Gaining User Experience Patterns by Drawing from Science and Industry

A Combinatory Pattern Approach

Alexander G. Mirnig, Alexander Meschtscherjakov, Nicole Perterer, Alina Krischkowsky,
Daniela Wurhofer, Elke Beck, Arno Laminger, Manfred Tscheligi
Christian Doppler Laboratory for "Contextual Interfaces"
Center for Human-Computer Interaction, University of Salzburg
Salzburg, Austria
{firstname.lastname}@sbg.ac.at

Abstract— **Findings from scientific disciplines with close ties to the industry – such as Human-Computer Interaction – can be useful for advancing both the scientific discipline itself as well as the associated industry. It is, therefore, an additional challenge to consolidate and convert the scientific knowledge gained into a format of which is applicable and understandable in practice in order to provide meaningful and usable tools for practitioners in their daily work routines. We used patterns to combine research results and industry know-how into solutions for distraction-related design problems in the automotive domain. In this paper, we present our pattern generation process that resulted in the creation of 16 patterns with input from scientists, as well as industrial stakeholders, in several key phases. Thereby, we discuss the advantages of patterns as a means to put scientific knowledge into practice. The contribution of this paper is a pattern generation and validation process, together with an accompanying pattern structure tailored towards combining scientific results and industry knowledge that resulted from this process.**

Kewords-basics on patterns; design patterns; pattern identification and extraction; validate patterns.

I. INTRODUCTION

This paper is an extension of a full paper presented at PATTERNS 2015 [1]. Patterns are a method to capture proven design solutions to reoccurring problems. They are a structured description of best practices and, as such, highly problem-oriented and reusable [2]. The use of patterns in design can improve the design process (regarding both time and effort spent) to a considerable degree [3][4][5]. Patterns are also a recognized way of facilitating communication between different stakeholders. Since scientific research in Human-Computer Interaction (HCI) is closely interconnected with the industry, patterns could serve as a tool to communicate scientifically proven solutions to industry stakeholders. In our work, we aimed at generating patterns for HCI researchers and industry stakeholders based on scientific findings and transform them – by directly involving industry practitioners – into solutions that are relevant for and usable by these stakeholders. The underlying research questions are (1) how scientific findings may be translated into design patterns usable for practitioners in their daily routines, and (2) how such patterns may be generated by including scientific and industry stakeholders.

The outcome of our efforts was a pattern structure that incorporates scientific results and fits industry stakeholder needs, as well as a first set of 16 automotive User Experience (UX) design patterns. We refer to UX design patterns as patterns that tackle User Experience issues in their core.

In this paper, we present the final pattern structure, as well as the phases of the pattern generation process involving both scientists and industry stakeholders (We use the term 'generation' to delineate our approach from pattern finding methods, which usually focus only on actual implementations, and not theoretical or scientific works). Furthermore, we critically reflect upon issues and problems that emerged throughout our proposed pattern generation process itself, but also about the cooperative process on generating the patterns between scientific and industry stakeholders. In this paper, we begin with an overview of current pattern literature in Section II. In Section III, we describe our pattern finding process via the concrete pattern structure example and its development. In Section IV, we provide a summary of the overall process, together with a brief discussion on the limitations and potentials of our approach.

II. RELATED WORK

In order to provide best practices and specific knowledge, the patterns approach has been well established in the domain of HCI [1]. Recently, specific domains in HCI, such as UX research, also deployed patterns to collect and structure their knowledge [4][5].

Köhne [7] (based on Quibeldey-Cirkel [8]) outlines specific steps for generating patterns. The process starts with discovering patterns, so-called *pattern mining*, by identifying whether a solution is valuable to solve a problem. The next step consists of *pattern writing*, where the problem solution is described in a defined structure. This is followed by *shepherding,* in which an expert provides support in improving the patterns content. Thereafter, a *writers workshop* is conducted. In such a workshop, a group of pattern authors discuss a pattern. Based on the feedback from the writers' workshop, the pattern author revises the pattern (*author review*). In a next step, the patterns are made public in a *pattern repository*, which is open to *anonymous peer review*. Finally, the pattern collection is published in a *pattern book* making the final patterns available for a wide readership.

Similarly, Biel et al. [9] split the process of defining trust patterns for interaction design into four subtasks. The first task is *identifying a pattern* by analyzing the solutions used by designers. Second, the *pattern gets categorized* in order to make it reusable and accessible for designers. Third, the *pattern is described* following a specific structure. The fourth task is *evaluating the pattern* to prove its quality before it is introduced to a pattern library.

Aside from starting the pattern mining from designers' practical knowledge, patterns can also be harvested from scientific research findings. Martin et al. [10] use patterns to describe findings from ethnographies. For creating their patterns, they started by looking for specific examples in a particular domain in ethnographic studies and then tried to expand the observed phenomena to other domains (similar but different examples). Krischkowsky et al. [11] introduce a step-by-step guidance for HCI researchers for generating patterns from HCI study insights. According to them, the first step is giving novice and expert HCI researchers a *brief overview on the concept of patterns* and, more specifically, Contextual User Experience (CUX) patterns [5] (i.e., patterns to enhance user experience in a particular context). After this, the next step of the guidance concerns the *reflection and selection of relevant UX related results* from empirical studies conducted by the researchers. In a third step, HCI researchers *develop their own CUX patterns*, which are then internally *evaluated by researchers* following a checklist. In the last step, the researchers give *feedback on the pattern generation process*.

Following a user centered patterns generation approach, we aimed at including industry designers within a specific domain (in our case automotive user interface design) in the patterns generation process. This was done in order to bring the target group into the loop as early as possible and to avoid the error of not including industry stakeholders in the pattern finding process. In the following section, we outline and reflect on our pattern generation method. Further, we describe a seven-step approach that describes how we generated an initial set of automotive UX patterns from a scientific knowledge transfer workshop (step 1) to final pattern iteration (step 7). Based on a reflection of our work, we conclude with a novel patterns generation approach consisting of five phases. In addition, this paper presents an according pattern structure for distraction-related design problems in the automotive domain. Both, the patterns generation approach as well as the pattern structure for automotive UX patterns, are the main contributions of this paper.

III. THE PATTERN GENERATION PROCESS

Within our research activities, the need for pattern guidance occurred within a national project focusing on contextual interface research in the automotive domain. In particular, the following section outlines the process of how we developed a pattern structure that provides insights, information, and guidance on how to design for a positive User Experience (UX) for the driver. This general aim was divided into several more specific goals related to distinct UX factors (e.g., *workload*, *fun*, or *trust*). As the focus of our work was on the pattern generation process and the pattern structure, we decided to select one specific UX factor and improve the process and the structure by developing patterns for this factor. We chose to generate patterns for reducing workload that is caused by distraction, as this constitutes one of the most prevailing and severe problems in the automotive domain. In the next paragraphs, we outline each phase in the generation process in detail, reflecting on each step individually.

