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VISUAL DESIGN PRINCIPLES: AN EMPIRICAL STUDY OF DESIGN LORE

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ABSTRACT

Many books, designers, and design educators talk about visual design principles such as balance, contrast, and alignment, but with little consistency. This study uses empirical methods to explore the lore surrounding design principles. The study took the form of two stages: a quantitative literature review to determine what design principles are mentioned most often in discourse on design, and a card sorting exercise to explore the relationships designers, design educators, and design students saw among the most common design principles. Along with the card sorting exercise, I used pre- and post-exercise surveys to gauge how participants felt and thought about design principles and their use in design practice.

INTRODUCTION

From the Arts and Crafts of William Morris through the Bauhaus of László Moholy-Nagy and beyond, design built a tradition based on genius. Designers used a finely honed instinct to fashion objects that were useful and beautiful. In discussing and promoting their craft, they developed sometimes codified and sometimes implicit design principles to guide new designers. Accordingly, training in design often involved learning these principles, as we can see in Jackson's popular 1891 textbook *Lessons on Decorative Design*, which discussed and gave examples of principles such as repetition, variety, contrast, radiation, and symmetry [1].

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http://baywood.com

However, in more recent decades the movement toward design research has grown from a trickle to a torrent. This movement began as designers, influenced by the scientific management of Henry Ford and Frederick Taylor, attempted to justify and guide design empirically, often through market research. Beginning with the founding of the Design Research Society in 1966, these methods were developed into a consistent approach to design methodology. In the 1990s our attention shifted to usability and usability testing, such as popularized by Nielsen [2], Barnum [3], and many others. User-centered design, championed by scholars such as Johnson [4], became the watchword in fields including graphic design, product design, and technical communication. Today, design research has designers involved throughout product development in an iterative design cycle that applies research to successive prototypes, continually improving usability. The state-of-the-art of user research includes systems that continuously monitor user interaction, gathering data for designers to use to make further improvements to websites, software, and hardware (see for example Johnson [5]).

One would think from this narrative that we have progressed from the murky days of the craft tradition to the more enlightened and progressive landscape of empiricism. But, in fact, design training still typically involves an introduction to visual design principles, which persist as criteria for judging designs and as heuristics for making design decisions. Many instructional books in graphic and document design include visual design principles. Nielsen [6], the oft-proclaimed guru of usability, recommends expert heuristic evaluation using design principles as a valid usability research method. There's even a recently-started online journal entitled *Design Principles and Practices* [7].

This persistence invokes some questions:

- What is a design principle?
- How do design principles relate to each other?
- How and when do designers use design principles, particularly in these days of user-centered, research-driven design?

None of these questions have straightforward answers. Although many authors refer to design principles, hardly any define what they mean by the term. A few, such as Williams and Stimatz [8] or Blair-Early and Zender [9] generally refer to design principles as "rules of thumb"; as such, principles are heuristic methods that help us make design decisions quickly. But these rules of thumb can be variable and ambiguous, because they are based on individual designers'experience and on the advice they absorb from their training and reading. Depending on the situation, designers may employ different design principles at different levels of consistency. Designers, in fact, often talk about the need to "break the rules" on occasion to bring attention or interest to a design. Some designers even deny using design principles at all, arguing that they rely on instinct, artistic sensibilities, or a "good eye." This ambiguity leads Johnson to comment that these

principles "are not written in stone at all, but in something more like finger jello: loose, pliable, and hard to pick up" [10, p. 58].

So at best, design principles are a kind of lore. Lore is a kind of contingent knowledge based in practice, and as North has argued for composition studies, it has a value that is often overlooked. However, lore being what it is—anecdotal, implicit, and often idiosyncratic—I think there is good justification to bring research to bear on it. Accordingly, in this article I apply empirical techniques to understand the lore of design principles more fully.

This study took the form of two stages: a quantitative literature review that catalogued and analyzed visual design principles mentioned in books and websites on design; and a card sorting exercise with survey questions (Texas Tech University IRB 100407). The first stage investigated what visual design principles published experts recommend most often. The second stage asked designers, design educators, and design students what they thought about design principles and how they thought design principles related to one another.

Two articles, Ahmed [12] and Park [13], have taken a similar approach as stage one of my study by looking at the design principles listed in published texts to find some sort of general picture. My study differs from these in three important ways. First, I examined significantly more sources, 47, than Ahmed or Park, with 14 and 10, respectively. While 47 sources hardly exhausts the many sources that mention design principles, spreading my net more widely gave me a more comprehensive picture than these other studies offer. Second, neither Ahmed nor Park analyzes how many authors refer to specific design principles, which I think leaves an important piece of data on the table—frequency. Third, both Ahmed and Park combine and categorize a raw list of design principles into a smaller list based on the author's own design sensibilities or some exterior theory—Static, Dynamic, and Neutral for Ahmed, and Yin and Yang and the Five Elements for Park. I used a card sorting exercise to explore empirically how designers, design educators, and design students arranged these principles.

QUANTITATIVE LITERATURE REVIEW OF VISUAL DESIGN PRINCIPLES

Literature Review Methodology

To gather the lore surrounding visual design principles, I examined 47 texts published from 1904 to 2011. These texts included books, textbooks, scholarly articles, and websites that focused on visual design, web design, graphic design, typography, and similar subjects. I excluded texts if they focused on design principles in some significantly different area than these: for example, Brown and Ruf [14] discuss software design principles, Rosario and Widmeyer [15] discuss game design principles, and Kali et al. [16] discuss educational technology design principles (see Table 1).

