Patterns for HCI and Cognitive Dimensions: two halves of the same story?

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Abstract

This paper firstly surveys the search for Patterns and Pattern Languages (PL) in HCI, and examines some of the problems that the search has encountered. Secondly, some aspects of the Cognitive Dimensions (CD) framework are examined and I suggest that there may be a relationship between the two endeavours, to the probable enhancement of the pattern endeavour and the possible enhancement of the expression of the CD framework.

The first half of the story

To make a single narrative of the two endeavours of patterns in HCI and CDs, I shall have to start by telling two separate stories. However, these stories are not equal. I am an "insider" when it comes to patterns and an "outsider" with regard to CDs. So the patterns story is told from what I know …

What are Patterns and Pattern Languages?

Patterns (as such) were defined and named by Christopher Alexander in his two works *A Timeless Way of Building* (Alexander, 1979) and *A Pattern Language* (Alexander, Ishikawa, & Silverstein, 1977) within the domain of architecture specifically and the built environment generally. They espouse an approach to design—which is codified in the patterns—that focuses on the interactions between the physical form of buildings and the way in which that form inhibits or facilitates various sorts of personal and social behaviour (Bayle et al., 1998). Important aspects of Alexander's patterns are:

- they were devised with the express intention of providing a common vocabulary between users and architects, as well among architects themselves
- patterns are not created or invented; they are identified via an invariant principle (of good design) as manifest across different places and cultures (several examples are given in each pattern).
- they are structured around the problems that designers face, and those problems are addressed by the provision of a "solution statement". "Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander et al., 1977. p.x)

Each "pattern" follows a prescribed form that is based on evidence for, and examples of, the use of the pattern, together with instructions for how to achieve its effect. Each pattern is named, and illustrated with both photograph and a diagram.

NAME	(usually describes the effect of using the pattern)
A PHOTOGRAPH	showing an archetypal example of the pattern in use
AN INTRODUCTORY PARAGRAPH	which sets the pattern in the context of other, larger scale patterns
THE HEADLINE	an encapsulation of the problem (one or two sentences)
THE BODY	of the problem (this can be many paragraphs long)
THE SOLUTION	the heart of the pattern, always stated in the form of an instruction
A DIAGRAM	shows the solution in the form of a diagram
A CLOSING PARAGRAPH	shows how this pattern fits with other, smaller patterns

Figure 1. Alexandrian Pattern Format. The sections and descriptions are from Alexander (Alexander et al., 1977), the comments in brackets are mine

The 253 patterns that Alexander identifies are collected together into a pattern "language", which allows them to be used in combination with other patterns (often at different scales) so that whole environments can be constructed along these principles.

Since Alexander's specific construction, other groups have tried to replicate the approach in other domains (notably software, see: (Gamma, Helm, Johnson, & Vlissides, 1994),(*Patterns Home Page*, 2001) latterly pedagogy (*The Pedagogical Patterns Project*, 2001) and more recently, for "shaping the network society" (*DIAC*, 2002))

What are Patterns and Pattern Languages for HCI?

From at least 1997 (Bayle et al., 1998), some part of the HCI community has believed that patterns and pattern languages could have a place in the interaction design lexicon. There have been two forces, which have driven this:

- One is that it is relatively easy to make an analogy between the domains of architecture and UI design, based on concern for the quality of the affect of physical space on personal and social behaviours and the interplay between those spaces.
- The second is that Alexander's patterns (which have historically been the "first encounter" with patterns for most) are peculiarly and particularly seductive. The instructional format based on a distillation of considerable expertise "makes sense" to practicing designers; the subject matter is apprehensible to a lay audience, so everyone can relate at least one of his patterns to their own local environment and imagine how they "work"; lastly, but by no means least, they are compellingly and elegantly written.

Perhaps because of the strong (positive) reaction to Alexander's work, efforts to construct a PL for HCI have been dominated to date by a search for *form*. The order of the work has been that a number of specific patterns have been proposed, and a number of pattern-forms have been proposed. With the notable exception of Jenifer Tidwell (Tidwell, 1999) only very recently has there been work that starts to look at putting these individual instances together, in fragments of pattern languages.

What are the problems for Patterns and Pattern Languages for HCI?

One of the most often-cited problems of constructing a PL for HCI is the lack of variation within the domain. Architecture has a history of two millennia (at least) and the wealth of example from which patterns can be harvested is enormous. There are thousands of expressions of "windows" and the search for the recurrent examples of good design within that form is problematic and arduous work, certainly, requiring both critical insight and persistence, but is not hampered by a paucity of raw material. UI design is both far more recent and displays far less variety of artefact.

