Pattern design in the context space

A methodological framework for designing auditory display with patterns

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ABSTRACT

This paper introduces a methodological framework for contextual design with patterns (paco). Its development was driven by the lack of guidance in designing audio in the user interface and by the need to communicate design knowledge within the community and to designers outside the field. The fundamental concepts presented in this paper, however, are generic and might be applicable similarly to other disciplines. The framework provides methods to create, apply and refine design patterns considering the particularities of small or pre-mature scientific disciplines which have less successful examples to draw upon - such as auditory display. After providing background on research in auditory display and current design practice, a set of requirements for the framework is developed, an appropriate format for design patterns is discussed and the context space is introduced as a key concept to facilitate the workflow within the framework. An example workflow shows the usage of the framework during the life-cycle of a design pattern and we elaborate on the next steps discussing an online design tool and the evaluation of the framework.

1 Introduction

Auditory displays - Why should we bother?

The use of audio in human-computer interaction was widely neglected in the past, but due to new interaction paradigms emerging from different fields like mobile computing and better technical capabilities for sound creation, it receives increasing attention. The design of audio in user interfaces, however, is driven by skill, experience and intuition. Good design is considered to be an art rather than the result of a process with informed design decisions.

For the last 13 years the International Community for Auditory Display (ICAD) has been the prime forum for research on conveying information by non-speech sound and many contributions have proven that auditory displays can be effectively employed in a wide range of contexts. However, in contrast to these results, audio has little significance in most commercial user interfaces and is mostly reduced to the use of plain speech and assistive technology. Arons stated in 1994 *"... the lack of design guidelines, common for the creation of graphical interfaces has plagued interface designers who want to effectively build on previous research in auditory interfaces"* (Arons and Mynatt, 1994) and little as changed since. For auditory displays as a field of research this means that building effectively upon each other's findings can be cumbersome. For the average designer the unavailability and/or the inaccessibility of common design knowledge leads to ad-hoc solutions and prevents them from taking full advantage of auditory displays.

We approached this problem by developing a design framework for auditory displays based on the use of design patterns with the aim to make design knowledge available, accessible and transferable. The following sections provide further background for the motivation and related work in the field of auditory displays.

1.1 Motivation

To restrict interaction with technology to the visual channel (for feedback) and the tactile channel (for input) raises a number of problems. Foremost, this leaves many devices inaccessible for the visually impaired. The Apple iPod™, for example, has a single auditory cue - the click of the wheel - that supports the user interface making it very difficult for the visually impaired to use. For other devices there exist screen-readers that enable visually impaired users to access the interface. The sequential manner of speech, however, does not offer the same usability as visual screens putting the people concerned at a major disadvantage in using information technology. This imposes many social and work-related difficulties on them.

But not only the visually impaired can benefit from a full-featured auditory interaction channel. An increasing number of devices is ubiquitously incorporated into our everyday life. Mobile phones, MP3 players or PDAs became indispensable companions. The miniaturised form factors and mobile interaction paradigms, however, make it increasingly difficult to use visual screens. Auditory displays offer an alternative in contexts in which the eyes are occupied by other tasks or when devices got too small to put a screen on them.

Summarising, there are a number of good reasons for why the design of efficient auditory displays is desirable and will become increasingly important in future.

1.2 Guidelines, principles and design methodologies

Guidance for designing auditory cues in user interfaces is scarce. An early attempt to organise principles was made by Kramer (1994). He investigated the mapping of data on perceptual parameter dimensions of sound focusing more on the sonification[1] of data than on user interfaces. In the same book, Gaver presented techniques to create auditory icons – natural sounds that convey meaning by exploiting a common metaphor (Gaver, 1994). Blattner et.al. developed guidelines for the construction of more abstract sounds (earcons) based on musical motifs that can be combined (Blattner et al., 1989). Later, Brewster refined those guidelines (Brewster, 1994) and also investigated the concurrent use of earcons (McGookin and Brewster, 2003). More specifically Lumsden and Brewster developed guidelines for earcons to support graphical widgets like buttons (Lumsden and Brewster, 2001).