Table 1. Texts Used in Quantitative Literature Review

Anderson [17]	Faigley et al. [18]	Lynch and Horton [19]	Selleck [20]
Ball and Arola [21]	Gatto [22]	McClurg-Genevese [23]	Skaalid [24]
Batchelder [25]	Graham [26]	Meggs [27]	Stewart [28]
Beaird [29]	Hashimoto [30]	Odell and Katz [31]	Vegh [32]
Bear [33]	Horn [34]	Palmquist [35]	Webb [36]
Berger [37]	Kimball and Hawkins [38]	Peterson [39]	White [40]
Brainard [41]	Kostelnick and Roberts [42]	Pettersson [43]	Williams [44]
Bringhurst [45]	Lauer [46]	Porter [47]	Williams [48]
Carter [49]	Lauer and Pentak [50]	Präkel [51]	Wong [52]
Chen et al. [53]	Leborg [54]	Reynolds [55]	Yeh and Cheng [56]
Dondis [57]	Lidwell et al. [58]	Rhead [59]	Zelanski and Fisher [60]
Evans and Thomas [61]	Lupton [62]	Schriver [63]	

These 47 texts are naturally only a portion of publications that refer to visual design principles, but I collected materials widely by searching for the terms *design principles* and *principles of design* in library databases, Google, Google Books, Google Scholar, WorldCat, MyiLibrary, NetLibrary, Safari Books Online, and the Internet Archive. I also had to set a cutoff point beyond which I would not include further texts in the study; inevitably, after that point I discovered texts I wish I could have included, such as Jackson [1] and Lupton [64].

Many of these texts explicitly use the terms *principles of design*, *design principles*, or *graphic design principles* to describe their collection of principles. However, I did not necessarily exclude texts that used other terms. For example, White used the term "design components," but listed concepts that multiple other authors more explicitly identify as design principles, such as balance, hierarchy, space, and unity. Not having a settled definition of design principles prior to the study (which I hoped would help reveal such a definition), I chose to let the texts themselves determine their inclusion.

So my general criteria for including design principles in my data set were as follows:

- Include as a design principle whatever a text calls a design principle or something similar.
- Include as a design principle any principle labeled as such in other texts, even if the author does not explicitly call it a "design principle."

Similarly, I found considerable variation in the terms used to describe individual design principles, which led me to regularize the data set somewhat. For example, some authors refer to "symmetry" (Chen et al. [53]; Lidwell et al. [58]), while others refer to "symmetry and asymmetry" (Meggs [27]; Lupton [62]) or to "symmetry/asymmetry" (Leborg [54]). Or some authors (Bear [33]; Lupton [62]) refer to "white space," while others refer to "space division" (Brainard [41]), to "spatiality" (Berger [37]), or just to "space" (Wong [52]; White [40]; Leborg [54]). In cases where there is a relatively clear central term, I used the central term. So for "symmetry," "symmetry and asymmetry," or "symmetry/asymmetry," I settled simply on *symmetry.* Or if most authors use one term, I substituted that term for the variants; for example, because three of the seven authors describing space simply use the term "space," I substituted *space* for "white space," "space division," and "spatiality."

However, if an author combined related terms that other authors listed individually (for example, "similarity and contrast" in one work as opposed to "similarity" and "contrast" in another), I divided those terms so as to consider them separately (*similarity*; *contrast*). (This differs from the case of "symmetry and asymmetry" mentioned above because no text referred to "asymmetry" by itself.) Also, if authors used similar terms to describe different concepts, I kept the entries distinct. For instance, while the concepts might be related, Wong's [52]

description of the principle "form" differs considerably from Lidwell et al.'s [58] inclusion of Louis Sullivan's dictum, "form follows function."

Conversely, if authors used distinct terms to refer to a similar concept, I let the distinct terms remain separate. Park [13] claims that "Dominance [sic] principle is compatible to Emphasis [sic] principle that determines the visual weight of a layout." But we have only Park's sensibility to rely on in making this connection. In my study, four texts used the term *dominance* (White [40]; Leborg [54]; McClurg-Genevese [23]; Anderson [17]), and 14 used the term *emphasis* (Gatto [22]; Zelanski, and Fisher [60]; Lauer [46]; Skaalid [24]; Graham [26]; Carter [49]; Ball and Arola [21]; Stewart [28]; Brainard [41]; Faigley et al. [18]; Palmquist [35]; Beaird [29]; Lauer and Pentak [50]; and Pettersson [43]). No text used both terms. These terms may well describe the same central principle, but I kept them separate so participants in the second stage of my study could determine whether such was the case.

Finally, in one case I excluded duplicates because a single author used the same design principles in more than one work: *contrast*, *repetition*, *alignment*, and *proximity* in Williams [44] and Williams [48]. This brought my list of texts to 46.

Literature Review Results and Discussion

This quantitative review produced a raw list of 198 design principles. This number might seem discouragingly high except for two outlying works: Leborg [54], which lists 41 principles, 33 of which are unique, and Lidwell et al. [58], which lists 100 principles, 87 of which are unique. Lidwell et al.'s broader focus on "universal principles of design" rather than visual design principles means that many of their principles fall outside of the scope of my study. (Some even stretch the concept of design principle—for example, "uncertainty principle" and "normal distribution.") If we were to exclude Leborg's and Lidwell et al.'s unique principles, the list of design principles contracts from 198 to 77—still high, but more reasonable. However, because I included unique principles from other texts, I retained all of Leborg's and Lidwell et al.'s principles in the raw list.

