Evaluating a Pattern Language as Shared Language for Interaction Design

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Abstract
Few studies have empirically evaluated pattern languages as a shared language for interaction design. In the HCI community, interaction patterns proliferate, but consensus on what constitutes a pattern language is missing. We evaluate four criteria required of a pattern language, and its impact on shared understanding.

Keyword
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ABSTRACT
Building shared understanding, between users and designers, through a common language for design appears to be a fundamental assertion shared between HCI and Architecture about pattern languages. Despite the popularity of interaction patterns, there are very few empirical studies evaluating this premise of a shared language for design. In this paper we briefly summarize our experimental design for a planned study involving users, designers, and pattern languages. We propose four criteria (cohesiveness, generativity, design guidance, coherence) to qualify a pattern language, and evaluate it using a pattern-sorting exercise. Preliminary findings show that a pattern language influences shared understanding, or a shared organization, irrespective of an explicit design task.

Author Keywords
Pattern Language, shared understanding, empirical study, interaction design

INTRODUCTION
Interaction patterns are a hot topic in HCI [13]! An interaction pattern captures the essence of solutions to a recurring design problem, in a specific context. While an interaction pattern targets a specific type of interaction problem, a pattern language consists of a cohesive network of related interaction patterns that might help design an interactive system of some kind, e.g. website, interactive exhibit, kiosk [10, 17].

Despite the popularity, there is a lack of empirical studies evaluating whether the premise of shared understanding through pattern languages is valid. Lack of empirical work on using pattern languages in HCI is its primary weakness [14]. The only three known controlled studies explored the benefits of pattern languages only with designers (or novice designers), not users [12, 27, 31]. It could be argued experts already have access to a pattern language of some kind, and hence may not be the right audience. [15, 16, 20] report the use of pattern languages within a participatory setting with users, but even though users reported a positive experience, it is difficult to differentiate the impact of pattern language from the facilitator’s expertise.

In this paper we briefly describe the experimental design for a larger controlled study involving both users and designers, and the impact of a pattern language on the design of interfaces. The study would evaluate if patterns languages are usable to both users and designers. The focus of this paper is on validating four criteria to qualify a collection of interaction patterns as a pattern language: cohesiveness, generativity, design guidance, and coherence, using a pattern-sorting exercise. This exercise evaluates whether exposure to a specific design task affects how pattern-users organize a collection, which satisfy the four criteria. Findings show that, to a large extent, users (of the language) are able to see a shared organization, independent of the specific task. This validated pattern language will be used in the main study.

RELATED WORK
This section reviews the origins of the pattern concept in architecture, and its subsequent adaptation by HCI and other design communities, notably Software Engineering (SE). This is followed by a summary of empirical studies on evaluating pattern languages in HCI.

Pattern Adaptations
The concept of a pattern is popular, and actively discussed, within SE and HCI communities. Origins of these adaptations, software design patterns and interaction patterns, lie in architecture. Christopher Alexander and his colleagues compiled a set of 253 patterns, which they published as “A Pattern Language” for architecture [2]. They claimed that each living space is designed to support a pattern of activities that takes place within this space. In more general terms, the form we design depends on the context. Furthermore, they argued, it was possible to extract a spatial arrangement of elements in the space that help minimize (remove) the misfit between the form and context, or resolves the forces that exist. The forces could refer to the opposing requirements we have from a space, e.g. communal rooms seek a balance between a feeling of community and privacy. In response, the Alcoves pattern ([2], p. 253) describes how we could design the space to resolve these opposing forces.

Software design patterns and interactions patterns are two notable adaptations of patterns in Architecture. Although
the pattern concept has inspired adaptations in other domains, e.g. groupware design patterns, pedagogical patterns, socio-technical patterns, SE and HCI are prominent having devoted more research attention to the discovery of patterns in their respective domains. This is evident in the number of published patterns [22].

Software design patterns have taken up the explicit goal of re-use of best practices in software design; object-oriented software design to be specific. These best practices describe how to build code that works, is efficient, and easy to maintain. Gamma, Helm, Johnson, & Vlissides [21], who are attributed for coming up with software design patterns, state the purpose of design patterns as a way to, "...help the designer to get a design right faster" (p.2).