At a higher level in the design process Barrass developed a case-based approach that is supported by a formal Task and Data analysis (TaDa) (Barrass, 1998). He also made an attempt to create the auditory equivalent of the colour space in graph design. More recently Barrass investigated the use of design patterns (Barrass, 2003). By proposing to "cultivate design" patterns in a collaborative community effort Adcock and Barrass hoped to create an extensive collection of common knowledge (Adcock and Barrass, 2004). The efforts, however, stalled and little patterns were written.

Mitsopoulos adapted Foley's framework for dialog design for auditory displays and created a design theory founded on the findings of Bregman's Auditory Scene Analysis (Mitsopoulos, 2000; Bregman, 1990). The use of rich use case scenarios in the design of auditory cues is proposed by Pirhonen et.al (Pirhonen et al., 2006).

1.3 The missing link

Although there are some guidelines and principles for the design of auditory displays they are little used in reality and auditory display design remains an ad-hoc process (see also Lumsden and Brewster, 2001). Skill, craft and experience seem to be the main factors for successful design. The results of a recent survey on common practice in the design of audio in user interfaces conducted by the authors supports this point of view (Frauenberger et al., 2007).

In conclusion of the findings in this survey, the authors developed a set of requirements for a methodological framework to support the design of audio in the user interface. The following table summarises these:

[1] Sonification: perceptualisation of data by auditory means

Domain	Requirements
Bigger picture	Blend in with established methods in HCI. Extendable for multi-modal designs. Conceptualise the design space to make designers aware of the range of possibilities.
Opinion shaping	Appealing to overcome prejudices and common disbelieve in audio. Incorporate aesthetics.
Simplicity, Experience & Creativity	Simple to use to provide a low entry barrier for novices and experts. Allow experts to incorporate their experience. Allow designers to exercise their creativity rather than being restricted by templates.
Tools	Support the framework with design tools. Provide means for designers to express and communicate their initial ideas easily – auditory sketching.

Myers et.al. (2000) studied the evolution of software tools to create user interfaces. In his findings he identified a number of factors that made some tools successful, while others were less accepted. Although focused on software tools rather than design theory, many of the factors match with the ones stated above. Most importantly, the low entry barrier for novices and the potential power for experts appears to be key. Myers also acknowledged the issue of the "moving target" by which he meant the capability of a tool to be flexible enough to shift the context in which the resulting user interface is employed seamlessly. This feature is addressed by the set of the "bigger picture" requirements above.

2 The framework

paco and auditory display design - paco ad

The development of proposed framework was driven by the needs of the scientific field of auditory display. Its concepts are, however, more generic and may be applicable to other fields. Therefore, we coined the name paco - pattern design in the context space - for the generic concept and will use paco ad for its application in the field of auditory display.

In the remainder of this section, we will focus on paco ad to introduce the key concepts and show an exemplary workflow, before discussing the benefits of the framework in general in the subsequent section.

2.1 Approach

Design patterns were chosen (over other possibilities such as guidelines) as carrier for design knowledge in our framework as they satisfy most of the requirements above: Their textual form leave open many ways of instantiating them, while making the core qualities of the solution explicit, encouraging creative design. Additionally, the textual form provides a low-entry barrier which, combined with example implementations provide an easy way for designers new to the field to get started. Patterns also allow for conveying fundamental values, which like in architecture can be used to communicate forms of aesthetics. One of the key concepts in Alexander's patterns was the inclusion of all stake-holders in the process of design (Alexander, 1979). This property of patterns addresses the variety of scientific fields and makes them suitable as a lingua franca. For new and emerging design fields patterns potentially provide other benefits: By applying an appropriate organising principle patterns can be generative and help a scientific field to develop new designs for the gaps between existing patterns (Dearden et.al. 2006). Making good practice explicit also has the potential to *"...positively influence the design of emerging applications by helping designers find good solutions and avoid adopting poor standards"* (Chung et.al. 2004).

On the other side, the common practice of creating patterns is not favouring young scientific disciplines with a small number of successful designs and potential pattern authors. E.g. there might still be valuable design knowledge in a concept that was not already used extensively and hence, is not a pattern in the original sense. We nevertheless believe that patterns are able to reflect such design knowledge too, and intend to address this issue through the method of creating design patterns in the framework.