As might be expected, some of these principles are considerably more common than most. Overall, of the 198 principles in the raw list, 160 were mentioned in only one work. The 198 design principles were listed cumulatively 420 times in the 46 texts; 61.9% of these listings referred to principles used in at least two works. Despite the large number of unique principles, they were used only in 38.1% of texts.

While the unique principles may have some heuristic value, they are clearly not as widespread in the lore of design as other principles, so I excluded them from the card sorting exercise. Doing so produced a final list of 38 visual design principles referred to in at least two of the 46 works (see Figure 1). Figure 1 visualizes the frequencies of the most common principles in a Pareto chart, excluding the long tail of individual mentions.

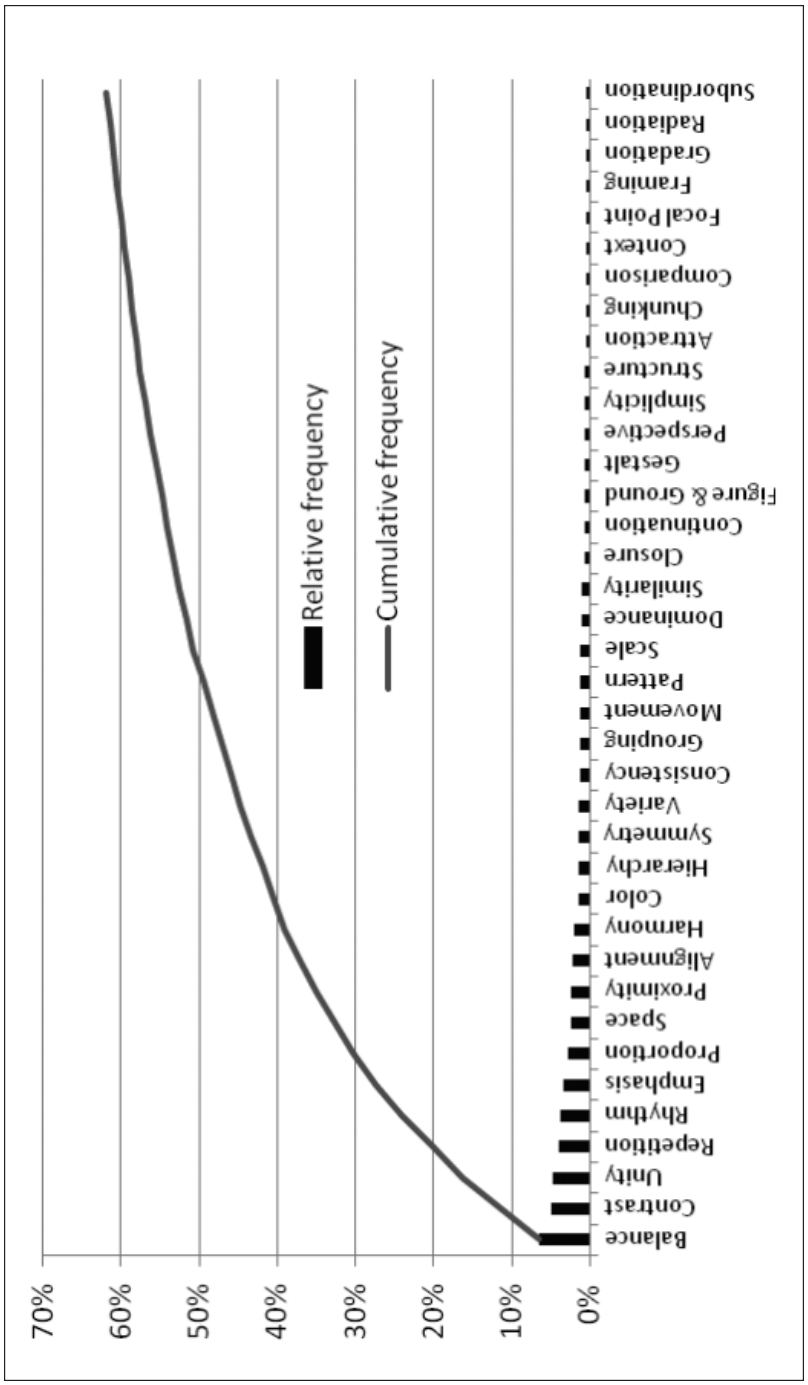

Figure 1. Frequencies of principles mentioned by two or more works.

On average, texts included 9.24 principles each. However, if we exclude the unique principles from Lidwell et al., the average is 7.35 principles per work; if we also exclude Leborg, the average is 6.3 principles per work. If we include only the 38 principles mentioned in two or more works (that is, excluding all of the unique principles), the average is 5.65 principles per work. These figures suggest that despite the 198 principles in the raw list, for most authors a relatively small handful of principles, perhaps 5-7, serves most purposes.