In comparison, patterns and pattern languages in HCI have been proposed as a *lingua franca* for design [6, 18], a common language that could be used by designers and users to communicate. Carroll in his comments on [14], refers to patterns as a "powerful, yet simple idea that could be explored." He states patterns possess a "moderate level of abstraction", but are concrete enough to facilitate communication within, and among, users and designers. Importantly, "...they help to anchor design rationale and design values, making it easier for designers to articulate and manage the embedded meanings and consequences of their designs" ([11], p.2). The HCI community has asserted that HCI is more similar to architecture than software engineering. Fincher et al [19] suggest that

"It’s relatively easy to make an analogy between the domains of architecture and UI design, based on concern for the effect of a constructed artifact on personal and social behaviors … " (p. 1044).

[7] & [9] propose that interaction patterns should be readable to users, and usable to anyone with a stake in the design. Here, the patterns not only aim to serve as a format, but also aim to deliver design advice usable to designers and non-designers.

Author co-citation (ACA) studies in HCI [32] and design in general [4] have shown that Alexander’s work is viewed as contributing to Design Complexity and Theory research. ACA belongs to a larger body of techniques devoted to the quantitative study of academic literature. ACA implies relationships between authors based on the number of times two authors are cited together in one document (reference section). These studies show a degree of similarity between Alexander and Donald Schön (*Design Theorists*), Nigel Cross (*Design Taxonomists*), Horst Rittel and Chris Argyris (*Design Complexity*). This seems to validate that HCI cares about pattern languages as an approach to design.

**Empirical Studies**

Despite all that has been written about patterns and pattern languages in HCI, there is little empirical support verifying benefits of patterns and pattern languages in design, or validity of published patterns and pattern languages themselves [14]. Even fewer studies have explored the premise of pattern languages as a shared language for interaction design. Patterns have been frequently discussed for more than a decade in the HCI community. There is merit in the concept of patterns for the broad HCI community. But, while descriptions of pattern collections proliferate, discussions of pattern languages are fragmented.

Dearden and Finlay [14] in their survey of pattern languages report that empirical studies evaluating impact of pattern languages in design, or design process, remains its biggest weakness. To our knowledge only three controlled studies exist [12, 27, 31], but all of them evaluate the impact of a pattern language on the quality of the designed product with designers.

In a controlled study, Chung et al. [12] explored if pre-patterns were helpful for communication between designers, and if using pre-patterns yielded better designs in the area of Ubiquitous computing (Ubi-Comp). Pre-patterns by definition are not Interaction patterns, but represent candidate Interaction patterns emerging in Ubi-Comp. This controlled study compared use of pre-patterns by experienced and novice designers. They reported novice designers found pre-patterns helpful in understanding a new domain. The experienced designers rated pre-patterns higher in terms of allowing them to finish task quickly and overall usefulness for the task.

Saponas, Prabhaker, Abowd and Landay [27] empirically evaluated the impact of pre-patterns on early stage designs for digital home applications and communication of design ideas. The participants were professional designers with varying years of design experience. They determined pre-patterns lead to higher quality designs on the basis of fewer heuristic violations. The study found difference in the ratings for level of completeness and quality not significant.

Wania and Atwood [31] compared the impact of using pattern language on design of interfaces for an information retrieval system in a controlled study. This study also compares pattern language with heuristics. The primary contribution of this work is in the discovery of a information retrieval pattern language, which is being tested in the study. They showed that when provided with a pattern language, participants were able to see common
relationships among interaction patterns, validated by a pattern-sorting exercise.

**Pattern Languages and Shared Understanding**

A shared language for design and shared understanding could be considered as the primary contribution of a “A Pattern Language.” Pattern languages in HCI have been proposed as a way to compete with a growing diversity and complexity of interactive systems [6], to serve as a common language for interaction design.

In interaction design, the concrete and contextual nature of design advice in patterns and the generative nature of the language have the potential to embolden users to participate in the design process [18]. Providing design methods usable to users would allow them, if they choose so, to step out of the traditional informative and evaluative roles they are unintentionally cast into, to play a more participative role in design of systems being designed for them [3]. Such benefits cannot be easily overlooked by HCI, especially when interactive systems are pervading multiple contexts of use and spanning diverse stakeholders [5].

Given the significance of shared understanding to pattern languages, none of the controlled studies, described earlier, have explored this aspect of pattern languages. With the exception of [15, 16], these studies rely on evaluating pattern languages with designers, not users.

The availability of over 400 interaction patterns in pattern libraries or collections (web and print) [17, 22, 28], paired with reasonable maturity in how websites are designed and used, sets the stage for re-visiting the discussion on pattern languages and shared understanding. Research attention has persisted long on discovery of interaction patterns and not on building pattern languages. As a result, interaction patterns proliferate [22], but consensus on what constitutes a pattern language is missing.

In the following section we propose four criteria to qualify a pattern language, and describe how interaction patterns were chosen for the pattern sorting exercise.