With the introduction of the context space in the next section we provide a key concept of the framework around which the methods for the creation, application and refinement of design knowledge are constructed. It will enable us to exploit the benefits of patterns in this domain and to circumvent possible issues with patterns.

2.2 The Context Space

The context space serves as the organising principle for design knowledge. It is a multi-dimensional space in which design problems, design solutions and design patterns can be classified according their context. According to Fincher and Windsor (2000), an organising principle for patterns in UI design should provide a taxonomy, means of expressing proximity, means for evaluation and generative power. Similarly, the purpose of the context space is to be able to conceptualise the design space and efficiently match design problems and design knowledge. Therefore, the context space is not only home to patterns, artefacts and design problems, but also links patterns to other patterns by their location in the context space and provides the syntax to a pattern language.

Similar to the ontology used in model-based user interface design the context space features the user, the environment and the platform (together the context of use) as key dimensions (Thevenin et al., 2003). To be able to "localise" designs in the context space (i.e. to fully assess the context), it is also necessary to introduce the purpose of the design. This not only includes the functional purpose (i.e. the task of the user of the artefact), but in a wider sense the desired user experience and social context.

Some of the dimensions in the context space can be represented by an ordinal dimension, for other this is hardly feasible. Hence, all dimensions provide keywords (tags) to be specified in more detail. With the popular tagging paradigm, relations between descriptors into the context space can be made apparent by comparing their usage patterns like in social networks (e.g. http://del.ico.us.com). The following screenshots show a prototype of an interface that enables designers to specify contexts in the context space. It was created for the evaluation study described below.

The locator pages.

Above: Specifying the ordinal part of the dimension "User" showing the help note.

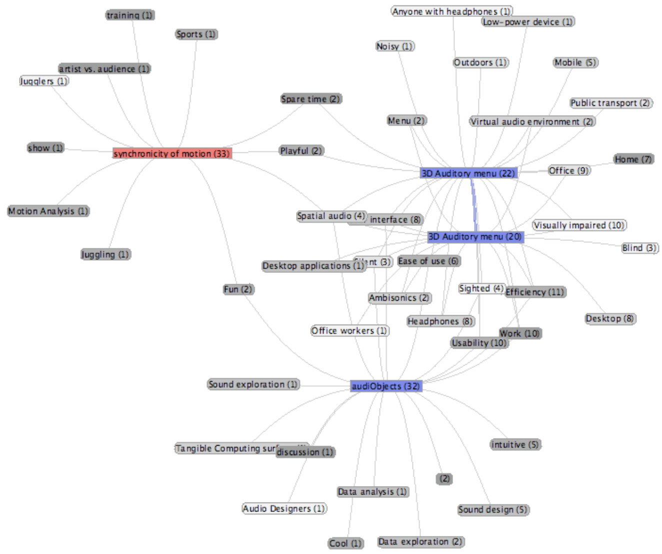
Below: The tagging pop-up showing recently used tags and the help note.

To "localise" design problems or solutions in the context space means to determine values for each of the dimensions of the context space. In the prototype pictured above this is solved as to specify values for all dimensions that provide a nominal value, plus providing tags for each dimension. For example, the *User* dimension features a nominal part determining the scope of the user group ranging from mass market products to highly specific prototypes tailored towards a well-defined user group. Additionally, the dimension is defined by its tags. Here, designers may specify user groups (e.g. visually impaired, accountants etc.) or special skills and other properties of the user group. For *User experience* there exists no nominal part and it is exclusively defined by its tags (e.g. fun, trust, efficiency etc.). With this taxonomy designs, design problems and design patterns can be classified.

To present a complex, multi-dimensional space like this to designers in an accessible way is a serious challenge. In the evaluation of this framework, described below, we are experimenting with an interactive visualisation augmented with a sonification of the space. This allows us to make as much information as possible perceivable and enables designers to conceptualise, i.e. build a mental model of, the design space. The figure below shows a screen shot of such a visualisation. All patterns (or artefacts or design problems) and tags are shown as nodes in a graph, coloured blue and in shades of grey respectively. The grey edges in the graph link patterns with the associated tags, thick blue edges link related patterns (i.e. patterns derived from others). Using forced directed layout, patterns (or artefacts or design problems) with a similar context are automatically arranged next to each other as they share links to the same tags.