These results offer some interesting opportunities for reflection. For example, *balance*, which I have always denigrated to my students as the most vague and difficult of design principles, actually turns out as the most common, with 27 texts (58.7%) listing it. Gestalt itself, despite the very strong influence of this school of psychology on two-dimensional design, appeared in only three texts (6.52%), although principles based on the Gestalt laws, including *alignment*, *proximity*, *grouping*, *closure*, *continuation*, and *figure/ground*, appeared as well at a variety of frequencies.

While the resulting 38 principles are obviously not the only ones used by designers or design writers, they are the ones most often conveyed by these texts on visual design (see Table 2).

VISUAL DESIGN PRINCIPLES CARD SORTING EXERCISE

Having determined which design principles are mentioned most commonly in literature on design, the next question is, how do these design principles relate to one another? Rather than arranging the design principles according my own sensibilities or some separate theory (Ahmed [12], Park [13]), I decided that it would be more interesting to ask practicing designers, design educators, and design students how they think these 38 visual principles should be grouped.

By design educators, I mean professional educators who teach design either as a primary focus or as a part of their primary focus. By practicing designers, I mean people who do design as part of their professional work. By design students, I mean people currently studying to become practicing designers or design educators.

Card Sorting Methodology

To answer this question, I conducted an online card sorting exercise. Card sorting is a flexible technique for discovering how people group items. Designers and usability experts often use this technique to help determine information architecture, such as for website navigation orproduct list arrangement [65, 66].

This approach does involve some limitations for my study. Under small, closely controlled studies, such as those for information architecture, it is

Table 2. Design Principles Appearing in Two or More Works

Principle	Frequency	% of works	Relative frequency (%)	Cumulative frequency (%)
Balance	27	58.70%	6.43%	6.43%
Contrast	21	45.65	5.00	11.43
Unity	20	43.48	4.76	16.19
Repetition	17	36.96	4.05	20.24
Rhythm	16	34.78	3.81	24.05
Emphasis	14	30.43	3.33	27.38
Proportion	12	26.09	2.86	30.24
Space	10	21.74	2.38	32.62
Proximity	10	21.74	2.38	35.00
Alignment	9	19.57	2.14	37.14
Harmony	8	17.39	1.90	39.05
Color	6	13.04	1.43	40.48
Hierarchy	6	13.04	1.43	41.90
Symmetry	6	13.04	1.43	43.33
Variety	6	13.04	1.43	44.76
Consistency	5	10.87	1.19	45.95
Grouping	5	10.87	1.19	47.14
Movement	5	10.87	1.19	48.33
Pattern	5	10.87	1.19	49.52
Scale	5	10.87	1.19	50.71
Dominance	4	8.70	0.95	51.67
Similarity	4	8.70	0.95	52.62
Closure	3	6.52	0.71	53.33
Continuation	3	6.52	0.71	54.05
Figure/Ground	3	6.52	0.71	54.76
Gestalt	3	6.52	0.71	55.48
Perspective	3	6.52	0.71	56.19
Simplicity	3	6.52	0.71	56.90
Structure	3	6.52	0.71	57.62
Attraction	2	4.35	0.48	58.10
Chunking	2	4.35	0.48	58.57
Comparison	2	4.35	0.48	59.05
Context	2	4.35	0.48	59.52
Focal Point	2	4.35	0.48	60.00
Framing	2	4.35	0.48	60.48
Gradation	2	4.35	0.48	60.95
Radiation	2	4.35	0.48	61.43
Subordination	2	4.35	0.48	61.90

possible to use sophisticated statistical techniques to analyze the results. In part, this sophistication is made possible by the control the researcher has over the items to be sorted. As Spencer suggests, "The content you use in the card sort has to be similar enough to suggest potential groupings. . . . You can choose to leave some content items that don't have obvious partners in the deck in order to learn something about them, but these should be the exception rather than the rule" [66]. Yet, for my study, I gave over control of the input to the authors whose works I examined; I was constrained to include design principles not by my choice, but by the choices of others. I could not even be sure whether participants would think that all of the 38 items they were sorting were actually design principles. Given the ambiguity of design principles (one driver for conducting this research), the many approaches to statistical analysis of multivariate data, and the idiosyncrasies of designers, I did not, from the outset, think that this technique would give completely reliable statistical results.

However, I was confident that card sorting techniques would provide a good opportunity for exploring perceived relationships between common design principles. This methodology also allowed me to stay open to the possibility that design principles are so idiosyncratic that no meaningful structure or relationships might emerge.

Card sorting is typically conducted in one of two ways: closed sort or open sort. In a closed sort, participants sort the cards into predefined categories. In an open sort, participants sort the cards into categories they create themselves. Due to the exploratory nature of my study, I used an open sort so designers could group the design principles as they saw fit. I also did not require participants to sort all of the cards, but restricted my analysis to those who sorted at least 75% of the cards.

Traditionally, in a card sorting exercise the researcher writes items on standard 3" × 5" index cards and asks participants to sort the cards into categories. The researcher then records the groupings and category labels and compares them over multiple participants. To expand the reach of my study, I used an online card sorting tool, Optimal Sort (http://www.optimalworkshop.com). Instead of index cards, this online tool displays digital shapes that participants can drag and drop on screen to create groups, which they can then label (see Figure 2). This tool also allowed participants to provide feedback through before and after survey questions.

