations far too early, before they have thought critically about what information is required to address the research problem, methodological knowledge on finding, describing and explaining research phenomena is seen as a missing cognitive resource (Horváth, 2016). This paper addresses the related issues and proposes an approach for handling research phenomena in the inquiry with rigor. The focus will be on proposing a method for systematic handling, rather than on defining the subject of phenomena in specific project contexts. The starting point of our argumentation is that a proper clarification and scoping of the research phenomenon investigated in a research project or a research cycle reduces or even eliminates some of the uncertainties and hesitations originating in the fuzzy front end. This is an important issue since conducting systematic and rigorous design research when hardly anything is known about the investigated subject matter at the outset of the project is challenging. It is usually based on educated assumptions and personal intuitions (Denzin and Lincoln, 2008). The literature identifies this type of research by the term 'open exploratory research' (OER). A fundamental characteristic of OER is that the studied phenomenon either has not been discovered yet, or if it has been, then it has not been described appropriately and/or the influencing factors, correlations, and causalities have not been explained sufficiently. This also entails that no earlier research model (RM) is available as a starting point and a basis of the planned new inquiry, and/or no exiting research design (RD) can be adopted. Therefore, the task of identifying, selecting, and scrutinizing proper research phenomenon or phenomena is tightly coupled with the task of developing new research models and research designs.

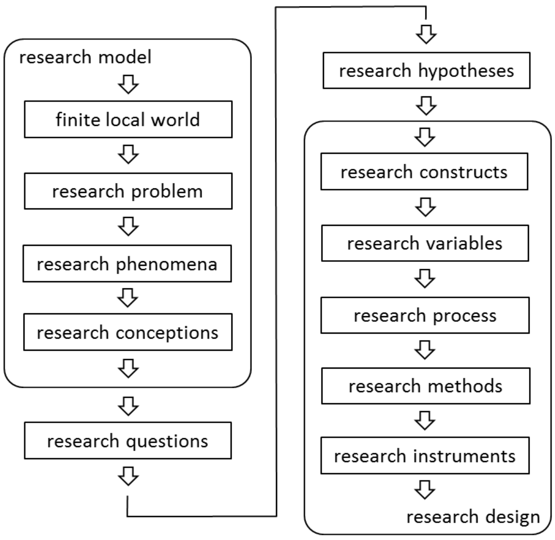

Figure 1. The position of research phenomena in a research model and with regard to research design

The primary objective of the fuzzy front end of design research is conceptualization of a RM that eventually identifies the conceptual items, which the follow up investigations are based on, specifies their relationships, and derives an effective research design based on these. This is shown in Figure 1. A RM is an overall conceptual framework used to look at the subject of research, but it is also a road map for transforming a research idea into feasible and efficient research designs. Research models are typically grounded on a particular science philosophical platform. The development process is typically intuition driven, context dependent, and flecked with idiosyncratic features. Technically, RM is an abstraction and/or simplification of a studied local world of the whole existing or imaginable reality (domain of knowledge). It captures the local world of interests in terms of the phenomena that populate it and their interactions. A RM can be derived in both experimental and speculative manners. It can be quantitative, qualitative, or hybrid. While the research model defines what the inquiry will be about, the research design specifies how the research should be done procedurally. The link between RM and a RD is established through working research questions (expressing specific curiosity in the phenomenon) and working research hypotheses (functioning as seeds of theorising). A RD has a methodological flavour in as much as it: (i) clarifies the possible procedures and identifies the most appropriate and efficient protocols, (ii) selects and arranges the applicable research methods (for data aggregation, theorizing and justification, and (iii) determines the most relevant research instrumentations (tools) and set-ups.

A central element of a RM is a research phenomenon (RP), no matter which way it is generated and whatever form it manifests. According to the definition introduced by Woodward (2000), phenomena are stable, repeatable effects or processes that are potential objects of prediction and systematic explanation by general theories and that can serve as evidence for such theories. The objective of this paper is to clarify the essence of RP and to contribute to reduction and elimination of fuzziness and uncertainties of the front end of design research through operationalization of intrinsic knowledge that is naturally associated with research phenomena. Towards this end a specific method is presented. The next section focuses on the various (generic) interpretations of research phenomena. Section 3 presents the method proposed for a systematic specification of research phenomena. Section 4 discusses a demonstrative application example of the proposed method. Section 5 reflects on the work and the findings of this study from the viewpoint of the previous work documented in the literature. Finally, Section 6 concludes about the outcomes and briefly sketches up possible future research.