A. Starting from scientific knowledge

In this first phase, we started from pure scientific knowledge about distraction-related design problems in the automotive domain to create an initial draft set of patterns. This seemed like a logical first step, since we wanted to go from the science to the practice. As we would learn later on, however, a slightly different approach would have been even better. This will be reflected in the discussion section. The first phase can be segmented into four sub-steps, outlined in the following sections.

B. Scientific knowledge transfer workshop

Within the first step, a knowledge transfer workshop, organized by pattern experts and HCI researchers in the automotive domain, was conducted. Hereby, the main goal was to give experts in the automotive domain know-how on pattern generation. This know-how was provided by HCI pattern experts, in order to facilitate the development of an initial draft of patterns. The workshop lasted approximately four hours. Overall, six HCI researchers, all closely familiar with the automotive context, and two HCI pattern experts, who led the workshop, participated in this workshop.

In this initial knowledge transfer session, participants were introduced to patterns in general and the role of patterns in HCI in particular. We used the pattern definition of Cooper et al. [12]. In their definition, the authors define patterns as *'(Design) patterns capture useful design solutions and generalize these solutions to address similar problems.* We also included aspects such as the usefulness of patterns as a tool for documentation, collection, communication, and representing knowledge [1]. The participants were also introduced into the differences between patterns and guidelines. It was important for us that the participants understood the particular differences to guidelines, which are in contrast very short and concise, whereas patterns are supposed to be structured, have a well-defined context, and often provide several solutions to one problem.

After that, example patterns from other domains were presented (e.g., [13], [14], [15]). Subsequently, participants where shown the main goals for the development of patterns in the automotive domain (e.g., collect a number of UX related patterns, structured guidance on how to design for a good UX regarding advanced in-car systems). Thereafter, a presentation of the initial pattern structure was given, based on the CUX patterns approach [5]. This approach has already proven its value for collecting and structuring knowledge on UX [4]. The CUX pattern approach was chosen, as it explicitly considers the relation of UX and contextual aspects. In order to provide a better understanding of the CUX pattern approach, an exemplary CUX pattern reflecting on *increased workload by font size* was shown to the participants. At the end of the workshop, participants were introduced to the entire, initially defined, pattern structure for UX patterns in the automotive domain (see Table I, not-underlined parts).

C. An initial set of patterns

After the workshop, the HCI researchers (and pattern experts) received the task to create two patterns each within the following 10 days based on literature, e.g., state of the art knowledge, desktop research of empirical studies, existing structured knowledge (guidelines, norms, heuristics), and/or their own research activities. They received a template with the pattern structure as a guideline for creating a first set of patterns related to a car driver's workload caused by distraction. Furthermore, the HCI researchers were also encouraged to give individual feedback to the pattern experts about issues and problems concerning the generation process, as well as the suggested structure (i.e., CUX pattern structure template). More details about the identified issues and problems are outlined in the next section.

Within this first generation phase, 16 patterns focusing on workload caused by distraction were developed (i.e., two patterns per person). All patterns were derived on the basis of scientific literature (e.g., research articles or book chapters referenced in the pattern). Also, two pattern experts were involved in this process and generated two patterns each. The generated patterns (an example is shown in Figure 1) were each about one page long and exclusively dealt with design solutions (e.g., voice interaction, interface multimodality, gesture input, or information presentations) addressing the problem of increased workload due to distraction. At this point, they were still lacking in detail, especially regarding solutions and examples.

D. First iteration based on participants feedback: and a refined pattern structure

The first round of pattern generation led to the identification of several issues with the initial pattern structure. During creating their patterns, the HCI researchers listed and forwarded encountered problems to the pattern experts. In a second workshop, the HCI researchers discussed their experiences with the provided pattern structure and the pattern creation process (i.e., reflect the different ways to generate patterns) with the pattern experts and collected further problematic issues. The pattern experts then used the feedback for improving the pattern section structure and the related instruction for how to generate patterns based on the provided structure.

The refined pattern structure, as the outcome of the third step, is presented in Table I. Changes to the section name and instruction are marked with an underline; parts not underlined are those from steps 1 and 2. The proposed pattern structure consists of nine parts: *name* (a description of the solution of the pattern), *UX factor* (the addressed automotive user experience factor), *problem statement* (a very short description of the problem that should be solved by the pattern), *forces* (a more detailed explanation of the problem), *context* (the application context of the pattern), *solution* (the proposed solution of the particular pattern), *examples* (concrete examples of best practices), *keywords* (phrases related to the pattern), and *sources* (origin of the pattern).

Most of the issues brought forward were concerned with what makes the pattern a high-quality pattern and what supports the comprehensibility of the pattern. More specifically, the HCI researchers had difficulties with *achieving the aim of a pattern to provide best practices*. The HCI researchers experienced it as challenging to judge whether the provided solutions are the "gold standard". They also felt uneasy about whether "old" literature can serve as basis for pattern creation. Thus, it would be more realistic to speak of providing existing knowledge to the best of one's judgment, i.e., preferably using the newest knowledge for underpinning a specific pattern and using as many potential evidences (studies, norms, etc.) as possible. Our patterns suggest solutions for specific UX demands in the car area based on existing knowledge (e.g., studies, best practices).

TABLE I. INITIAL AND REFINED PATTERN STRUCTURE (ITERATION CHANGES UNDERLINED)

Instructions on Each Pattern Section		
#	***Section Name***	***Instruction on Each Section***
1	Name	*The name of the pattern should shortly describe <u>the solution</u> suggested by the pattern (2-3 words would be best).*
2	UX Factor	*List the UX factor(s) addressed by the pattern <u>(underpinned with a definition)</u>*
3	<u>Problem Statement</u>	*As short as possible - the best would be to describe the <u>problem</u> in one sentence.*
4	Forces	*Should be a detailed description and further explanation of the <u>problem</u>.*
5	Context	*<u>In general, our patterns should focus on the driver.</u> Describe the detailed context in which <u>the pattern can be applied in this section.</u>*
6	<u>Solution</u>	*1) Can range from rather general suggestions to very concrete suggestions for a specific application area <u>(e.g., " Presenting High-Priority Warnings")</u>. 2) <u>A successful solution is</u> based on existing knowledge (e.g., state of the art solutions, empirical studies, guidelines, etc.). 3) More than one <u>solution</u> is no problem but even better than only one. 4) There can also be a general <u>solution</u> and more specific "sub-<u>solutions</u>".*
7	<u>Examples</u>	*Concrete examples underpinned by pictures, standard values <u>(e.g., angle, size)</u> etc. Examples should not provide a <u>solution</u> (this is done in the <u>solution</u> part) but rather underpin and visualize the <u>solution</u> presented above.*
8	Keywords	*Describe main topics addressed by the pattern in order to enable structured search.*
9	Sources	*Origin of the pattern <u>(cf. the different ways to generate patterns)</u>*

System-initiative dialog strategy

UX factor:

Workload caused by distraction

Problem:

The problems of driver information systems with a voice user interface, which require user-initiative, are the steep learning curve and the high demand on memory to recall the correct voice commands.