The primary advantage of this online approach was quick and efficient access to participants. However, there were two disadvantages. First, in a face-to-face card sorting exercise, the researcher often observes the participant as he or she sorts the cards and uses the talk-aloud protocol to gather further information about participants' thinking during the exercise. Because I would not attend the card sorting, this kind of observation was not possible. Second, I would have little control over who agreed to participate. The possibility for spam is always present with online media.

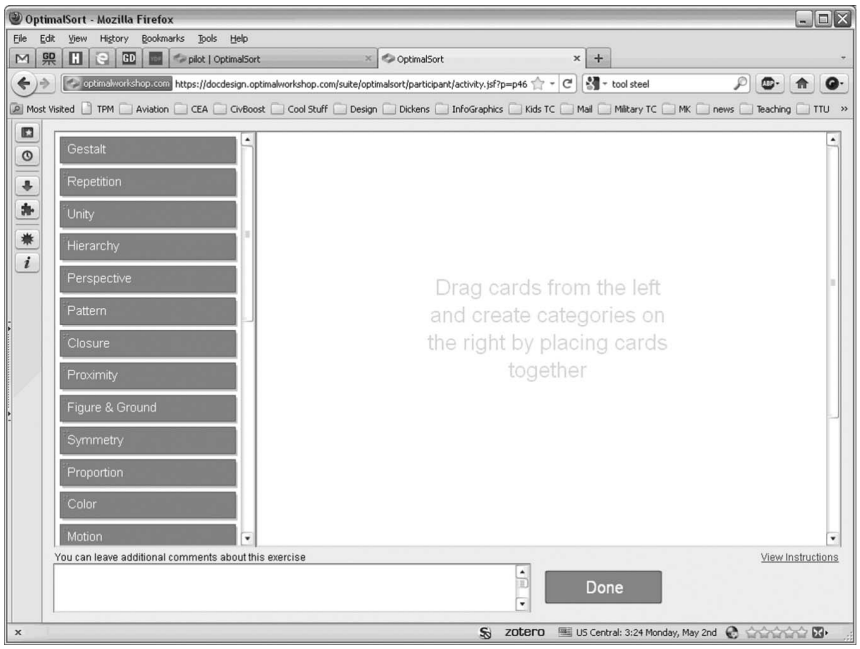

Figure 2. OptimalSort Online Card Sorting Tool, http://www.optimalworkshop.com/

If I had used a traditional face-to-face card sorting exercise, however, the number of participants would be lower, and they would be less likely to be part of the group I wished to study: designers, design educators, and design students. Also, because I have authored a book on document design that includes design principles, drawing from my local population might give biased results because my colleagues and students have read my book. I also hoped that the survey questions would give some qualitative feedback to substitute for the talk-aloud protocol. Finally, given the exploratory nature of my study, it seemed reasonable to use this online tool to gather information from a broader pool.

To invite participation, I sent e-mails to two professional academic listservs in technical communication and rhetoric—ATTW-L and techrhet—and created posts on the five most active design forums on the web: Graphic Design Forum (GDF); HOW; estetica design forum; AG Design (AGD); and YourDesignForums (YDF). The academic listservs, I hoped, would reach educators and students interested in design in the field of technical communication and rhetoric. The design forums, I hoped, would reach professional designers, design educators, and design students. I kept the card sorting exercise open for about a month.

After closing the online card sorting exercise, I used common statistical software (SYSTAT) to conduct a cluster analysis of the results.

Survey Methodology

As I mentioned, Optimal Sort allowed me to survey participants before and after the card sorting task (see Figure 3). In addition, the software includes a single default comment field directly below the card sorting area, which users can fill in with general comments (see the bottom of Figure 2).

Specifically, before the exercise I asked some basic questions about participants'current design activities and roles. I also asked—before showing them the 38 principles in the exercise, which might bias their responses—what design principles they had learned about in their schooling, training, or reading; what design principles they use in practice; and how they would define what a design principle is. I worded these questionsto allow a participant to respond that he or she does not know about or has not used design principles. After the exercise gave participants an opportunity to think about design principles, I asked some questions about when and how we should use design principles, particularly in relation to the empirical methods of design research.

In introducing these survey questions, I asked participants to focus specifically on visual design principles. All of the questions asked for text responses except for the first pre-survey question, which gave several options of positions from which to choose. I did not require responses to any question except question 1.

Participants

Sixty-six people began the study, most of them completing the pre-exercise survey questions. However, 23 participants abandoned the exercise without sorting any cards, and some sorted fewer than the whole set. I removed participants from the card sorting analysis who sorted fewer than 75% of the cards, but I included their survey responses in my qualitative analysis.

In addition, I removed one participant from the cluster analysis who sorted all the cards, but in such a way as to skew the results. With a sharp wit, this participant created only two categories: "Byproducts of nuclear decay," which contained only one card, *radiation*; and "What an academic thinks of when he or she misinterprets design as the synthesis of a set of design principles," which contained all of the remaining cards. I did, however, include this participant's survey responses, as they reflected an attitude toward design that favored artistic sensibility over using more formal methods such as design principles or design research. I address this attitude more fully in the conclusion to this article.

This scrubbing left me with 38 participants for the card sorting exercise. This number more than doubles the 15 participants recommended by Nielsen [65] for typical card sorting exercises. My participant group also exceeds the number recommended by Tullis and Wood [67], who compared results from

Instructions

Answer the survey questions below, then click on the "continue" button. Please focus your answers on *visual* design principles. "Design principles" is a broad term that could apply to almost anything, but we are concentrating this study on principles of visual design.