However, I have argued elsewhere (Fincher, 1999), (Fincher & Windsor, 2000) that the more pressing problem for HCI is the "language" that individual patterns might fit into, the structuring principle on which they are organised and the value system against which they are measured. For classificatory convenience, I refer to these two as being separate components of a PL, but they are clearly related and may, possibly, be the same thing.

To examine what I mean by "structuring principle" and to illustrate why I believe it to be of importance, I want to talk about some other efforts, in quite different domains, where something of the same kind can be seen.

A short digression into the Engineer's Sketchbook

I have been quite clear that Alexander invented "patterns", and coined the term, and for modern, practical purposes, that's not wrong. He was the first to codify design notions into such a form. However, there are other works which, whilst they cannot be said to be part of the same genre, certainly exhibit similarities. An interesting early example is the *Engineer's Sketchbook* (Barber, 1946), first published in 1889 (and which, going through seven editions, remained in print until the 1950's). This book was written to assist mechanical designers in their work. The author expresses his purpose thus:

> "Several valuable works have already found numerous users, and there is no lack of admirable collections of memoranda, rules and data for designing and proportioning the various constructive details of machinery; but, as far as I am aware, there is no work in existence which aims at the same purpose as is attempted in the following pages, viz. to provide side by side suggestive sketches of the various methods in use for accomplishing any particular mechanical movement or work, in a form easily referred to, and devoid of needless detail and elaboration. A sketch, properly executed, is—to a practical man—worth a folio of description; and it is to such that these pages are addressed"

For the purposes of this discussion, however, it is not this striking similarity of audience, or intent, that are the most interesting. It is the way in which Barber organises the components of his work—how he defines the "language" which structures his "patterns". He mentions this only *en passant*: "[my]… private notes and sketches, gathered promiscuously, until the difficulty of selection and arrangement became so apparent that I began to classify them, as they exist in the following pages" His subsequent classification is not of whole designs, nor yet of the *type* of designs—Boilers, Cranes, Steam Engines, Pumps etc.—it is by reference to something that lives outside of the work entirely: to the principles of mechanics. Consequently, in the section entitled "anchors" we find not only anchors for use at sea—mushroom anchor, double fluke anchor, Martin's patent anchor (with swivelling flukes) and rock anchor—but also fencing posts, wall eyes, a rope pulley anchor ("a car which grips by sinking its wheels into the soil; employed for ploughing tackle") an anchor plate, a screw mooring and, even, a heavy stone. The selection and grouping of the contents of this section would be quite baffling to someone unfamiliar with the mechanical concept, which underlies them all (and which is not itself explicated in the text). The structuring principle here is *local contextualisation of principle*. Barber expects that his audience will know their context and their problems, and be able to use his work to find a good solution.

A short digression into poetry

Another example of a structuring principle at work, perhaps more closely allied to a value system, can be seen in a recent anthology of poetry compiled by the UK Poet Laureate, Andrew Motion (Motion, 2001). In this work, the poems are arranged not alphabetically by author (or title); nor chronologically by when they were written, nor chronologically by when the author lived; nor categorically, by extrinsic categories discussed and agreed upon, such as "The Pre-Raphaelites", "The War Poets" or "The Metaphysical Poets". Here, the poems are arranged in a series of

ten concentric circles: Self, Home, Town, Work, Land, Love, Travel, War, Belief and Space. This arrangement is a profound embodiment of a structuring principle. We all have meanings for these categories and most of us can find one of more poems that we should like to place within them. But use of this structuring principle carries additional significance: the act of placement of a poem (within, perhaps, Work rather than Self) speaks to the values of a specific world-view, not a generic one.

By this structure we recognise something else, too: that the placing of a poem within one of these categories is as significant as the choice of poem itself. Then it becomes apparent that the relationship between the poems within a category (and the relationship of that category to another category) is also meaningful. The act of placement within this system is not merely one of organisational convenience, of being able to "put your hand on them" when you need them again (as would be the case with an alphabetic organisation). The structuring principle here is that the *structure is as important as the components*; symbiotically, and cyclically, the one is revealed by the other.