Forces:

In contrast to many telephone applications where the caller can use his full concentration on the task of communicating with the system, the primary task in the car is driving. So, one of the main requirements for driver information system with dialog strategy in the vehicle is to distract as little as possible.
Most of the users come up against the driver information system without previous training. Thus, if the dialog system is not to be disregarded, it is absolutely vital that it can be used intuitively with a gentle learning curve.
Even experienced users might have problems with the system when they are using it in situations requiring high levels of concentration for the traffic. (Ackermann & Libossek 2006)

Context:

A system-initiative driver information system with dialog strategy is suitable for users who don't know the functionality and the limitations of the system, and who have no other means of finding out how to use it than to make a lot of mistakes and try to learn from whatever error messages they get. Whereas users who know the system by heart, and know exactly what to say, so they can skip any lengthy explanations, and detours through supermenus, will probably prefer a user-initiative dialog strategy. (Ackermann & Libossek 2006)

Solution:

Provide a driver information system which is built as command-and-control, but the strategy is system-initated, as the speech output of the system consists (mainly) of questions illiciting replies. This is done by presenting the most probable options to the user. (Ackermann & Libossek 2006)

Examples:

One example is the prompt when the user enters the navigation menu. Here he would be presented with three options "enter destination", "city" and "street" as possible input commands: "To enter a destination please say enter destination. If your destination is in Germany say city, if your destination is in Munich, say street."
(Ackermann & Libossek 2006)

Key Words:

Driver information system, system-initiative, dialogue strategy, questions, mental workload

Sources:

Ackermann, C. and Libossek, M. 2006. System-versus User-Initiative Dialog Strategy for Driver Information Systems. In: Proc. of Ninth International Conference on Spoken Language Processing, Pittsburgh, PA, USA, September 17-21, 2006, p. 457-460.

Figure 1. Example of an early pattern

Another difficulty is related to *deciding on the abstraction level of a pattern.* The HCI researchers were unsure whether they should create very general patterns (global patterns) versus very specific patterns (sub-patterns, local patterns). They finally agreed on providing patterns that are abstract enough to make generalizations, while providing practical solutions at the same time, i.e., focus on the lower level with potential for higher level expansion. Thus, both elements (i.e., generalization as well as a concrete example) should be provided.

Identifying the stakeholders of the patterns was also an issue. Initially, it was unclear to the HCI researchers whom they should address with the patterns; whether the future users of the created patterns are designers (expert or novice), domain-specific users (e.g., industrial manufacturers), researchers, or developers.

The HCI researchers also experienced difficulties in *creating a pattern name;* should the pattern name be formulated as a solution or as a problem? It was eventually decided to opt for a solution orientation of the pattern name and modified the pattern instruction accordingly. Moreover, *using technical terms in the pattern name* sometimes lead to comprehensibility problems among the HCI researchers. A pattern needs to be easy to understand and quickly assessed. Consequently, very specific technical terms should not be used in the pattern name and, if they occur in the description of the pattern, they need to be explained.

Furthermore, the first round of pattern generation revealed that the HCI researchers deployed *different ways to generate their patterns*, which are based on existing state of the art knowledge/experience in the field, on own empirical studies, on literature (desktop research of empirical studies), as well as on existing structured knowledge. For ease of use and consistency, the patterns should be as homogenous in style and structure as possible. Different methods of initial pattern mining might, in some cases, cause differences in the final patterns. In order to reflect this, the section on sources (#9) was expanded to also include ways to generate patterns, where appropriate.

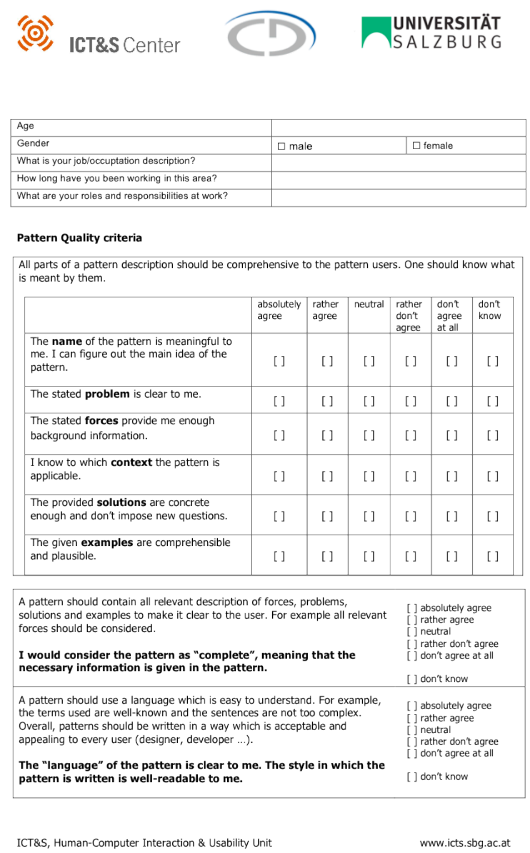
E. *Participants iterate patterns based on refined structure*

Finally, the HCI researchers' task was to iterate their initially created patterns based on the refined pattern structure. Each researcher received the detailed report from the previous workshop along with an action point list containing the necessary components (and level of detail) for the iterated patterns. Then, they converted the existing pattern they originally wrote into the new pattern structure. Parts were reformulated, where necessary, and other parts were added. After this iteration round, all patterns were reviewed by another HCI researcher for completeness and consistency. Where necessary, patterns were returned to the original authors with further instructions for revision. This process continued until the patterns were deemed complete and complying with the iterated structure by the reviewer.

F. *Industry stakeholder workshop on pattern structure evaluation*

Since the iteration and review process after the previous workshop had not involved any industry stakeholders, we felt the need for additional assessment by practitioners and industry stakeholders in order to further iterate and finalize the pattern structure. We involved the industry stakeholders in a workshop with the aim of evaluating the current pattern structure on the basis of two representative patterns.

1) Setup: The workshop was conducted at our facility with five participants (one female and four male) of our industrial partner from the automotive domain. The participants' age ranged from 20 to 45 years, job experience from 7 months to 20 years. Their professional background was software developers, engineers, and designers. After a 10-minute general introduction to patterns and our pattern structure, participants received printouts of one of our automotive UX patterns with the instruction to read through it attentively (duration: 10 minutes). After that, they had to fill in a questionnaire regarding the quality and understandability of the pattern (as seen in Figure 2). The questionnaire's general purpose was to assess how understandable, meaningful, and/or helpful the participants perceived the patterns presented to them. Items were measured on a 5-point Likert Scale; meaning 5 'do not agree at all' and 1 'absolutely agree'.