An example visualisation of the context space.

Patterns in blue (focused in red), directly related (derived) patterns linked with blue edge. Tags in shades of grey, according to the dimension (user, environment, device, application domain, user experience, social context) also showing total number of occurrences.

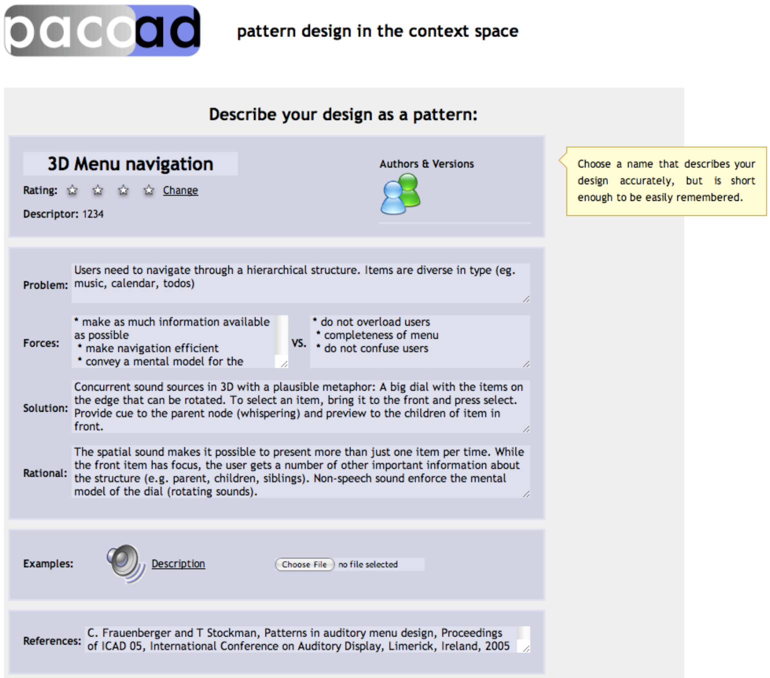


Force directed layout positions the elements in the graphs automatically according to an underlying physical model. Nodes repel each other, edges act as springs and drag forces are applied. This layout mechanism lends itself to model-based sonification to augment the visualisation aurally (Hermann and Ritter, 1999). Each node can be "shaken", the movement will result in a sound and because of the propagation of the force in the model, all connected nodes will also sound, but in different intensity and delayed creating a unique pattern of sounds. Combining these methods with multiple filters (e.g. maximum distance from selected node, tag types etc.) enables the designer to explore the space efficiently and build up a mental model of the design space.

Summarising, the introduction of the context space as an organising principle in the framework provides the following advantages:

1. The context space allows to conceptualise the design space and the problem domain. It functions like a map that identifies gaps in current research.
2. It serves as an organising principle for design problems and solutions allowing for efficient matching of those.
3. It facilitates the workflow in the framework and allows for a novel, systematic approach to creating design patterns from research prototypes.
4. It stresses the importance of the context for solutions in human-computer interaction design.

Subsequently, we will elaborate on the format of design patterns in the framework, before we will put the concepts together and describe the workflow in the framework.



The pattern page as used in the current prototype including the help hint for the name field.
Pop-up panels are implemented for Authors & History and Rating.

2.3 Design patterns

Design patterns have been applied successfully to various fields. In human-computer interaction pattern design has recently received increased attention and pattern sets have been published for various application domains. The design of interactive web content, for example, has shown that there are many recurring design tasks that can be described through patterns to provide other designers with guidelines (Tidwell, 2005). There are also pattern sets for common graphical user interfaces or specialised sets for mobile devices (e.g. http://www.welie.com/patterns/mobile/index.html) and the design of museum exhibits (Borchers, 2000). In all these applications design patterns were used to capture design knowledge, make it easily accessible to designers, enable its reuse and provide a lingua franca for all stake-holders involved.