A short digression into Chemistry

In 1894 the Newland/Mendeleev Periodic Table did not include the "noble gases". William Ramsay was partly minded to look for Argon (and, in fact, did discover it) by noticing that there was a section in the Newland/Mendeleev table where it could fit: if it *were* to exist, there was already a place for it within the existing structure. The following year he discovered Helium, which he could also place: however, what he now had was the first and third elements of a new group. He expressed his dilemma thus "Here is a supposed gas, endowed no doubt with inert properties, and the whole world to find it in". Spurred by recognition of this "hole", he worked on, and identified Neon two years later (Davies, 2000)

This digression is, it might be said, written more in hope than expectation, but it could be imagined that *a strong structuring principle would be predictive*; allowing researchers to identify and seek out areas indicated by "holes" in the content.

The search for invariance

I have spent time dwelling on the purpose and nature of structuring principles and value systems, and some of their manifestations and potential combinations, because in part the search for patterns in HCI has been a search for invariance. This has been both masked and made apparent by the way the activity has developed. The patterns that have been proposed have had nothing to link them, to make them coherent. They may (or may not) each represent something good/useful/interesting, but they stand alone, or in "collections" that are collections only in as much as they have all been written by the same person or group (Tidwell, 1999), (*The Brighton Usability Collection*,, 1998). Where Structuring Principles *have* been proposed, they have focussed on common physical properties of interfaces (or aggregations of physical properties) or common usages (Fincher & Windsor, 2000), (van Welie, 2001). These organisations are both arbitrary and infinitely malleable; they represent nothing but temporary convenience. They are, "a neat way to capture a bunch of good ideas" (Alexander, 1996).

Now, invariance in Alexander *does not* come from the physical expression/codification of patterns—or from the physical properties of the spaces they pertain to—but from a particular quality of the relationship between physical and psycho-social space. In the first book to be published in the area *A Pattern Approach to Interaction Design* (Borchers, 2001) the patterns are sub-divided into three areas: the application domain (in this case blues music), HCI for interactive exhibits and software engineering for interactive music software. Invariance, the call to what is "good", is most apparent in the patterns of the application domain, where the appeal is to music-theory. As we have already seen, Thomas Walter Barber's invariance comes from physical laws and Andrew Motion's from a strong and certainly conceived world-view. Consequently, it would seem to be more fruitful to seek for the "invariant principle" for HCI patterns *away* from the practice that is captured in the patterns themselves.

The second half of the story

Unlike Patterns for HCI, I have not worked within the area of Cognitive Dimensions, nor participated in their construction. So I am much less intimate with the details of the arguments and the problems that CD "insiders" consider themselves to be facing. The story I tell here is constructed from the CD literature and my construction may be wrong—authors seldom tell "where the bodies are buried" in published work.

What are Cognitive Dimensions?

Cognitive Dimensions are conceived of as a descriptive and evaluative tool. A set of concepts that give designers a common vocabulary (and therefore a common way to think about) designed artefacts. Because their primary referent is to the cognitive domain, the type of artefact to which they relate is very broad, encompassing "notational systems" from pen-and-paper representations, such as sheet music, through word processors also including "information artefacts" which have a physical representation, such as radios and watches.

Deliberately constructed to be "broad brush", couched in apprehensible language, and focussed on users and their tasks, around a dozen dimensions are commonly agreed to constitute the core of the framework (Green, 1996), (Green & Blackwell, 1998), although there are others proposed (Blackwell, 2000):

- Viscosity: resistance to change
- Visibility: ability to view components easily
- Premature commitment: constraints on the order of doing things
- Hidden dependencies: important links between entities are not visible
- Role-expressiveness: the purpose of an entity is not readily inferred
- Error-proneness: the notation invites mistakes and the system gives little protection

- Abstraction: types and availability of abstraction mechanisms
- Secondary notation: extra information in means other than formal syntax
- Closeness of mapping: closeness of representation to domain
- Consistency: similar semantics are expressed in similar syntactic forms
- Diffuseness: verbosity of language
- Hard mental operations: high demand on cognitive resources
- Provisionality: degree of commitment to actions or marks
- Progressive evaluation: work-to-date can be checked at any time

If the space that these cognitive dimensions define is "notations", the way in which the dimensions work within it is analogous to "capturing physical laws" and therefore (in the manner of physical properties) demonstrating the precise demands of trade-offs.

> "I like to compare the cussedness of information structures with the behaviour of idea gases. Three quantities, temperature, pressure and volume, describe an ideal gas. If you want to increase the temperature, you can keep the pressure constant (but the volume must be allowed to increase) or you can keep the volume constant (but the pressure must be allowed to increase). Taken in pairs, these three dimensions are orthogonal. But you cannot raise the temperature while holding constant both the pressure and the volume" (Green, 1996)

What are the problems for Cognitive Dimensions?