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Age		
Gender	☐ male	☐ female
What is your job/occupation description?		
How long have you been working in this area?		
What are your roles and responsibilities at work?		

Pattern Quality criteria

All parts of a pattern description should be comprehensive to the pattern users. One should know what is meant by them.

	absolutely agree	rather agree	neutral	rather don't agree	don't agree at all	don't know
The **name** of the pattern is meaningful to me. I can figure out the main idea of the pattern.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
The stated **problem** is clear to me.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
The stated **forces** provide me enough background information.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
I know to which **context** the pattern is applicable.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
The provided **solutions** are concrete enough and don't impose new questions.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
The given **examples** are comprehensible and plausible.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

A pattern should contain all relevant description of forces, problems, solutions and examples to make it clear to the user. For example all relevant forces should be considered. **I would consider the pattern as "complete", meaning that the necessary information is given in the pattern.**	[ ] absolutely agree [ ] rather agree [ ] neutral [ ] rather don't agree [ ] don't agree at all [ ] don't know
A pattern should use a language which is easy to understand. For example, the terms used are well-known and the sentences are not too complex. Overall, patterns should be written in a way which is acceptable and appealing to every user (designer, developer ...). **The "language" of the pattern is clear to me. The style in which the pattern is written is well-readable to me.**	[ ] absolutely agree [ ] rather agree [ ] neutral [ ] rather don't agree [ ] don't agree at all [ ] don't know

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Figure 2. Page 1 of the modified questionnaire (i.e., socio-demographic data, c_1, and two items of c_2)

The first part of the questionnaire collected general information about the workshop participants, such as age, gender, job/occupation description, length of professional experience, and roles and responsibilities at work. The second part focused on the pattern quality criteria framework, which we clustered into four main criteria c_1, c_2, c_3, and c_4. The first quality criterion (c_1) is an overall criterion that states that all parts of a pattern description should make sense to the pattern users. This implies they should have a meaningful name, a clear formulated problem statement, enough background information for the provided scenario, concrete solutions, and plausible examples. The second quality criterion (c_2) goes into more detail and addresses five aspects: (1) completeness, i.e., necessary information is given in the pattern; (2) clarity of the language, i.e., the style of the pattern is well-readable; (3) problem-centricity, i.e., the scenario, solutions, and examples are coherent and clearly related to the problem description; (4) good balance between concreteness and abstractness; and (5) helpfulness, i.e., the presented patterns support stakeholders to develop better interactive systems. The third criterion (c_3) requested a subjective overall assessment of the patterns regarding their applicability and usefulness. The fourth criterion (c4) applies, as opposed to c_1 to c_3, to the whole pattern collection and not to each individual pattern. It states that the whole collection of patterns captures *relevant knowledge* about User Experience and provides a *suitable common basis* for designers, developers, and researchers. Since the participants did not receive (and would not have had enough time anyway) the whole pattern collection, they were asked to imagine a collection of patterns qualitatively similar to the ones they were presented with and then provide their ratings.

Participants then received another pattern printout and were again given 10 minutes to read it thoroughly. This was done to ensure that the participants had a means of comparison and also to reduce bias regarding the quality (or the lack thereof) of the pattern structure based on only one pattern. After these preparations a discussion session (total duration: 1.5 hours), began. This moderated discussion was audio recorded and later transcribed for further analysis. During the course of the discussion, participants could voice concerns they had encountered when reading the individual patterns, together with suggestions for improvements to the pattern structure, as well as the existing automotive UX patterns in particular.

2) *Results:* We will now outline the most important outcomes of the workshop, in reference to the iterated structure shown in Table I.

The results of the quality criterion (c_1), rated on a scale from 1 (absolutely agree) to 5 (do not agree at all), show that the patterns had clear problem statements (M=4.00, SD=0.45) and provided concrete solutions (M=3.60, SD=0.55). Lowest mean values were identified in the quality criteria c_1 until c_4: i.e., for meaningfulness of the pattern name (c_1:M=2.8, SD=0.45), clarity of the context (c1: M=3.00, SD=0.00); clarity of the language used in the patterns (c_2: M=2.80, SD=0.45), and suitability of the pattern as a communication tool (c_4: M=2.80, SD=1.10).

As our data revealed from the discussion, participants were confused by the separation of *problem* and *forces*, stating that they did not understand why those were two separate categories and that they found the term 'forces' itself difficult to understand. Additionally, the participants were not entirely sure about the context and its relation to the rest of the pattern either. Especially in one pattern, they identified a rather confusing overall structure, in which the context referred to the forces, but the solution to the problem, which also tied into their confusion regarding forces.

One of the biggest complaints was that participants found that they had to read quite far into the patterns before they knew what the patterns were exactly about. The most prevalent criticism was the explanation of the UX-Factor (i.e., a definition), which was deemed as unnecessarily long and should have appeared at a later stage. According to the participants, such (for them) auxiliary information should not be excluded from the pattern, but appear at a less prominent position and in far less detail (one or two lines, the rest as a reference).

Generally, the participants desired an "abstract" for each pattern, containing scope, context, and possibly an outlook on the solution in a very compact format. To achieve this with the current pattern structure, the participants suggested more descriptive pattern names (e.g., in the case of pattern 1: mentioning the concrete modalities as well as ADAS in the pattern name itself) as well as an expanded and weighted keyword system, with anti-keywords (i.e., keywords the pattern is *not* related to) and reference-keywords (i.e., main keywords of related patterns). The patterns should also be re-structured, so that the most important information (at the very least: *name*, *keywords*, and *problem*) is at the very beginning of the pattern. Or, as one participant put it, "*If using a pattern collection is more cumbersome than using Google and produces lesser results, then there is little reason to use that pattern collection.*"

Another interesting point that was raised during the discussion concerned examples and their visualizations: The participants considered images of actual devices as unsuitable and thought them to resemble an advertisement more than a mere illustration ("Use this device and all your problems will be solved!"). It is important to capture the essence of a pattern without too much distracting details. For pattern 2, that essence was not considered to be the actual steering wheel, but the viewing angle. An illustration of said viewing angle (side view of the driver with lines indicating viewing angle) might therefore have been appropriate in this case. The participants did not reach a consensus on whether depicting an actual implementation could be acceptable in some cases, but they expressed a general preference for graphs, schematic illustrations, and similar visualizations.

The writing style and vocabulary used in both patterns was perceived as very unusual by the participants and more "scientific" than what they were used to. More specifically, they were not used to citing sources for every claim and the rather high number of technical terms used in each pattern. While they found the scientific writing style to be an overall pleasing quality that should be kept, they suggested a minimal citation style (numbers only, full references only at the very end of the pattern collection). The issues identified in the workshop were then further discussed and transformed into concrete instructions for another pattern structure overhaul.