On the next screen, read the card-sorting instructions and click the "continue" button to go on to the exercise.

After sorting the objects, click the "done" button to go on to the final three questions.

Pre-Survey Questions

1. What is your current position?
   - ○ Web Designer
   - ○ Graphic Designer
   - ○ User Experience Designer
   - ○ Interaction Designer
   - ○ Design Educator
   - ○ Undergraduate Student
   - ○ Graduate Student
   - ○ Other
2. If you answered "other" in question 1, how would you label your current position?
3. Please describe what kind of design you do.
4. Please describe your formal education or training in visual design.
5. What (if any) visual design principles did you learn about in your design education or training?
6. What (if any) visual design principles have you learned about through your own reading?
7. What (if any) visual design principles do you use consciously in your design practice?
8. What visual design principles do you think are important for new designers to learn?
9. How would you define a visual design principle?

[Card Sorting Exercise]

Post-Survey Questions

1. Were any of the visual design principles you use consciously in practice missing from the sorting exercise? If so, please list them below.
2. In doing a design project, when do you rely on design principles to make decisions, and when do you use empirical research (like usability testing, focus groups, etc.)?
3. How do you think design principles should be used in design projects?

Figure 3. Pre- and post-exercise survey questions.

subsets of a large card sorting exercise of 168 participants and found that anything over 20 participants gave an average correlation to the whole of 0.95.

Participants' Current Positions

Of the 66 participants who completed the pre-survey, 44 (67%) identified themselves as design educators or described themselves as "other" in terms that makes it clear that they teach at least some design (see Table 3). Twelve participants identified themselves as professional designers of some sort (web, print, graphic, or user experience design). One participant chose "other," but listed retired graphic designer as his or her position; I included this person as a designer, for a total of 13 designers (19.4% of the total participants). Eight participants (11.94%) identified themselves as students, and an additional two (2.99%) identified themselves as "other": the designer of the website of an anthropological research archive and a fine artist.

After the population was scrubbed of participants as described above, the percentage of design educators rose somewhat (76.32%), while the percentage of design students (5.26%) and designers (13.16%) dropped somewhat.

The higher response rates of design educators compared to other groups could suggest that design principles are interesting for design educators, perhaps because they find them useful or know them as traditional tools for teaching students how to create visual designs. The relatively high number of educators could also be a function of the fact that most of the educators probably came from my solicitation on academic listservs, where researchers often ask for participants for studies. Always aware of "survey karma," researchers are arguably more likely to participate in studies when they know that they might have to ask for participants at some point themselves.

The relatively low number of responses by practicing graphic designers might suggest either a lack of interest in design principles, or lower visibility of my solicitation due to the medium of web forums. The graphic design web forums on which I solicited participation have a high volume of postings that (depending

Table 3. Current Positions of Participants

Position	Raw #	Raw %	Scrubbed #	Scrubbed %
Design Educator	43	65.15%	29	76.32%
Design Student	8	12.12	2	5.26
Designer	13	19.40	5	13.16
Other	2	3.03	2	5.26
N =	66		38	

on user preferences) are not necessarily delivered to members' e-mail, as with a listserv. This mode of delivery might have made my solicitation less obvious than on the academic listservs. Unfortunately, I did not ask participants to reveal where they came across my solicitation; that would have been a useful question.

Participants' Design Activities

As might be expected, when asked what kind of design they do, a good number (19) of participants responded that they teach design. However, six of these educators also responded that they also do design themselves. The remaining participants reported doing a wide variety of design activities, including web, graphic, print, and document design. This response suggests that even though they might not call themselves professional designers, most of the participants actually do at least some design, either as a professional focus or as part of their job.

Participants' Formal Education or Training in Visual Design

Most participants reported that they had degrees or coursework in graphic design, art, visual communication, or journalism. Specifically, 20 participants reported having an undergraduate or graduate degree. Two additional participants reported postgraduate diplomas or certificates in design, and 27 participants claimed undergraduate or graduate course work.

In addition, 20 participants volunteered that they were self-taught or learned on the job. Seven participants claimed no formal design education or training. (The sum of these numbers exceeds the total number of participants because some participants claimed multiple kinds of training.)

CARD SORTING RESULTS AND DISCUSSION

The card sorting exercise resulted in the similarity matrix in Table 4. To build the similarity matrix, I used the Card Sort Cluster Analysis Tool [68], which assembled the scores into a matrix of n columns by n rows (in my case 38×38), with the agreement scores entered at the intersecting cells of each pair (Table 4). The scores represent how many of the 38 participants placed each pair of cards together in a group; for example, 19 participants put *framing* in the same group with *structure*. Accordingly, higher scores in the matrix suggest a stronger (more frequent) pairing, and lower scores suggest a weaker (less frequent) pairing. The Card Sort Cluster Analysis Tool also rearranged the order of design principles to bring the strongest matching pairs closer to the hypotenuse.