As CDs have evolved from a being an idea devised by researchers into a tool being used by practitioners outside of the originating group, some problems have emerged. Both these problems are concerned with usage, and both are concerned with notions of transfer of knowledge. They seem to be: the problem of how CDs actually operate and the problem of how a CD novice can find out what situations typify at least the ends of the dimensions, if not all the graduations in between.

The problem of how CDs operate "for real" is not as simple as expressed in the model. Unfortunately, design trade-offs are not constraining in the same way as physical laws. A rise on one axis doesn't *necessitate* a drop on another, and not all dimensions may be pertinent to any given "notational system" under consideration. These problems have led to refinements and further formulations—of "activities" and "profiles"—to constrain the number of CDs which are relevant to specific systems, and, equally, to use those constraints to delineate a smaller area within the larger structure that CDs represent.

At the same time, these formulations have been marshalled into service to address the problem of describing CDs to new users. In a way, these "profiles" seem to be taking the form of "situated (design) sketches" giving practitioners a "way in" to the CD properties and the framework as a whole. However, there is little consensus on what those descriptive sketches should consist of, or of how they should be formed to best effect. The lack of commonality in these expressions (of content or form) makes it hard for a newcomer to select or compare CD approaches.

The search for form

I see these problems as being manifest within the CD endeavour as a search for form. Here is a list of the problems of description and formulation from a recent publication: *Cognitive Dimensions of Notations: Design Tools for Cognitive Technology* (Blackwell et al., 2001):

> object of description; effect of manipulation; applicability; polarity; choosing names; length of name; vernacularity; supporting apparatus; examples; pictorial examples; impact; trade-offs; sources; manoeuvres and workarounds

In that paper, they are presented *as* problems—sort of a series of "open questions"—which the CD endeavour has to resolve to move forward

A new story?

So, it seems to me that HCI patterns are strong in that they have a well-developed, effective and expressive form, but weak in structure/call to invariance, and have an impoverished set of examples to draw from. CDs are strong in structure and invariance, and encompass many domains of artefact, but weak in defining the relationship of parts to the whole, and in their expressive form. Might the deficiencies of one system complement the other?

It is interesting to note how closely elements of the list describing constituents of a CD form (as listed above) map the essentials of a pattern-form. (The form I have chosen to use is that of the INTERACT'99 workshop as being a fairly representative minimum.)

Pattern	
Name	Should encapsulate the pattern's intent. Ideally, short and pithy
Sensitising example	A concrete example of implementation of the pattern. In Alexander, the photograph conveys this example of implementation, in GoF patterns (Gamma et al., 1994) it is the code sample. We took it that the purpose of these components is to sensitise the reader to the application of the pattern. "In looking at the photograph, a reaction is invoked. The intention is that the reaction is favourable-"Wow, that's good. I'd like to live there"-and from that point the reader is

	sensitised so that the information that the rest of the pattern contains becomes more accessible, more useful in a specific implementation". Our expectation was that for UI patterns, this example would most likely be a photograph or a screenshot of an interface, or (depending on medium) possibly a video of a task being accomplished.
Problem Statement	Normally expressed as a conflict between forces
Body	Textual description
Solution Statement	Tells you what to do, not how to do it
Technical representation	We considered this to address the audience of HCI experts, rather than users, or experts in other domains (i.e. the audiences most receptive to the sensitising example). It differs from the sensitising example in that it should represent the solution less impressionistically and with less potential for ambiguity. A possible medium might be UML
Related Patterns	Other patterns which either: are peer to this one, enhance this one or complete this one.
Attribution	

Figure 2. INTERACT' 99 Pattern Format. From The Pattern Gallery (Sally Fincher, 2000)

CD	
Choosing names; length of name	It seems like one or two words should be enough
Pictorial example	It would be very useful for every "killer example" to be supported by a pictorial illustration
Examples; vernacularity; supporting apparatus	CDs should sound both technical and approachable at the same time A CD is more than just a name and a definition … all … are supported by a range of documentary and tutorial apparatus
Impact	Different dimensions have different impacts on various activity types and profiles
Sources	Research sources should be cited … to give appropriate credit to previous researchers

Figure3. CD format. From Cognitive Dimensions of Notations: Design Tools for Cognitive Technology *(Blackwell et al., 2001). The phrases are all abstracted from the text of the paper.*

So, matching the expression of what would be *desirable* as a form for capturing examples of CDs against what has been well-worked with regard to patterns, we can see an interesting commonality:

CD	Pattern
Choosing names; length of name	Name
Pictorial example	Sensitising example
	Problem Statement
Examples; vernacularity; supporting apparatus	Body
Impact	Solution Statement
	Technical representation
	Related Patterns
Sources	Attribution

Figure 4. Comparison of elements of pattern-form and CD-form.