2 VARIOUS INTERPRETATIONS OF RESEARCH PHENOMENON

The term 'phenomenon' came into the modern philosophical and scientific usage through Kant and Guyer (1998), who contrasted it with the noumenon. They considered a noumenon as a posited object or event as it appears in itself independent of perception by the senses, but as not directly accessible to observation. A research phenomenon is supposed to be approachable both empirically (observed through the senses, including seeing, hearing, smelling, tasting, and touching) and deductively (observed through the mind). For a sufficient explanation, the concept of phenomenon should be approached from both ontological and epistemological perspectives. From an ontological perspective its manifestations (separation of occurrence from non-occurrence) and the reasons of manifestation are to be considered. Usually (i) natural, (ii) constructed, and (iii) conceived phenomena are distinguished. The way of considering a RP is influenced by the philosophical platform, which researchers depart from (e.g. realist, pragmatist, constructive, instrumentalist, etc.).

Philosophical realism claims that reality exists independently of observers. Contemporary philosophical realism is propagating the belief that some aspects of reality are ontologically independent of our conceptual schemes, perceptions, uttering, beliefs, etc. Standing on the side of realism, researchers may claim that phenomena for investigation are to be discovered as existing in the physical words. It is another issue if it is possible to observe them at all and to observe them correctly through the human senses or by means of available assistive instruments. The possibility of perception is a major issue for critical realism. From this perspective researchers claim that some sense-data accurately reflect external objects and may provide an understanding of the phenomena of the mind-independent world. For realists, a true understanding of phenomena consists in a correspondence between the experimentable reality and the cognitive representations. This correspondence is not supposed to be absolute - the accuracy and fullness of approximation and understanding of reality can be improved. In the realist methodology, a phenomenon needs to be discernible and directly accessible to observation or intervention in real life, or reproducible under controlled circumstances in the local world of investigation.

Other philosophical stances consider the mind-dependent aspects of learning and understanding the phenomena of the physical world or even give floor to a reality-independent existence of phenomena. From the non-realist perspectives, a phenomenon can be a product of thought or intuition, rather than only a spatiotemporal object or happening in the physical world that may become known through the senses. Philosophical constructivism assumes that human mind and knowledge play an active role in constructing beliefs of phenomena either in a reality-independent realm. It is widely argued in the constructivist epistemology of scientific research that science consists of mental constructs that are created as a consequence of measuring and interpreting the existing reality (the natural world) and the imaginable reality (the conceptual world), respectively. In social contexts, social phenomena are identified based on how human consciousness makes meaning from experiences with objects, processes, and relationships. Another exhibition of constructivist creation of phenomena is recognizable in mathematics research, where there is a necessity of constructing (abstract) mathematical objects and to prove that they (logically) exist.

From an epistemological perspective, capturing information about the existence and providing information about the occurrence of a phenomenon are the main issues. The inquiry in phenomena is largely influenced by the objectives of the study (i.e. discovery, description, explanation, prediction, or control). Identification, description, and explanation of a phenomenon may need different background knowledge (e.g. monodisciplinary, interdisciplinary, multidisciplinary, transdisciplinary) according to its nature. In addition, the type of design research (e.g. research in design context, design inclusive research, or practice-driven design research) has also influence on the selection of the phenomenon for study (Horváth, 2008). Evidently, no phenomenon can be described with absolute exactness because of the infinite degree of precision of empirical reality and empirical methods.

The fuzzy process of unearthing research phenomena is intertwined with creating mental-models or conceptual 'schemas'. This process also involves creating a cognitive space for absorbing and accommodating new findings, and seeking for their meaning (to make sense of a phenomenon), often against subjective believes and fixations. These give floor to instrumentalism, i.e. to see research phenomena as instruments for generating new thoughts, knowledge, and means-end relations. In the instrumentalist view, instantiation of phenomena is seen as a result of operationalization of experience or imagination, without denying the role of chances. Pragmatism appends it with the view that research phenomena are best viewed in terms of their practical uses and impacts. It endorses phenomena based on how effectively they contribute to inquiry and understanding, as opposed to how accurately they describe the objective or imaginary reality.