Because one goal of my study was to find how participants perceived relationships between design principles, I used cluster analysis to explore the similarity matrix data for groupings. Myatt and Johnson describe cluster analysis, or clustering, as "a widely used and flexible approach to analyzing data, in which

Table 4. Similarity Matrix

	Framing	Structure	FocalPoint	Perspective	Scale	Proportion	Space	Gradation	Color	Radiation	Context	Emphasis	Subordination	Hierarchy	Dominance	Chunking	Grouping	Comparison	Alignment	Proximity	Contrast	Gestalt	Closure	Continuation	FigureGround	Similarity	Consistency	Variety	Movement	Rhythm	Repetition	Pattern	Symmetry	Balance	Harmony	Unity	Simplicity
Framing																																					
Structure	19																																				
FocalPoint	15	14																																			
Perspective	13	9	25																																		
Scale	13	11	11	12																																	
Proportion	14	10	13	14	20																																
Space	10	7	10	13	13	13																															
Gradation	7	5	8	9	9	8	9																														
Color	8	4	10	11	13	8	10	19																													
Radiation	6	7	11	9	5	9	5	18	7																												
Context	13	7	13	12	3	5	7	5	2	6																											
Emphasis	9	7	14	8	7	7	5	5	7	6	17																										
Subordination	7	14	8	8	6	5	2	5	2	6	10	15																									
Hierarchy	9	18	9	8	7	7	4	4	2	7	11	13	28																								
Dominance	9	10	12	7	9	8	2	5	3	7	13	19	23	20																							
Chunking	12	15	3	4	5	6	10	4	2	7	10	9	13	14	8																						
Grouping	15	14	5	4	9	4	9	7	6	6	7	10	12	13	9	19																					
Comparison	7	7	4	5	8	5	8	4	7	5	10	13	15	13	14	16	16																				
Alignment	9	12	9	4	11	8	7	6	6	8	4	4	3	5	6	6	11	7																			
Proximity	5	4	4	7	4	6	10	3	2	5	8	8	7	7	6	14	14	10	13																		
Contrast	6	4	9	9	12	7	8	8	12	5	4	8	5	6	9	4	7	9	12	10																	
Gestalt	4	7	7	12	4	4	6	4	5	8	10	5	6	5	6	7	4	4	6	11	8																
Closure	5	4	4	7	6	3	2	5	2	6	14	7	6	5	8	6	5	7	8	13	6	18															
Continuation	4	4	3	5	4	3	5	6	5	10	7	6	6	4	7	4	9	7	7	11	8	17	17														
FigureGround	10	10	10	15	10	8	8	8	9	6	7	7	5	4	5	4	6	5	6	11	9	17	12	14													
Similarity	5	4	3	4	2	4	6	5	6	4	9	7	7	7	9	7	12	10	10	14	10	9	12	13	9												
Consistency	6	3	6	5	8	10	5	4	7	4	9	5	5	6	4	3	7	10	8	2	7	4	12	11	2	16											
Variety	6	4	7	6	8	7	9	9	7	10	9	9	3	5	6	5	8	10	6	1	11	6	7	9	3	9	15										
Movement	10	5	10	11	10	10	14	13	8	15	9	10	7	6	6	8	7	7	3	4	6	7	6	9	7	8	6	10									
Rhythm	6	4	7	5	9	8	6	6	8	12	5	8	4	5	8	2	6	10	7	1	8	4	3	12	5	10	12	13	17								
Repetition	6	5	6	3	8	5	6	8	7	8	7	8	7	5	7	3	8	14	11	6	12	3	7	13	5	11	15	12	11	17							
Pattern	8	11	5	6	11	7	9	9	12	10	4	6	8	11	5	10	11	14	9	4	10	3	3	10	7	11	15	12	10	16	14						
Symmetry	7	6	8	7	12	15	7	5	8	6	3	5	3	2	4	1	7	4	12	6	7	6	9	14	8	13	14	10	5	12	12	12					
Balance	5	5	6	6	13	16	10	5	9	4	2	4	3	2	3	3	3	3	9	5	10	9	8	7	9	9	7	6	8	10	5	4	19				
Harmony	1	4	5	3	10	10	8	4	8	3	5	4	3	2	4	2	1	6	6	1	8	6	6	5	2	12	16	10	7	12	10	9	15	16			
Unity	4	7	5	4	9	10	10	4	7	3	4	5	4	3	4	3	6	6	7	1	5	9	8	10	3	9	16	9	6	13	10	11	16	16	22		
Simplicity	5	6	7	5	8	9	9	4	6	3	8	6	3	3	3	2	3	5	8	3	5	7	9	4	4	6	15	11	5	9	8	6	13	14	21	18	
Attraction	4	4	9	7	6	7	7	6	9	10	8	6	7	7	9	9	5	11	6	7	10	11	10	10	5	6	12	9	10	12	5	10	8	9	11	8	11

observations are automatically organized into groups. Those observations within a particular group are more similar to each other than to observations in other groups" [69, p. 67]. Cluster analysis is a common way to analyze the data resulting from card sorts because it measures how similar cards might be in terms of how often participants grouped them together.

Cluster analysis includes two general approaches: hierarchical and partitioning. Hierarchical cluster analysis also subdivides into two approaches: divisive and agglomerative, which is the most common. For my study I explored design principles using both agglomerative hierarchical and partitioning techniques.