So, we can see there is a good fit between the sorts of things these two endeavours are trying to express. However, there remain elements from the CD list that are not represented here. These break down into three groupings:

"Object of description"

"There is an outstanding question regarding what it is that the dimensions are supposed to describe"(Blackwell et al., 2001). This problem is one that is shared by the patterns endeavour. It remains unclear precisely what nature of practice a pattern captures: whether it is a component-level widget deployed at implementation to addresses a specific need, or a principle to guide the choice of given functions, or a codified example of higher-level principles, or something else entirely (S Fincher, 2000). At the moment, examples of all these levels and types of practice can be found described within different HCI pattern collections.

"Applicability" "trade-offs" and "manoeuvres and workarounds".

The problem that this group represents for CDs is the relationship of the framework to actual design practice, and the articulation of the areas of practice to which particular dimensions apply. In an attempt to address similar problems, there is a section in many HCI pattern-forms, called "forces".

> "…patterns generally solve a problem of conflicting 'forces', or interests"
> "Since patterns should always capture design solutions that balance the various interests in a useful way, it should always be possible to express those conflicting interests as opposing 'forces'"
> "The forces further elaborate the problem statement. They are aspects of the design context that need to be optimised. They usually come in pairs that contradict each other". (Borchers, 2001)

As it happens, I disagree with the inclusion of 'forces' within a pattern-form. I believe that, for patterns, 'forces' are an attempt to second-guess the local context of the designer; if a pattern is appropriate to a situation I believe that a designer can be trusted to find it appropriate without being told what they already know about their situation. Nevertheless, it can be seen that "applicability" "trade-offs" and "manoeuvres and workarounds" could be mapped to "forces" where a pattern-form included them.

"Polarity" and "effect of manipulation".

As these facets are not so easily construed from their names alone, it is worth repeating their definitions here:

- Polarity: "As CDs are not supposed to be either good or bad … they should have interesting properties in both directions"
- Effect of Manipulation: "It ought to be possible to consider each dimension and say 'if you change the design in the following way, you will move its value on this dimension'. This is a criterion of understanding how the dimension works …"(Blackwell et al., 2001)

If we consider the use of a pattern-form to describe points within the CD framework then these facets have their expression not within the pattern-form itself, but by the position of a pattern within the CD framework. In this way, "polarity" might be articulated by the location of a pattern along a CD, and/or its situation within the framework as a whole: "effect of manipulation" might be indicated by the relationship of a pattern to its neighbours. These could be captured within the "related patterns" section of a pattern-form (or a suitably modified section).

This provides a more comprehensive match of the CD and pattern elements:

CD	Pattern
Choosing names; length of name	Name
Pictorial example	Sensitising example
	Problem Statement
Applicability; trade-offs; manoeuvres and workarounds.	*Forces*
Examples; vernacularity; supporting apparatus	Body
Impact	Solution Statement
	Technical representation
Polarity; effect of manipulation	Related Patterns
Sources	Attribution

Figure 5. More complete comparison of elements of pattern-form and CD-form.

What Patterns might bring to CDs

As I have explored above, the content areas required to describe CDs are well-matched to the constituents of patterns. Adopting the powerful and expressive form of patterns might bring an explanatory power to the use of CDs. For instance, the form might be used to characterise the ends of dimensions, providing a more apprehensible "way in" for the new user: or they might be used to illustrate the points of intersection between CDs, exemplifying design trade-offs.

However, there is a less obvious property of the pattern-form that has additional implications here. What patterns might bring to CDs is not only form, but value. "Design"—in whatever medium—is a creative, value-laden activity, and patterns are expressly motivated by values; these are made *apprehensible* through the distinctive pattern-form and *applicable* by their instructional nature. The pattern-form is explicitly structured to capture *good* practice, *good* design. If patterns might be thought of as kind of map, they don't show the bad places.