We may conclude that phenomena are 'mental constructions' independently of having empirical or theoretical roots. Their inception is a matter of chance, while their formulation is a matter of knowledge and choice. Cognition, knowledge, learning, heuristics, curiosity, and associating play almost equal role in the process of inception. The chance has not only ontological and epistemological dependence, but also a subjective flavour for the reasons that researchers think in their own worldview (philosophical stance) and that they construct their own understanding and originate their curiosity according to their personal mental models, perceptive/cognitive experiences, and tasks at hand.

3 AN APPROACH OF SYSTEMATIC SPECIFICATION OF RESEARCH PHENOMENA

For the sake of this study, we abandon the commonsensical interpretation (according to which 'phenomenon is a certain type of event or process that regularly occurs under definite circumstances') and give preference to the interpretation of Bunge, (1979). According to him, a phenomenon can be anything that is observed to exist or happen, and is experienced as given. Evidently, it creates different inquiry situations if the phenomenon has been discovered and described/explained to some level before the start of the research, or if it is undiscovered and non-qualified. While in the context of research in exact sciences a phenomenon is something that needs to be explained (i.e. a potential explanandum) (Hacking, 1983), in design research a phenomenon may also be 'the something' that contains the explanation (i.e. a potential explanans). Putting the phenomenon into the explanandum position entails an external view, while putting it into the explanans position entails an internal view.

Let us take the phenomenon of rainbow as an example. In the explanandum position it means an optical illusion that can in certain circumstances be viewed by an observer on the part of the sky directly opposite the sun, but that cannot be physically approached as a particular object. Rainbow as a phenomenon in the explanans position means a spectrum of light appearing in the air as a multi-coloured arc due to reflection, dispersion, and refraction of sunlight on water droplets. The first view is about what the phenomenon manifests itself in, and the second view is about how the phenomenon manifests itself. These two views complement each other and none of them can be neglected or preferred to the other. This duality must be considered at developing a generic model of research phenomena. As explanandum, a phenomenon is a kernel of descriptive theories, while as explanans it is a kernel of explanatory theories.

In the process of model development, we need to demarcate: (i) simple phenomenon, (ii) composite phenomenon, and (iii) complicated phenomenon. A simple phenomenon does not lend itself to and does not need further reduction. A composite phenomenon can be decomposed into a finite set of interrelated phenomena that can be investigated on their own. A simple example of a composite phenomenon is falling of an object, hitting a desk, making sound, and causing a depression on the surface. These and similar constituent phenomena can be observed and measured individually. A complicated phenomenon is a composition of constituent phenomena that cannot be observed and measured individually due to their confounding nature. Though this type phenomenon occurs quite frequently in real life, explaining the essence of it is not as straightforward as that of a composite phenomenon. For the sake of explanation, take an example. Let us assume that two teams including different number of boys and girls play soccer with each other. In case the team including more girls wins, the simple phenomenon of sex difference in action and the phenomenon of competence of playing (which is taken as a simple phenomenon here) are confounding. Their effects and relationships cannot be demarcated. (This fact, by the way, implies confounding also in terms of the independent and dependent research variables).

It must be mentioned that the above-introduced notions of composite and complicated phenomenon are different than the notion of 'complex phenomenon' that is frequently mentioned in the literature. This latter term has been coined to refer to phenomena that are beyond the classic mono-disciplinary research problems. They are ill-defined and open-ended, multidimensional, ambiguous, and unstable, as Klein (2001) characterised them. We did not deal with modelling of complicated phenomena in our study. We concentrated on modelling simple and composite research phenomena (SRPs and CRPs). Below we introduce an abstract model of SRPs that is able to capture the commonalities in very diverse phenomena and lends itself to a systematic formalization and analysis. We presumed that logical (semantic) decomposition of a CRP to multiple SRPs happens before the compilation of the contents of the research model. We used so-called ‘observational terms’ (OTs) as a basis for the formal specification and representation. A term is observational if there are means of determining its extension, at least in part, that do not rest upon any axiom of any theory. OTs can specify both the static and the dynamic properties of a phenomenon. In fact, we used four sets of OTs in modelling. The proposed conceptual model is shown in Figure 2.