In the first attempts to adapt design patterns to auditory display design, Barrass created a Wiki[2] for the community to collaboratively work on design patterns. Another approach was to reformulate GUI patterns to be mode-neutral and use those as the basis for auditory interpretations (Frauenberger et al., 2005). In both cases the format of the patterns was derived from those originally proposed by Alexander (1979) as they were closer to the task of designing audio than the more formal ones used for software development.

For paco ad we further developed the format we used previously and added the descriptor into the context space and a way for accessing the version history of the pattern. The descriptor "localises" the pattern in the context space and hence, links it with other patterns and design problems.

The "authors and versions" link provides access to the different versions of the pattern in its process of creation. This feature can be seen as looking for the roots of a pattern which can give

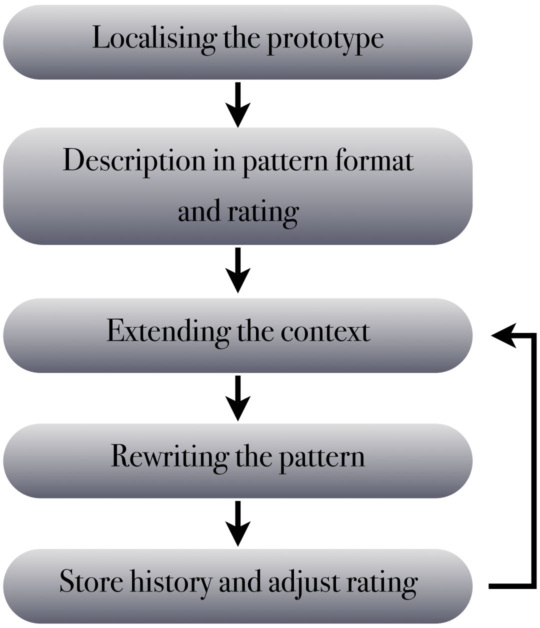
[2] http://c2.com/cgi-bin/wiki?SonificationDesignPatterns

valuable insights into understanding and interpreting the pattern. Further benefits are the ability to link changes in the patterns to specific authors and enable them to provide reasoning for those changes as a log message; a concept familiar to practices in open source developments. The rating indicates the level of validity of the solution presented. It is set by the author and follows a rating scheme presented in the workflow below.

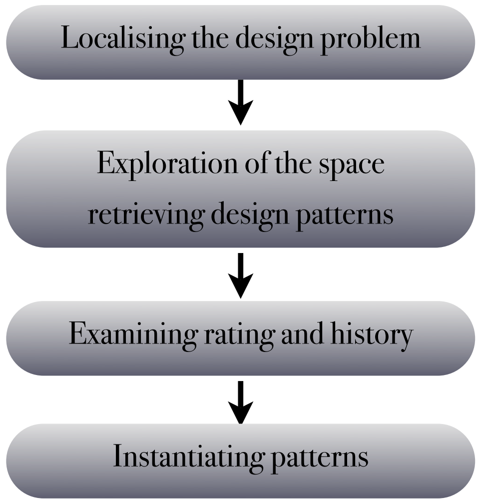
Because of the nature of the discipline the format is designed to be presented in digital incorporating other media and hyperlinks. Although the possibility of incorporating audio into patterns gives authors a greater freedom in how to describe their ideas, it is still not ideal. “Writing about music is like dancing about architecture - it′s a really stupid thing to want to do.” (Elvis Costello, Musician magazine No. 60, October 1983); while not being music, the quote might be appropriate in this case too. Future research has to address this problem by developing better ways of representing auditory designs in patterns and tools for creating low-fi auditory sketches with very low effort to illustrate them.

2.4 The workflow

This section will introduce the methods in the framework through the description of a typical workflow spanning the whole life-cycle of a design pattern: creation, application and refinement. To illustrate the workflow we use an example of a design for an auditory menu in an Mp3 player.