Assuming that patterns evolve and grow more numerous over time, the participants also considered it necessary to know, when patterns become obsolete or what to do if there were several patterns giving conflicting solutions for the same problem. According to the participants, each pattern should have a time stamp, which shows when the pattern was created. Since that information alone is not enough to know, whether a pattern has actually been superseded by another or is simply a very old pattern, an additional label for obsolete patterns should be contained somewhere in the pattern. To help users decide on which pattern might be more appropriate for their problem, a rating system for each pattern could be implemented. However, the participants were skeptical of employing a simple rating system (e.g., 1 to 5 stars), since the meaning of a certain rating would be left ambiguous (Is the pattern simply well-written? Does the solution work well?). Full comments might be more useful, but supplementing ratings with user comments users could also require administration and editing of said comments – resources that might not be available in many cases.

3) *Summary:* It can be summarized that the pattern workshop showed some very interesting discrepancies between the general intentions of the CUX pattern structure and practitioners' needs and preferences. The participants expressed a need for more brevity, which would be more fitting for traditional guidelines, while at the same time desiring an example- and solution-oriented pattern structure and approach. The patterns generated a rather positive resonance overall and were generally seen as a valuable supplement to existing work practices. We were able to collect a good number of valuable suggestions for improvement as mentioned before, which would help to increase the quality of the existing pattern set and any future patterns generated within the project.

G. Final pattern structure iteration

Based on the feedback gained from this workshop, the pattern structure underwent a final iteration, which would then become the basis for all further patterns (see Table II). Similar to the pattern structure shown in Table I, the final pattern structure consists of nine elements. Like before, the *name* of the pattern should focus on the provided solution. The *intent* should include the main category of the pattern, a short problem statement, and briefly outline the context in which the pattern should be used. It replaces the problem statement (3) and the context (6) of the initial structure presented in Table I. The new element *topics* is a structured list of keywords describing the problem scope. The element *problem* replaced the forces (4) section. The new element *scenario* gives a detailed description of the problem in a scenario like style. The *solution* section describes the solution to the problem. Within the final structure, we provide a structured approach for how to present the solution. *Examples*, as before, should show best practices of the pattern. *Keywords*, again, should aid with finding related patterns. Finally, *sources* link to the origin of the pattern. The element "UX factor" (2) from the initial pattern structure was omitted at all. The new structure focuses on informing the reader as concisely as possible about whether the pattern is relevant for them. *Name*, *intent*, and *topics* are standardized and kept brief so that only a minimal amount of time is needed to read and process them. *Context* and *forces* are combined into the new Scenario-category, since the stakeholders had a hard time differentiating between them and found the distinction to be inconsequential in practice.

TABLE II. FINAL PATTERN STRUCTURE

Instructions on Each Pattern Section		
#	***Section Name***	***Instruction on Each Section***
1	Name	*The name of the pattern should shortly describe the solution suggested by the pattern (2-3 words would be best).*
2	Intent	*Short statement in three parts:* *a) Main category of pattern (e.g., visual information presentation)* *b) Short issue/problem statement (e.g., effective display position)* *c) Short context preview (e.g., while driving)*
3	Topics	*Max. 8 Keywords describing problem scope: 1) who is affected (driver, co-driver, etc); 2) which modalities are addressed (visual, haptic, acoustic)*
4	Problem	*Should be a detailed description and further explanation of the problem.*
5	Scenario	*Provide a detailed example of a case, in which the problem occurs*
6	Solution	• *First, provide a general (either high level or one that is applicable in the most cases) solution.* • *Then provide alternative solutions, together with delineating criteria to determine, when such alternative solutions apply.* • *Whenever possible, reuse (modified) figures, illustrations, etc. from other patterns, for a more consistent style and easier combination of pattern solutions.* • *A successful solution is based on existing knowledge (e.g., state of the art solutions, empirical studies, guidelines, etc).* • *More than one solution is no problem but even better than only one.*
7	*Examples*	*Concrete examples underpinned by pictures, standard values (e.g., angle, size) etc. Examples should not provide a solution (this is done in the solution part) but rather underpin and visualize the solution presented above.*
8	Keywords	*Describe main topics addressed by the pattern and related patterns in order to enable structured search.*
9	Sources	*Origin of the pattern, related literature, related patterns (if they are not part of the same pattern collection), norms and guidelines, other references. Citations format: Numbers and endnotes, to distract the reader as little as possible.*

Pattern 7: Intuitively used voice user interface

Intent:
This pattern is about a system-initiated, question-based approach to reduce distraction by voice user interfaces of driver information systems while driving.

Topics:
Workload caused by distraction, driver, acoustic, input/output

Problem:
The problems of driver information systems with a voice user interface, which require user-initiative, are the steep learning curve and the high demand on memory to recall the correct voice commands. This can lead to elevated mental workload while driving.

Scenario:
A system-initiative driver information system with dialog strategy is suitable for users who don't know the functionality and the limitations of the system, and who have no other means of finding out how to use it than to make a lot of mistakes and try to learn from whatever error messages they get. Whereas users who know the system by heart, and know exactly what to say, so they can skip any lengthy explanations, and detours through supermenus, will probably prefer a user-initiative dialog strategy (Ackermann & Libossek [16]).
In contrast to many telephone applications where the caller can use his full concentration on the task of communicating with the system, the primary task in the car is driving. So, one of the main requirements for driver information system with dialog strategy in the vehicle is to distract as little as possible.

Solution:
Most of the users come up against the driver information system without previous training. Thus, if the dialog system is not to be disregarded, it is absolutely vital that it can be used intuitively with a gentle learning curve. Even experienced users might have problems with the system when they are using it in situations requiring high levels of concentration for the traffic.
The solution is to provide a driver information system which is built as command-and-control, but the strategy is system-initiated, as the speech output of the system consists (mainly) of questions illiciting replies. [16]
This is done by presenting the options (e.g., FM menu, AM menu, CD menu in the example dialogue, see Figure below) to the user (Hassel and Hagen [17]).