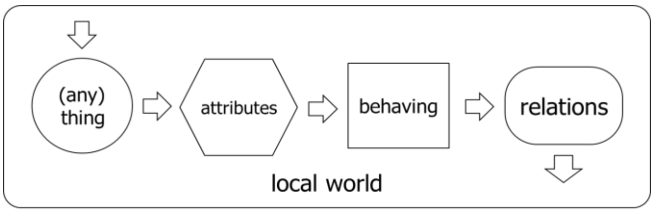

Figure 2. The proposed conceptual model of research phenomena

The initial assumption was that a phenomenon (Π) manifests itself in a local world (Ω). Referring to the above example of rainbow, the local world can be a region of a sky, the neighbourhoods of waterfalls, or the vicinity of spring fountains. There are four categories of OTs considered in the model: (i) (physical or imaginary) things {T}, (ii) (distinguishing) attributes {A}, (iii) (behavioural) effects {E}, and (contextualized) relations {R}. These all will be regarded as influential factors in the rest of the paper. Things are some animate or inanimate entities, natural or artefactual objects, or creatures of material or thought. It is accepted that they are not, and cannot be exhaustively described or precisely specified. Attributes are any essential qualities and quantities regarded as characteristics or features of things. Effects are discernible stereotype outcomes of the behaviours of the involved things under given circumstances. Together with the attributes, they are primary descriptors of the things manifest themselves. Finally, relations are significant associations between or among things as implications of the effects. Revisiting the example of the rainbow again, things are such as sun, light, water droplets,

air, observer, fountain, waterfall, secondary rainbow, etc. Attributes are such as airborne (water), discretized (water), shining (sunlight), sighted (observer), low altitude (viewing angle), clearness (sky), darkness (raining clouds), spectrum (colours), and order (colours). Effects are such as reflection, refraction, illumination, intensity change, and shape alteration. The most important relations are such as sunlight-rain, sun-observer, view angle-observer, primary arc-secondary arc, water droplet-refraction angle, and reflection depth-water droplet relationships.
With this reductionist approach, a research phenomenon can symbolically be specified as a five-tuple (Equation (1)):

$$\Pi = \{ \Omega, T, A, E, R \}, \quad (1)$$

where: T = (t1, … , ti, …, tK)T, A = (a1, … , aj, …, aL)T, E = (e1, … , ek, …, eM)T, R = (r1, … , rl, …, rN)T, and, in a general case; K ≠ L ≠ M ≠ N; and the last T indicates a transposed unordered vector of a particular set of observational terms. It is shown graphically in Figure 3. This diagram as a whole represents a conceptualization (C) of an imaginary composite phenomenon. The vertical blocks capture the observational terms belonging to the four categories. The bundles of polylines represent the semantic relations among them. The sub-bundles of solid, dashed and dotted polylines represent the conceptualizations of the constituent simple phenomena (C1, C2, C3), which add up the composite phenomenon at hand. Symbolically, C = C1 ∪ C2 ∪ C3, and the union of the constituent simple phenomena (Π1, Π2, Π3) is the composite phenomenon Π. In the case of a simple phenomenon, the cardinality of the vectors is equal with the pieces of knowledge that are deemed to be necessary and sufficient for providing a proper description. If there is no connecting line between certain OTs in the neighbouring vectors, then it means that they are semantically not related.

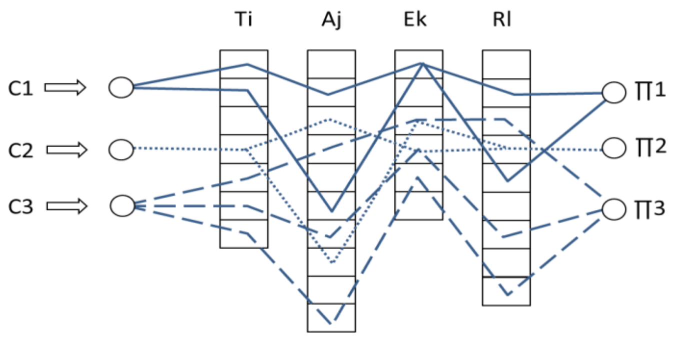

Figure 3. Conceptualization of simple phenomena constituting a composite phenomenon