**SELECTING INTERACTION PATTERNS FOR THE STUDY**

There are different perspectives in the literature on what constitutes a pattern language [23, 24, 29]. Based on a summary of views in the literature regarding pattern languages in HCI, this study proposes four criteria required of pattern languages: cohesiveness, by restricting the domain or narrowing the scope [24]; generativity, ensuring the connected nature of patterns [1, 8]; design guidance, guiding pattern users to feasible combinations of interaction patterns or qualifying conditions [26, 30]; and coherence, ability to yield concrete artifacts that could be validated against experience [1].

For this study, based on the proposed criteria, a pattern language for supporting an e-commerce buy transaction task was selected from a published collection of interaction patterns [17]. The E-commerce domain, and related buy transaction were chosen for two reasons: First, a reasonable degree of maturity of the domain ensured patterns were available in pattern collections; second, given the trend in e-commerce (B2C) transactions, there is a greater chance that the study participants have performed a buy transaction, thus allowing the participants to validate the presented interaction patterns against experience (concrete artifacts).

Design of Sites (DoS) [17], and van Welie’s Patterns in interaction design (PID) collections have interaction patterns clearly marked for E-commerce. Between the two, DoS collection was selected as the source for interaction patterns since it satisfies the four criteria mentioned earlier. During the selection process, some patterns were omitted if the referenced patterns did not pertain to the buy transaction. Using this process, thirty-nine interaction patterns were selected. For ease of sorting, as encouraged by similar studies [6], a one-page abridged version of each pattern was used instead of the two-three page long narratives available in print. These 1-page versions were edited so that references to patterns not included in this study were omitted.

**METHOD**

We first provide a brief overview of the larger controlled study before describing the pattern sorting exercise reported in this paper, to give readers better understanding of planned research.

The main study would assess the impact of a pattern language on shared understanding between users and designers. It will do so empirically by evaluating the outcomes (pay-offs) of a paper-prototyping exercise, completed by user pairs and designer pairs [12, 27], for a design task. This study argues, for a shared language, the users should be able to use it independent of designers, i.e. be an equal opportunity method. Two experts would judge the quality of paper prototypes using criteria derived from past studies [12, 27, 31]. The prototypes delivered by users would be compared to that created by designers to assess whether pattern languages in HCI are usable to users, and whether it contributes to a better design (comparison with control group). The pattern sorting exercise described below serves as an evaluation for the pattern language that would be used in the larger study.

**Participants**

Seventeen doctoral students in information studies participated in this study. All participants had prior experience buying products, e.g. books, on the Internet, and hence were familiar with the buy transaction. The larger study would make use of designer-designer pair and user-user pairs, but since this was a pilot experiment, some subjects were run as individuals and some as pairs. The breakdown is shown in the table 1 below. We understand mixing pairs and individuals may signal less than desired internal validity, we believe considering each pair as one
unit of analysis would help counter some of the bias in the presented findings.

<table>
<thead>
<tr>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 pairs</td>
<td>3 pairs</td>
</tr>
<tr>
<td>3 individuals</td>
<td>2 individuals</td>
</tr>
</tbody>
</table>

Table 1. Number of participants assigned to each condition

Procedure
As illustrated in Table 1, participants were divided in two groups. Both groups I & II received an alphabetical list of the 39 pre-selected patterns (one-page version). All participants received a brief tutorial on what was meant by an interaction pattern, by explaining the kind of information captured in the different sections of the Location Bread-Crumbs pattern [17]: what, use when, how, why, and related interaction patterns. Participants were then requested to sort the patterns into piles based on similarity (as perceived by them) between the patterns. They were permitted to have as many piles as necessary, even if a pile contained only a single pattern. They were provided sticky notes to name their piles as they go along, but were told not to worry if they could not find a suitable name for the pile.

The only difference in instructions between groups I & II was, Group-I participants were asked to first review a usage scenario before sorting the patterns. The scenario describes a user performing an online purchase. Following this, they were asked to sketch paper prototypes for interfaces that would support such a transaction. After drawing, Group I participants were asked to sort the interaction patterns such that someone new to this collection could use of the patterns for completing the described scenario. The sort data, which patterns were grouped into what piles, was recorded for data analysis to see if the participants have a shared understanding of the presented patterns.