Examples:
One example is the prompt when the user enters the navigation menu. Here he would be presented with three options "enter destination", "city" and "street" as possible input commands: "To enter a destination please say enter destination. If your destination is in Germany say city, if your destination is in Munich, say street." [16]
Another example is given by Hassel and Hagen [17]. Their speech interfaces were implemented as part of BMW's iDrive system. Over the speech channel, users can operate functions in the areas entertainment, communication and navigation. Users activate the speech recognizer with a push-to-talk (PTT) button on the steering wheel or in the middle console near the controller. The dialogue style is command and control

Img. 2: Display Control

Img. 1: Controller and PTT Button

Figure 3. Example of an iterated pattern, page 1 of 2

Examples (continued):

Novice		Expert	
user:	<presses PTT button>	user:	<presses PTT button>
system:	Speech input <beep>	system:	<beep>
user:	Entertainment.	(user:	Entertainment.)
system:	Entertainment. Say 'FM menu', 'AM menu', or 'CD menu'.	(system:	Entertainment.)
user:	FM menu.	(user:	FM menu.)
system:	FM menu. Say 'choose frequency', 'choose station', ...	(system:	FM.)
user:	Choose frequency.	user:	Choose frequency.
system:	Which frequency do you want?	system:	Enter frequency.
user:	96.3	user:	96.3
system:	You are hearing 96.3 MHz.	system:	<music is heard>

Samples of system initiated dialogues (see Novice column) and user initiated dialogues (see Expert column). (from Hassel [17])

Reference Key Words:

User initiative driver information system, system-initiative, dialogue strategy,

Sources:

[16] Ackermann, C. and Libossek, M. 2006. System-versus User-Initiative Dialog Strategy for Driver Information Systems. In: Proc. of Ninth International Conference on Spoken Language Processing, Pittsburgh, PA, USA, September 17-21, 2006, p. 457-460.
[17] Hassel, L., & Hagen, E. (2005). Evaluation of a dialogue system in an automotive environment. In 6th SIGdial Workshop on Discourse and Dialogue.

Figure 4. Example of an iterated pattern, page 2 of 2

H. Final pattern iteration

The entire set of 16 patterns was then revised, based on the above-mentioned structure (see Table II for the revised structure and Figures 3 and 4 for a pattern example). Some example details were removed and/or reduced in order to reduce the overall image size and not bloat the paper unnecessarily.

The iteration procedure was the same as the one described in Section E and was overseen by a team of two HCI researchers. Based on the results from the workshop, *Scenario*, *Solution* and *Examples* were focused on in particular and were adapted according to the stakeholders' requirements. If possible, solutions were also represented graphically or illustrations from cited publications were added. Concrete examples (state of the art) from recent production vehicles illustrated, if appropriate, the examples section. In general, care was taken to present the information in every pattern in a compact form, easily comprehensible and practicable. They were kept as short as possible to conform with the stakeholders' requirements.

I. Validating the patterns

For the final validation of the iterated pattern set, we conducted a second workshop at our facility with seven participants (4 employees from our industrial partner and 3 researchers; 6 male and 1 female). Age ranged from 21 to 48 years, job experience from one month to eight years. Regarding their professional background, they were software developers, engineers, designers, and HCI experts. Some of the participants from the first workshop also participated in the second one. To have a good mix of informed and fresh views, we involved two stakeholders who had already participated in the previous workshop, and two who were completely new to the topic. The overall goal of the second workshop was to assess the quality of the first UX pattern set, as well as to iterate the pattern set based on the industry stakeholders' feedback. Since the initial 16 patterns are only one part of a larger planned pattern collection, we also wanted to collect input on problems for the remaining two planned CUX-Factors (i.e., *Perceived Safety* and *Joy of Use*) to facilitate the generation of these pattern sets and ensure that the problems that will be tackled in the future are actual problems relevant to the industry.

In this workshop, the full iterated pattern set was presented to the participants and evaluated on a peer judgement basis. After a 10-minute general introduction to patterns and explanations of the iterated UX pattern structure from the first workshop, a researcher explained the purpose and the agenda of the one-day workshop to the participants. After that, the rating categories (c_1 to c_4) were shown and explained to the participants. They were informed that they would later have to rate each pattern according to these criteria.

Then, each participant received one pattern to read through thoroughly. Each of the 16 existing patterns was rated by each participant individually. To avoid serial positions effects and similar forms of bias, the patterns were presented to participants in different orders. Based on the various length of the pattern, we classified the patterns into short and long ones, which led to two separate rating sessions.

In the first pattern rating session, each participant was given a set of 6 patterns (printouts). They were then asked to read and rate them sequentially. Additionally, they were also asked to note any issues they find particularly note-worthy. Furthermore, they were briefed to keep all printouts for the discussion session in the end.

In the second pattern rating session, the participants were asked to read and rate the additional 10 patterns with the same instructions as mentioned before. The rating was done via the previously employed questionnaire (see Figure 2), in which the participants had to rate each pattern with regards to four quality criteria (c_1, c_2, c_3, c_4). The only change to the rating system was a slight modification to c_4: This criterion was intended to measure the overall quality of the pattern collection. We initially included this as a questionnaire item since we only had two patterns during the first workshop.

Thus, a rating of a potential pattern collection was sensible and could even have further highlighted quality differences in the patterns themselves (if differences in rating had been observed), but a discussion would not have been very useful since a representative pattern collection simply had not existed at that point. Since the participants now had a larger number of patterns to look at, it made more sense to exclude c_4 from the questionnaire and, instead, discuss it in plenum at the end of the workshop for a qualitative, *overall assessment* of the pattern set quality and applicability. This helped decrease workload and fatigue for the participants while still providing the necessary results (Ratings for c1 to c3 gave a good numerical indicator of the pattern quality, whereas c4 would be better suited as qualitative consensus with consolidation of further potentials for refinement).

After the rating of the patterns had concluded, the moderated discussion session took place, which was divided into two parts. The first part was the aforementioned discussion of c_4. During this first session, participants could voice all concerns they had encountered when reading the 16 existing patterns, together with suggestions for future improvements to the existing UX patterns. In order to trigger the discussion, two questions of criterion (c_4) from the quality framework were asked to the participants; these were: "Do you think that the presented patterns support the communication of designers, developers and researches by providing common basis?" Do you think the presented patterns capture relevant knowledge about user experience?" In a second discussion session, a researcher explained CUX-Factors 2 and 3 (*Perceived Safety* and *Joy of Use*) to the participants. The session was conducted as a brainstorming, in which the participants were asked to come up with any

Figure 5. One participant is filling out the questionnaire during the rating process

problems they had encountered (regularly or semi-regularly) and which they would desire solutions for. During the brainstorming, the problems were collected and compiled in a preformatted list, which would then be used to rate the problems with regard to importance and relevance. Each participant received a printout of the list and was then asked to rate each problem with regard to relevance on a scale of *very relevant – relevant – not very relevant*.

The two discussion sessions were audio-recorded and later on transcribed for further analysis. Due to the low number of participants, the questionnaire results were analyzed in descriptive form.

The results of the first quality criterion (c_1), rated on a scale from 1 (absolutely agree) to 5 (do not agree at all), show that the pattern set had a meaningful name (M=1.86, SD=1.08), a clear stated problem (M=1.48, SD=0.80), and enough background information of the stated scenario (M=2.03, SD=1.02). The two last categories of c_1, i.e., the solution (M=2.69, SD= 1.15) and the examples (M=2.60, SD=1.16), were rated as neutral.

The questionnaire responses of the second quality criterion (c_2) indicated a very positive overall picture with mean values all in a positive spectrum (lowest was 1.55) and the most negative responses being neutral ones (2.78). The responses were also rated on a scale from 1 (absolutely agree) to 5 (do not agree at all). Lowest mean values were identified clarity of the language used in the pattern (M= 1.55, SD=0.73) and the problem-centricity (M=2.16, SD=0.88).