There are three pivotal elements of the above presented approach: (i) systematic exploration of the target phenomena with a rigorous consideration of their compositeness and compositionality (the couplings of the constituting SRPs), (ii) critical analysis and combinative reallocation of the constituting SRPs, and (iii) breaking down the whole of the stated composite research phenomenon into simple phenomenon (in multiple steps, if applies). Considering these pivotal elements we named this approach as Systematic Combinative Breakdown Method and referred to it as the SCB-method. By means of identification and systematic combination of the various OTs, different conceptualizations of the SRPs constituting a studied composite phenomenon can be created. In the practice it means creating logical couplings between the subsets of semantically related entities within the vectors of things, attributes, effects, and relations. The proposed modelling makes it possible to capture all constituting phenomena in the case of a composite phenomenon, and to characterize them as compositions of the abovementioned OTs. In the case of a simple phenomenon, it enables identification of subordinate phenomena, if exist.
Composite, constituent and subordinate phenomena can be regarded as black-boxes at the beginning of the study. For specific investigation, the conceptualizations should be transferred into research constructs with the help of working research questions and hypotheses. In the practice it means that every OT should be transferred either to indicators, and then the relevant indicators should be expressed in terms of specific research variables, or directly to research variables and their logical relationships. The input variables (influences) and the output variables (implications) are to be specified for the research constructs, as well as the input-output correlations and cause-and-effect relations. The above specification of the conceptualization of simple phenomena provides sufficient basic information for

defining research constructs. This way the SCB-method also guides the development of research designs.

4 A DEMONSTRATIVE EXAMPLE FOR APPLICATION OF THE PROPOSED METHOD

In order to demonstrate the practical application of the SCB-method to analyse composite and simple phenomenon, let us take a fictitious example (which is actually underpinned by a real life research project). A new PhD student started at a university department and was required to make his own decision on the subject of his research project. His background was industrial design engineering, but he was also interested and somewhat trained in cognitive psychology. He expressed a strong intention to combine academic research with conceptualization of a novel product. His interest laid in safety of personal transportation, in particular in the development of ubiquitous assistive solutions for vehicle drivers. He had actually read a lot about this field of interest, and became aware of the fact that 'assistance based on perception' is a kind of modern trend in the development of driver assisting systems.

He has conducted forerunning inquiries in the form of studying topic related professional and academic publications and talking with driving instructors and technicians. These unfocussed knowledge aggregation actions enabled him to build a mental model of this domain of interest. He also formed a vision of what would be needed and where the largest knowledge gaps were. He learnt that not only foveal vision, but also peripheral vision could be involved in generation of perceptive sensations and might be exploited in increasing the awareness of drivers and the safety of car driving. In the end, he found the idea of using peripheral vision in driver assistance as the most interesting and challenging for him, and soon developed a kind of attachment to this topic. This also defined his local world for the further investigation.

Having similar interests, his daily supervisor and promotor were very pleased with the idea of doing research in the field of peripheral vision-based driver assistance, as well as with the idea of developing a first testable prototype of a possible system in the framework of the research project. The mentors advised him two things. First, they encourage him to continue aggregating knowledge on the current state of the art and the pioneering efforts and suggested to complete a systematic keyword-based web search. Second, the mentors informed him about their worry concerning the extreme large scope and possible multi foci of the chosen research topic (peripheral vision-based driver assistance). They advised him to find a manageable scope and focus for the four-year research project. They remind the PhD student to the challenges of dealing with the fuzzy front end of the research project and advised him to follow a systematic, rather just an intuitive approach. They advised to use the SCB-method to conduct a deep-going and critical analysis of the tentatively formulated research phenomena in order to find the necessary and sufficient scope and focus. Having finished the keyword-based literature search and analysis, the student concluded that the initial formulation of the subject of study was indeed too broad. The research problems (knowledge gaps) related to the overall phenomenon of peripheral vision-based driver assistance are multiple and challenging. Therefore, he considered it as a composite research phenomenon and tried to decompose it with the SCB-method to end up with a limited set of simple research phenomena to choose from. Peripheral vision (PV) is in itself a complicated matter (Mäkelä et al. 2001). As a perceptive capability and asset, PV is a part of the human vision system and complements foveal vision (Lou et al. 2012). It occurs outside the very centre of gaze, and it includes a very broad set of (non-central) points in the field of view. The range of PV is typically defined as far PV (viewing angle from ~60o to ~110o), mid PV (from ~30o to ~60o), and near PV (from ~10o to ~30o). The PV of animals has been found to be much stronger than that of humans, in particular at recognizing change and motion and at distinguishing shapes and colours. Biophysically, the difference of strength of distinguishing can be explained by the fact that the density of receptor cells at the edges of the retina is smaller than at its centre.