Data Analysis
The sort data was input into a pattern co-occurrence matrix for analysis. Two such aggregate co-occurrence matrices were constructed, one for each group (exposure to task/no exposure) and subjected to cluster analysis and Multi-Dimensional Scaling (MDS) in parallel: SPSS procedure CLUSTER with complete linkages, or furthest neighbor, produced clusters of highly similar patterns; and SPSS procedure ALSCAL (non-metric method) was used to generate a two-dimensional representation of similarity between interaction patterns. An MDS map helps visualize the relationships between individual patterns in a two-dimensional space. In MDS, R Square (percentage variance explained) and Stress value (<0.2 usually acceptable [25]) are considered indicators of goodness of fit. The overall congruence between the two co-occurrence matrices (group I & II) was measured using Quadratic Assignment Procedure (QAP), which reports a Pearson correlation along with a test of significance. QAP analysis is a procedure used for determining the similarity between networks, and can be performed using UCINET-X analysis tool (QAP correlation procedure).

PRELIMINARY FINDINGS
Earlier, we proposed four criteria based on suggestions in the literature that we believe are required of pattern languages and which, we further believe, capture most of the criteria proposed by others.

For these criteria to be satisfied, we would expect to see two results in the sort data reported here. First, the sorts should be reliable. That is, they should show a great deal of coherence and little variability between subjects. Second, there should be minimal differences between the sort performed by subjects who considered a specific interaction design task and those who sorted with no task information.

That is exactly what our findings show—participants see a common organization for interaction patterns irrespective of the task.

Figure 1 (Appendix A) shows the cluster-enhanced MDS map1 of the pattern-sort data for the group-I who were exposed to the design activity. Hierarchical cluster analysis gave a four-cluster solution where patterns were grouped by WEB-PAGE ELEMENTS/STRUCTURE, USER-ASSURANCE & HELP, TASK-FOCUS, and TASK-CONTEXT. (For reasons of space, the dendogram showing the results of cluster analysis is omitted.) In this case, plotting the co-occurrence data in two dimensions yields a good fit, with a high percentage of variance explained (RSQ=0.97146) and a low stress value (0.077). It shows that the participants in this group see a common arrangement or organization of patterns.

Figure 2 (Appendix A) shows a cluster-enhanced MDS map of the pattern-sort data for the Group-II. Group II participants were not exposed to the design activity, but were asked to sort patterns independently of a given application. Cluster analysis of the sort-data generated a four-cluster solution where patterns were grouped by WEB-PAGE ELEMENTS/STRUCTURE, USER-ASSURANCE & HELP, TASK-FOCUS, and patterns related to design of a PRODUCT PAGE. Plotting the co-occurrence data in two dimensions yields a very good solution, with a high percentage of variance explained (RSQ=0.958), and a low stress value (0.089). In this case too, the participants see a common arrangement or organization of patterns, with two dimensions for distinguishing between patterns.

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1 Patterns with similar co-occurrence patterns are placed near each other. Those with many links are placed closer to the center of the map, and dissimilar patterns are further apart. Patterns in close proximity but belonging to different clusters have important secondary links or boundary spanners.
Irrespective of whether they were focused on a specific interaction activity, subjects show very cohesive groupings of interaction patterns. But, how similar are these groupings? The degree of similarity indicates the extent to which pattern languages are independent of a given context rather than just a convenient way to describe a given context. Of the 39 patterns, 28 (72%) of them retained their cluster membership when sorts by groups I and II were compared. The Pearson correlation value returned by Quadratic Assignment Procedure (QAP) is used as a measure of the overall similarity between the two networks, or in this case, co-occurrence matrix. The Pearson correlation was found to be 0.62, significant at p < 0.05, which indicates that there’s a significant degree of overlap in the mental models, irrespective of an explicit task.

The high degree of variance explained in the two MDS maps, and a significant correlation between the two co-occurrence matrices, show that a pattern language influences the shared understanding of how the interaction patterns are related.

FUTURE WORK
Preliminary findings from the pattern-sorting exercise show that pattern languages influence a shared understanding, i.e. how participants make sense of the collection. It also reveals that four criteria: cohesiveness, generativity, design guidance, and coherence, we proposed earlier in paper, help qualify a pattern language, which in turn promotes a shared understanding. We believe using a somewhat cohesive participant pool might have influenced the sorting, but the main study would account for this by comparing users with designers. This planned study would make use of the context. Of the 39 patterns, 28 (72%) of them retained their cluster membership when sorts by groups I and II were compared.

REFERENCES


Figure 1. MDS plot for task based sort group-I. RSQ= 0.97146, Stress= 0.077 (very good if < 0.1)

Figure 2. MDS plot for non-task based sort group-II. RSQ= 0.958, Stress= 0.089 (very good if < 0.1)