CDs, in the very language of their discourse, eschew values for an objective representation of a space: they attempt to delineate "physical laws" as we have seen above, but the language of objectivity pervades their description: "…CDs are not supposed to be good or bad …" and " … it should be possible to describe the characteristics of a dimension without any evaluative emphasis …" By definition, CDs map an *entire* space, completely, with no instructional directions. They provide co-ordinates, but no cardinality. To explore what I mean by this notion I want to examine two illustrative examples from architecture.

A short digression into Architecture

When placing a building on a site, then "north" is a vital, and objective, component. A designer has to be familiar with, and works within, the space that the compass describes. Like any other building, when the Desert House (Hulen, 1999) was constructed, orientation was, of course, an important consideration.

However, the values that informed the construction of the Desert House—energy and water conservation techniques to make houses in hot arid regions more energy and water efficient—made it important to utilise passive solar heating. In the northern hemisphere, the winter sun appears low on the southern horizon, providing heat and light directly on south facing walls. During the summer, the sun appears higher in the southern sky while the walls are shaded by the roof overhang or other structures. So, the aspect of the summer and winter sun was a more crucial consideration here, and ultimately the axis against which they oriented the design of the building.

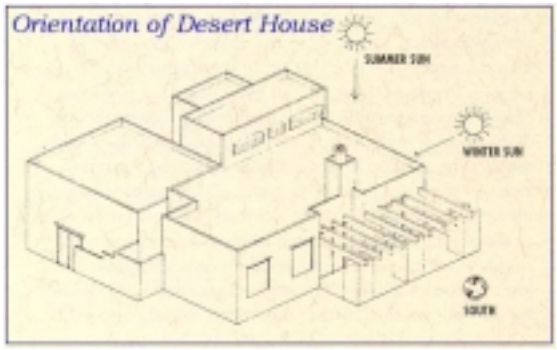

Figure 6 Orientation of the Desert House, Desert Botanical Garden, Phoenix, Arizona. http://www.dbg.org/center_dl/dh_passive_hc.html

This orientation does not invalidate the idea of "north"; it just is not of value in this design.

In a similar vein Frank Lloyd Wright, recognised the importance of value driving design when he drew up his (unrealised) plans for a new city of Baghdad. Here, none of his drawings use the standard compass rose. Instead, he perceived a more profound set of values governing use of the space, and labelled his plans with "To Mecca" defining the cardinality, where one would more usually expect to find "north".

The issue here is that whilst CDs may "completely" describe a design space, the *activity* of design is not to describe, or to observe, or to map: there is no non-interventionist objectivity about design: to design is explicitly to intervene.

If a pattern-form, with its inherent call to value, can be used to characterise CDs, then it may be that users—designers—might find that an easier way into CDs. It may be that "profiles", "activities" and "clusters" can be profitably identified by the values that inform their use.

What CDs might bring to patterns

If the invariance for HCI Patterns might be better sought away from the artefacts that provide the sources and examples for the patterns, then might this not be CDs themselves?

The elegance of the nature of the invariance that CDs provide is their grounding in, and adherence to, the cognitive domain, separate from the physical expression of any given system. The richness of that domain, and the quantity and complexity of "notational systems", would allow a deeper and, I believe, more interesting exploration for the pattern endeavour.

If CDs can be used as a value system for patterns then perhaps we would see different patterns emerging, because "Patterns don't justify the values they embody; the values inform the identification of Patterns."(Fincher & Utting, 2002). Additionally, it may be that different relationships between patterns would emerge, and an apprehension that the placement of a pattern along a specific dimension (or graphed as a combination of points along several CD axes) might be as important as the problem the pattern exemplified and the solution that it offered. (á la Andrew Motion, above).

If CDs can be used as a structuring principle for patterns, it would allow a selection and grouping of patterns which are similar in principle, but which may be currently dispersed (á la Engineers Sketchbook, above); perhaps, even, it would allow designers to look at a less-populated area of the structure and predict what it should contain (á la Ramsay, above).

Summary

In this paper I have looked at some ways in which Patterns and Cognitive Dimensions may be related, and where they may complement each other. I have suggested that CDs could be the invariant principle—the value system and structure—that the HCI pattern endeavour has so far lacked, and that patterns may provide the form for the detailed pragmatic expression of the CD framework.

References

As well as works specifically referenced in this paper, there are several collections on the web which provide excellent overviews of the areas:

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- Jan Borcher's *HCI Patterns Pages*: http://www.hcipatterns.org
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