Peripheral vision has been put into many research and application contexts. It was investigated if PV can compensate for the loss of the foveal vision, but the study was concluded with a negative result (Henderson et al. 1997). Strasburger et al. (2011) summarized the various strands of research in form perception by PV. Tynan and Sekuler (1982) investigated the mechanisms of processing motions in PV. Peripheral vision was also studied in the context of persons with dyslexia by Geiger and Lettvin (1987). There was research done in the context of scene recognition with the objective to determine how scene qualities depend on the size of viewing field (Thibaut et al. 2014). Several studies identified the need from some sensory and informing capability concerning correct identification of objects in the field of vision in various situations, e.g. detecting road side advertisements while driving, recognizing risk while using the phone during cycling. Frisén (1987) investigated the detection of high-pass spatial frequency filtered test targets generated by computer graphics. Webster et al. (2010) showed that perception of colours in PV is almost the same as that in the central vision. Lou et al. (2012) made several object recognition tests in the field of PV in order to study the influence of the object's colour, pattern and shape. Noorlander et al. (1983) examined sensitivity to colour contrast and target sizes at several retinal locations in the PV, and studied whether the peripheral retina is red-green blind or yellow-blue blind. Sex-related differences in colour vision in the peripheral retina were studied by Murray et al. (2012), focussing on hue and saturation. Huang et al. (2012) conducted experiments to learn what and how influences the search time needed by the eyes to find what we were looking for using peripheral vision. The above findings underlined that PV is indeed a composite phenomenon that involves many things, attributes, effects, and relationships, with some flavour of a complicated phenomenon. Therefore, the PhD student tried to mitigate the complexity by decomposing the composite phenomenon according to the principles suggested by the SCB-method. He constructed the matrix of the OTs considering and using the major findings of the web search (Figure 4). He also constructed the connectivity diagrams to see what kind of regular and confounding relations do exist. Below we show three examples for possible conceptualizations of some constituting simple phenomena what he made based on the observational terms included in the OT matrix of peripheral vision as a composite phenomenon.

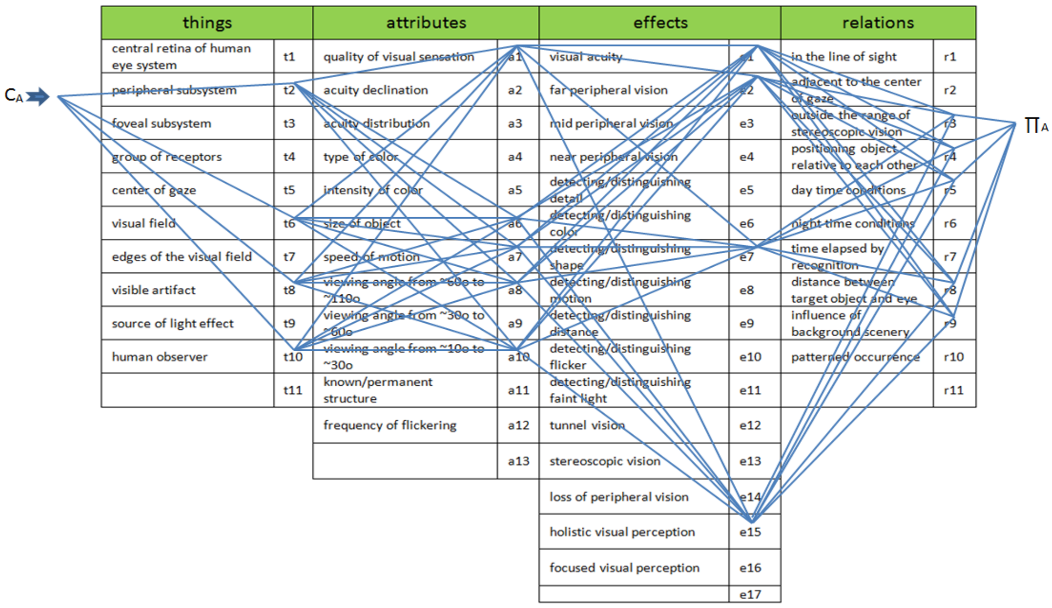

Figure 4. Matrix of the observational terms and an example of a connectivity diagram in case of peripheral vision as a composite phenomenon

Conceptualization A: $\Pi_A = \{ (t_2, t_6, t_8, t_{10}) (a_1, a_6, a_7, a_8, a_{10}) (e_1, e_2, e_7, e_{15}) (r_3, r_4, r_5, r_8, r_9) \}$

Interpretation: Dependence of far peripheral vision enabled recognition of distantly spaced large sized objects appearing within a given distance zone for the observer moving with a given speed day time.