Regarding the third criterion (c_3), the participants perceived only one pattern as implausible. Regarding c_4, the overall consensus was that the presented patterns support the communication of designers, developers and researchers, provide a common basis, and capture relevant knowledge about user experience.

The participants generally preferred to have various approaches to a solution that are underpinned with concrete examples to make a pattern more useful. Interestingly, however, they also made the suggestion to not only integrate state of the art solutions but also examples with "exotic" or creative designs. Unfortunately, we did not have enough time during the discussion to dive deeper into the motivations behind and feasibility of such pattern solutions, but the fact that this was explicitly desired by the participants, who were all industry practitioners, was very interesting nonetheless and worth mentioning.

The participants also missed a guidance that would help software developers, engineers, or designers work with the provided knowledge of a pattern – a sort of guideline to use patterns at the beginning of the pattern collection. As paradoxical as it might sound, this appears to be an interesting side effect of the decision to keep the patterns as short and to the point as possible (which happened based on feedback by the practitioners themselves). Since the participants often had different priorities and did not always encounter the same problems in their work, they also wanted to have the opportunity to rank the patterns. This means that the participants suggested providing a ranking system, which would allow them to rank each pattern regarding its importance for future reference

One recurring problem, which had sporadically been voiced during the previous workshop as well, was the (lack of) relevance of the problem statements in the discussion. The participants felt that the problems stated in some patterns were only partly relevant for them and while they appreciated the solutions, they would often have desired to be involved when identifying the problem statements beforehand. Our decision to identify potential problems together with the workshop participants during the validation workshop was, therefore, perceived as a very welcome change. This led us to modify our overall pattern generation approach to involve the industry stakeholders already during the very first step in the pattern generation process. This might seem obvious in hindsight, but we consider it a nonetheless interesting result of our focus on literature before practice in the initial pattern finding process.

The list of design problems that patterns are then generated for should, together with a rating regarding relevance and importance, come from the industry stakeholders themselves. Ideally, this should happen with guidance and assistance from researchers. Contextual inquiries or brainstorming with subsequent problem rating sessions with the industry stakeholders are both suitable methods to achieve this.

As for the pattern collection itself and the UX factors, *Perceived Safety* and *Joy of Use,* the following problems/topics were estimated as very relevant and suitable bases for future patterns:

<u>Perceived Safety</u>

- When should the information be presented to the driver?
- Where should the information be presented to the driver?
- What information should appear in the cockpit?
- How should the system status be displayed?
- When should warnings be displayed?
- What kind of modalities should be used to give warnings?

<u>Joy of Use</u>

- How much feedback does a button need?
- How long can you press a button until a reaction occurs?
- How useful is a double-assigned button?
- How long should a short or long button press be?
- How big should a touch display be?
- How many menus are useful?
- What kind of depth should a menu have?
- How can we use or design the front-seat passenger's place for work tasks?

Overall, the pattern validation workshop showed that the existing pattern set supports the communication between designers, developers and researchers by providing a common basis. The existing pattern set 1 generated a positive overall resonance and was generally seen as a valuable supplement to existing work practices.

The feedback from the two discussion sessions was particularly fruitful and will help us to increase the quality of existing patterns on *Mental Workload Caused by Distraction* and any future pattern sets (regarding the other UX factors *Perceived Safety* and *Joy of Use*) generated within the project. Strong focus will have to be put on two aspects: Does it make sense to rank the patterns? If so, who shall rank them and how can this issue be implemented in database and paper based solutions?

IV. Discussion

In this paper, we have described a seven-step approach to generate (automotive) UX patterns. It started with a scientific knowledge transfer workshop (step 1), which led to an initial set of patterns (step 2). A first iteration based on participants' feedback and the identification of problems in the generation process resulted in a refined pattern structure (step 3). An iteration of the patterns led to a refined pattern structure (step 4), with which we conducted a pattern structure evaluation workshop with industry stakeholders (step 5). Another pattern structure iteration (step 6) led to a final pattern iteration (step 7).

The industry practitioners were involved in most parts of these steps, but as mentioned earlier, it might have been beneficial to include the industry stakeholders before the first generation phase of the patterns. We came to understand that not all of the patterns that were initially developed were actually urgent problems for the practitioners from industry. By involving the industry practitioners in subsequent steps in the pattern generation process, we were able to better understand the practitioners' perspectives and the respective evaluation of identified problems derived from research. This different angle of how problems are perceived, allowed us to translate scientifically proven results into proven solutions for industry stakeholders.

The valuable cooperation between research and industry brought up implications for how to improve the pattern generation process according to the respective stakeholders' needs. From the industry perspective, they would have appreciated an approach by which they could identify problems of high priority right from the beginning (i.e., before the first generation phase of the patterns) of the development process to better identify problems to be dealt with in subsequent steps. From the researchers perspective, we focused on the pattern generation process and the pattern structure and less on the decision for and criticality of particular problems, to be selected for subsequent steps. We decided right at the beginning to develop patterns just for one specific UX factor in order to improve the process and the structure of the patterns. For us this was a logical step, as we wanted to go from science to practice. However, throughout this entire cooperation we came to understand that it is very critical to decide *when* to actually involve your industry partners also as active decision makers, to maybe also allow for bidirectional exchange of knowledge already in very early stages.

Nonetheless, the insights we gained have resulted in a pattern structure suitable for industry stakeholders' needs in the automotive domain. The structure focuses on clarity and brevity and should, with slight modifications, be adaptable for other industry domains as well. Furthermore, we have documented our pattern generation process, together with both scientists and industry stakeholders. A high level overview of the process can be seen in Figure 6. We broke down our seven steps into five main phases: The first phase is industry focused, in which industry problems are identified, and where patterns might be a beneficial way of helping to solve these problems. In phase 2, we suggest generating an initial set of patterns. Phase 3 includes evaluation and iteration through a scientific lens. Phase 4 includes evaluation and iteration with a focus from industry. In phase 5, the patterns are validated.

Apart from the patterns generation process, this paper presents a structure for automotive user experience patterns. It consists of nine elements (*name, intent, topics, problem*, *scenario, solution, examples, keywords*, and *sources)*, which proved to be a useful way to structure UX patterns in the automotive domain.

Phase 1: Problem identification (**industry** focus)
Phase 2: Generation of initial patterns (**science** focus)
⬇
Initial pattern set
⬇
Phase 3: First evaluation and iteration of patterns (**science** focus)
⬇
Refined pattern set
⬇
Phase 4: Second evaluation and iteration of patterns (**industry** focus)
⬇
Final pattern set
⬇
Phase 5: Final pattern validation (**industry** focus)

Figure 6. The five phases of the pattern generation process

The focus on brevity and quick solutions that resulted from iterations based on the industry stakeholders' needs presents an interesting perspective on the differentiation between guidelines vs. patterns.