The starting point for creating new design patterns is a working prototype. In our example a design for navigating the menu of an Mp3-player by auditory means. The design was driven by the designer’s experience and expertise and evaluated in a user test. The specific solution is “localised” in the context space (e.g. mobile context on a low power device in a potential noisy environment) and the solution is written up as a pattern supported by examples and the rational for the design. The author rates the resulting pattern “Menu” with 3 stars (out of 5) as it is validated design knowledge, but was not yet implemented in other prototypes (i.e. is not validated as a pattern). Subsequently, the designer derives a new version of this pattern by extending or altering the context for the pattern - e.g. is this solution applicable to a desktop solution? Can it solve other tasks? Every time the pattern is altered to reflect the new context, a new version is filed and the rating is adjusted. In our example, during this process the “Menu” pattern is renamed in “Hierarchical navigation & selection”, its context is broadened significantly and its rating has decreased to one star as there is no evidence that this is a valid solution in this broadened context. However, there is a lot of design expertise in informed guesses of expert designers. This process creates a multitude of patterns that reflect the expertise of the designer. Following, we discuss the application of design patterns.



A novice designer intends to develop an auditory solution for navigating the folder structure in an email-client on a desktop. First, the design problem is localised in the context space (e.g. office use, high processing power, privacy concerns...) through tags and assigning values to the dimensions as shown above. The designer is now able to explore the context space around the design problem and retrieve relevant patterns using the visualisation & sonification of the context space. The "Hierarchical navigation & selection" pattern covers the needs partly and after examining the rating and the history of the pattern (i.e. revealing the reasoning in its creation and its origin) the designer implements the pattern considering the new requirements and bearing in mind that the pattern reflects not yet validated design knowledge. The resulting design is evaluated in user tests and refined. The goal is to get initial prototypes closer to the finished solution, hence, making more iterations possible resulting in better designs.

A working solution was derived from the "Hierarchical navigation & selection" pattern. For feeding back the experience the designer uses the same process as with the creation of design patterns: The starting point is the specific solution implemented which is localised in the context space and described in pattern format. By extending the context the designer creates new versions of the pattern with ratings according to the same scheme as described above. Eventually, the original pattern,the solution was derived from, is also rewritten and its rating increases to 4 stars as it has now 2 authors and 2 example implementations. If the development of the solution revealed flaws in the pattern, the rating scheme reflects this by decreasing the ratings until a pattern "dies" and serves as an anti-pattern - a bad solution.

3 Discussion

Where does this get us?

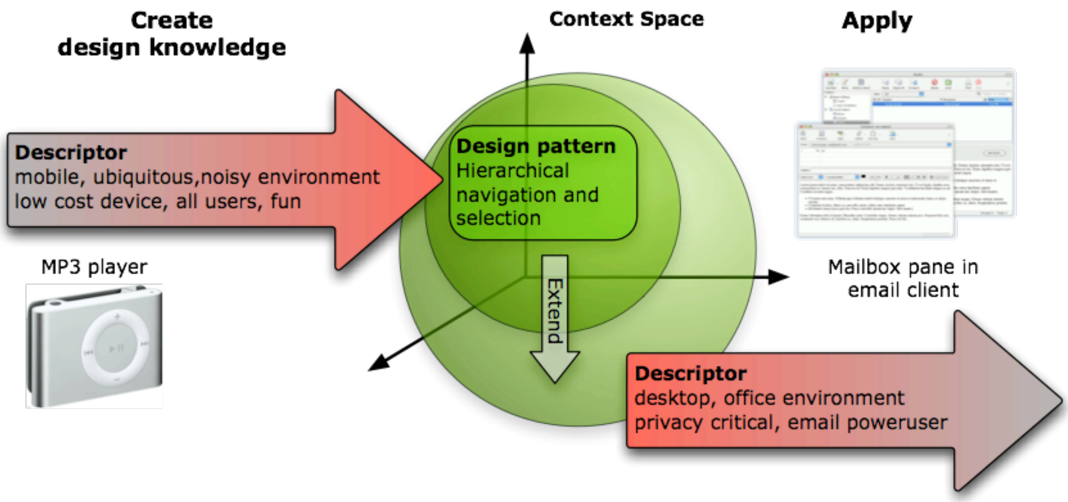
The above introduced the framework and illustrated the workflow through a concrete example of paco in the auditory domain - paco ad. In this section the benefits of the generic approach are summarised reflecting on the requirements we set out in section 1.3:

- paco enables designers to systematically create re-usable design knowledge from their expertise in the form of design patterns.
- Although developed for the design of auditory display, paco is a concept also useable in other domains; potentially supporting multi-modal interface design.