Research context: Investigation with the intent of facilitating an optimal detection of road-side advertisement boards by their proper placement in the peripheral vision of highway vehicle chauffeurs driving with the limit speed on highways.

In the case of Conceptualization A, the connectivity diagram of the OTs is shown graphically as a network in Figure 4. However, for the reason of visibility, the connectivity graphs of the two other conceptualizations, and that of large number of other possible conceptualizations, are not shown. They can be regenerated easily based on the symbolic expressions provided below. The presented connectivity graph indicates that the simple phenomenon specified by conceptualization A is actually only a quasi-simple one. Its connectivity measure is CM = | T | x | A | x | E | x | R | = 4 x 5 x 4 x 5 = 400 (meaning that theoretically 400 relationships may need to be investigated among the minimally 18 research variables representing the chosen OTs).

Conceptualization B: $\Pi_B = \{ (t_2, t_6, t_9, t_{10}) (a_1, a_4, a_5, a_6, a_9, a_{12}) (e_3, e_6, e_7, e_{10}, e_{11}) (r_3, r_7, r_8, r_9) \}$

Interpretation: Detection of a visible light effect occurring at a given distance from human eye by mid peripheral vision while driving during night time.

Research context: Providing knowledge to support the development of an internal indicator solution placed in the A-frame of personal cars in order to prepare the driver for turning onto highway exits or side roads in urban area during the night.

Conceptualization C: $\Pi_C = \{ (t_2, t_7, t_8, t_{10}) (a_1, a_4, a_5, a_6, a_7, a_8, a_{12}) (e_1, e_2, e_5, e_5, e_6, e_7, e_8, e_9, e_{10}, e_{11}) (r_3, r_5, r_7, r_8, r_9) \}$

Interpretation: Recognition of objects based on various attributes by far peripheral vision in different daily circumstances.

Research context: Development a toy for children to improve their peripheral vision capabilities to support thread recognition when involved in daily routine activities such as driving, cycling, chess playing, navigating, etc.

5 SOME REFLECTIONS AND FUTURE RESEARCH OPPORTUNITY

It must be emphasized that the related literature seems to be split concerning the prevailing or demanded observability of phenomena. The starting point is that many phenomena remain unobserved even if the natural sensory apparatus is extended with sophisticated instrumentation. According to Massimi (2007), unobservable phenomena can be pseudo-unobservable or not-at-all observable. Evidence for perceptually not-at-all observable phenomena comes from data that have been selected and organized into a data model (Glymour, 2000). Bogen and Woodward (1988) argued that phenomena have to be inferred from data, and that data provide evidence for the existence of phenomena. From an empiricist perspective, observable phenomena are those, which human beings are able to sense and recognize by the natural sensory apparatus. Weick (1989) claimed that recognition of phenomena in real life is often also associated with and is the result of informed commonsensical and/or critical reasoning. Various efforts were made to quantify complexity of phenomena, but the proposed measures do not inform about the decomposability of a complex phenomenon.

Our claim is that design researchers should consider both naturally existing and artificially created phenomena. Independent from this, they need to develop their research model and detailed work plan, and should start out with scoping the overall (composite) research phenomena and derive one distinct research phenomenon for each research cycle. We discussed that choosing phenomena for investigation and the interpretation of phenomena are influenced by many factors. We argued that researchers should not only identify, but also adequately scope the research phenomenon in the fuzzy front end. The phenomenon may originate in a disciplinary theory, the practical world of affairs, a personal experience, or professional insight. It may be perceived to represent an unsatisfying circumstance, a promising opportunity, a breakdown or anomaly in expected arrangements, or simply a topic of interest. The proposed categorization of phenomenon respects the fact that no phenomenon can be taken to be independent of other phenomena because they always exist in relation with each other and produced through a process of mutual constitution. The proposed SCB-method gives floor to so-called ‘phenomenon-driven research'. It is a problem-oriented method that focuses on capturing, conceptualizing, structuring, and documenting phenomena in order to facilitate progression of the research and knowledge creation process. Future research intends to address the issues of complicated research phenomenon and obtaining more information about the impact of the SCB-method in various practical applications.

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