In contrast to well-known strategies of how to capture patterns, i.e., where a pattern emerges from at least three uses of the same solution for a given problem (Gamma et. al), this paper presented a new and different approach to generate patterns. On the one hand, our approach draws from the large amount of already existing research knowledge (i.e., scientific literature) within specific domains (e.g., automotive), thereby complementing traditional observation-based approaches with scientifically proven results and knowledge. On the other hand, our approach furthermore allowed us to go beyond traditional observational strategies and research knowledge towards the involvement of practitioners' expert knowledge in the development process of the patterns as being part of truly *inclusive* cooperation.

V. Conclusion, Limitations and Future Work

The approach described in this paper is a departure from the common practice of documenting already working solutions, to a way to convert (proven) scientific results to working problem solutions. It is an extension of our efforts to apply the pattern approach to a wide variety of disciplines and areas [17], fostering knowledge preservation and exchange both within and among said disciplines and areas. The approach described in this paper focused on fusing scientific and industry expertise, more specifically scientific UX and industrial driver space design know-how. Branching out into other disciplines, even ones entirely unrelated to HCI, is planned in the future. Areas currently under consideration are knowledge transfer for study setups in Biological Neuroscience to reduce beginner's mistakes, as well as argument analysis patterns for Analytic Philosophy. These further expansions of the patterns scope are still situated well in the future, however, they are dependent on the success of – and iterations based on – the current, intermediary approach.

The evaluation of the approach described in this paper was based mainly on feedback of practitioners from the HCI car domain. We did not compare the quality of our patterns' problem solutions to those of other HCI patterns in our research. While the positive assessment of the overall process and its results (the patterns) provides a positive outlook, further evaluations (and possible iterations) are certainly needed to fully validate it as a reusable standard procedure in the community.

Overall, the pattern generation process and structure we gained will be used for generating additional UX patterns for the automotive domain. More specifically, we intend to also cover the factors *perceived safety* and *joy of use* and generate patterns for these. We have already begun the generation process by identifying common design problems related to these factors in a workshop together with the industry stakeholders. In the future, we intend to implement the full pattern collection as an online database based on the pattern framework proposed in [17]. We will continue using our inclusive pattern generation process to translate scientifically proven results into proven solutions for industry stakeholders and encourage others to employ and further refine our proposed method.

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REFERENCES

[1] A. Mirnig A. Meschtscherjakov, N. Perterer, A. Kischkowsky, D. Wurhofer, E. Beck., A. Laminger, and M. Tscheligi, "User Experience Patterns from Scientific and Industry Knowledge: An Inclusive Pattern Approach," The Seventh International Conference on Pervasive Patterns and Applications (PATTERNS 2015) IARIA, Nice, France, March 2015, pp. 38-44, retrieved: August 2015.

[2] C. Alexander, "The Timeless Way of Building," New York: Oxford University Press, 1979.

[3] A. Dearden and J. Finlay, "Pattern Languages in HCI: A Critical Review," HCI, Volume 21, 2006, pp. 49-102.

[4] M. Obrist, D. Wurhofer, E.Beck, A. Karahasanovic, and M. Tscheligi, "User Experience (UX) Patterns for Audio-Visual Networked Applications: Inspirations for Design," Proc. Nordic Conference on Human-Computer Interaction (NordiCHI 2010), Reykjavik, Iceland, 2010, pp. 343-352.

[5] M. Obrist, D. Wurhofer, E. Beck, and M. Tscheligi, "CUX Patterns Approach: Towards Contextual User Experience Patterns," Proceedings of the Second International Conferences on Pervasive Patterns and Applications (PATTERNS 2010), Lisbon, Portugal, 2010, pp. 60-65, retrieved: January 2015.

[6] T. Erickson, "Lingua francas for design: sacred places and pattern languages," Proceedings of the 3rd conference on Designing interactive systems (DIS '00), ACM, New York, NY, USA, 2000, pp. 357-368.

[7] S. Köhne, "A Didactical Aproach towards Blended Learning: Conception and Application of Educational Patterns", Dissertation, Universty of Hohenheim, Hohenheim, Germany, 2005 [Orig. title: Didaktischer Ansatz für das Blended Learning: Konzeption und Anwendung von Educational Patterns].

[8] K. Quibeldey-Cirkel. Design Patterns in Object Oriented Software Engineering. Springer, 1999 [Orig. title: Entwurfsmuster: Design Patterns in der objektorientierten Softwaretechnik].

[9] B. Biel, T. Grill, and V. Gruhn, "Patterns of trust in ubiquitous environments," Proc. 6th International Conference on Advances in Mobile Computing and Multimedia (MoMM 2008), Gabriele Kotsis, David Taniar, Eric Pardede, and Ismail Khalil (Eds.). ACM, New York, NY, USA, 2008, pp. 391-396. DOI=10.1145/1497185.1497269, retrieved: January 2015.

[10] D. Martin, T. Rodden, M. Rouncefield, I.Sommerville, and S. Viller, "Finding Patterns in the Fieldwork," Proceedings of the Seventh European Conference on Computer-Supported Cooperative Work, Bonn, Germany, 2001, pp. 39-58.

[11] A. Krischkowsky, D. Wurhofer, N. Perterer, and M. Tscheligi, "Developing Patterns Step-by-Step: A Pattern Generation Guidance for HCI Researchers," The Fifth International Conferences on Pervasive Patterns and Applications (PATTERNS 2013) IARIA, Valencia, Spain, 2013, pp. 66-72, retrieved: January 2015.

[12] A. Cooper, R. Reimann, and D. Cronin, "About Face 3: The Essentials of Interaction Design," Indianapolis: Wiley, 2007.

[13] M. van Welie and B. Klaassen, "Evaluation Museum Websites using Design Patterns" Internal Report, IR-IMSE-001, Faculty of Computer Science, Vrije Universiteit Amsterdam, The Netherlands, 2004.

[14] J. Borchers, "A pattern approach to interaction design", Wiley series in software design patterns, John Wiley & Sons, NY, USA, 2001.

[15] J. Tidwell, "Common Ground: A Pattern Language for Human-Computer Interface Design," 1999, http://www.mit.edu/~jtidwell/interaction_patterns.html, retrieved: January, 2015.

[16] D. Wurhofer, M. Obrist, E. Beck, and M. Tscheligi, "A Quality Criteria Framework for Pattern Validation," International Journal On Advances in Software, Volume 3, Issue 1-2, 2010, pp. 252-264.

[17] A. Mirnig and M. Tscheligi, "Building a General Pattern Framework via Set Theory: Towards a Universal Pattern Approach," The Sixth International Conference on Pervasive Patterns and Applications (PATTERNS 2014) IARIA, Venice, Italy, May 2014, pp. 8-11, retrieved: January 2015.