- Not multiple occurrences of similar solutions are the starting point for creating design patterns, but evaluated implementations. Hence, paco favours small or pre-mature scientific disciplines in which the small number of successful examples renders conventional approaches not feasible.

- The rating scheme ensures that successful patterns "live" and are ranked higher when multiple uses show the validity of the design knowledge, while others "die" and serve as examples of bad practice.

- The context space in paco allows for conceptualising the design space. This enables designers to systematically populate the design space with non-validated design knowledge that reflects their experience and expertise.



3.1 Evaluation

Evaluating a methodological framework such as paco and assessing its usefulness to the scientific field and its designers is a difficult endeavour. We have designed a study in which we intend to investigate the whole life cycle of design patterns - from creation to application and the feedback of refinements. More specifically, driven by the requirements we outlined above, we seek to answer the following questions by evaluating paco:

- ➡ Does paco enable expert designers to efficiently capture their design knowledge?
- ➡ Does paco support experts and novices in re-using design knowledge?
- ➡ Does paco help novices to create better designs?
- ➡ Is it easily accessible and productive?
- ➡ Is creativity and designer's craft supported?
- ➡ Can paco help designers to conceptualise the domain?
- ➡ Does it work with the limited number of successful designs available?

We intend to conduct two series of case studies: In the first phase we ask expert designers to create patterns from two of their most successful designs using the paco ad online system. Experts will be answering a questionnaire before and after using the system to probe for their design approach and changes in the conception of the design space.

In phase two, the design patterns created in phase one are presented to novices to the field. First, the novices are asked to describe the patterns in their own words and express what they think the main quality is the author intended to communicate. These descriptions are then fed back to the experts who wrote the pattern. Second, the novices get one of the more abstract patterns and a design brief matching exactly the one the expert was using as a starting point. Using paco ad the novices are asked to retrieve the relevant patterns from the online system. Finally, novices are presented with a design problem that is not similar, but close to one of the solutions described in the patterns. They then have one hour to sketch out a design; in a control group, novices create design solutions based on their intuition only. Participants of both groups are asked to present their solutions to a panel to assess the quality according to predefined heuristics. All design activities are video taped and followed by a post-questionnaire.

Methodologically we take a similar approach to the evaluation conducted for Ubicomp patterns by Chung et.al. (2004). The similarities between the scientific communities regarding size and maturity are evident. However, by extending the evaluation to cover not only the application of patterns, but also the process of creation and the conceptualisation of the design space we intend to add another important aspects to the study.

3.2 Tool support

The success of the framework will heavily depend on the momentum it can create in the community. Therefore, it is essential to make it widely available, accessible and appealing for designers. We intend to build an online information system with which designers can create and retrieve design patterns. As a basis for this development we will use the prototype currently used in the evaluation of paco ad. Also, the future development of ways to create auditory sketches would be highly beneficial as a tool to integrate in such an online tool.

In contrast to systems like CoPE (Schobert and Schuemmer, 2006) it aims not only to visualise the relations between the patterns, but also facilitate the navigation within the organising principle - the concept space - to localise design problems, real-world artefacts and patterns. However, many other aspects will have to be addressed similarly like collaborative editing.

4 Conclusion

What was it all about?

In this paper we presented a methodological framework for the design of auditory displays based on design patterns. We introduced the context space as the organising principle to navigate the design space and facilitate effective matching of design problems and design patterns. The workflow in paco ad considers the particularities of the design discipline and provides methods for creating, applying and maintaining design patterns. As next steps in the line of this research we intend to evaluate the usability and efficiency of the framework and to create an online information system to reflect the workflow in paco ad in a widely accessible design tool.

It is hoped that by introducing design patterns to this scientific field we can spark a community effort to build up a shared body of design knowledge.

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