Agglomerative Hierarchical Cluster Analysis

Agglomerative hierarchical cluster analysis of a card sorting exercise begins with a similarity matrix. Following Kaufman and Rousseeuw [70], I translated my raw similarity matrix (Table 4) into a percentage of similarity matrix by dividing each raw score by the total number of participants:

$$\%s = \frac{s(i,j)}{n}$$

Then I transformed this percentage of similarity matrix into a dissimilarity matrix by subtracting each of the similarities from 1:

$$d(i,j) = 1 - s(i,j) \qquad [70, \text{p. } 21]$$

This process resulted in a matrix with numbers from 0 to 1, in which lower numbers represent less dissimilarity (more similarity) and higher numbers show greater dissimilarity (less similarity). In other words, if the 38 design principles were cities and the numbers were the miles between them, the dissimilarity matrix would show which cities were closest together (smallest numbers) and which cities were farthest apart (largest numbers).

At this point I ran the agglomerative hierarchical clustering. Under this process, the least dissimilar (most similar) pair of cards—the pair that the highest number of participants put together in the same group—forms the first cluster. The scores in this cluster are then compared to each of the remaining scores, and the next closest pair of cards (or cards and clusters) forms the second cluster. This process builds cards into clusters and clusters into bigger clusters, continuing until all of the cards form one large cluster.

Cluster analysis can be complicated; in particular, choosing the linkage method and the distance measure involves a bewildering number of options. SYSTAT offers 10 linkage methods and 14 distance measures, all of which provide different results [71, pp. 1-87–1-88]. For my hierarchical clustering, I chose to use average linkage with an absolute distance measurement. Average linkage, also known as UPGMA (Unweighted Pair-Group Method using arithmetic Averages), measures the distance between one cluster and another by taking the average of

distances between each item in one cluster and each item in the other cluster [72, p. 15]. Because I was working from a dissimilarity matrix derived from pair-groups already formed by the participants, I was able to skip the formation of a raw data matrix such as would be necessary with data with mixed variables [72, pp. 178-181]. As a result, the absolute distance between clusters was the most direct way to measure distance for my study, rather than common distance measurements such as Euclidean or Manhattan.

The results of agglomerative cluster analysis are typically shown visually as a dendrogram, or tree diagram (see Figure 4). The strongest linkages are shown further to the left (lesser amount of dissimilarity), and the weaker linkages are shown further to the right (greater amount of dissimilarity).

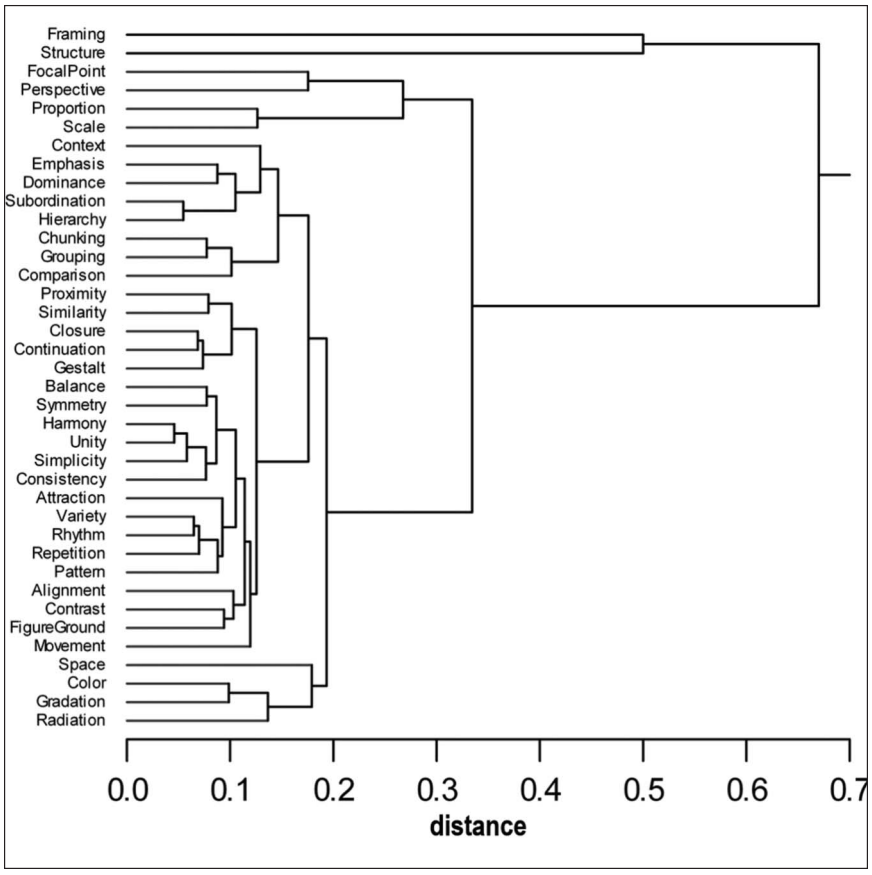

Figure 4. Dendrogram of results from agglomerative hierarchical clustering.

Although the dendrogram from the agglomerative hierarchical clustering looks neat and objective, we should approach it with caution. As Tan et al. [73] point out, "what constitutes a good set of clusters is open to subjective interpretation." The dendrogram could be interpreted as dividing the principles into groups in a variety of ways.

However, it is worth noting that [*subordination*, *hierarchy*], [*harmony*, *unity*], and [*chunking*, *grouping*] are among the strongest single pairings. These pairings lend confidence to the methodology by echoing logical expectations: if *subordination* and *hierarchy*, which 28 out of 38 participants put together, had not been directly linked, we might question whether the analytical method works. Another strong pairing, [*emphasis*, *dominance*], gives some empirical justification to Park's contention that "Dominance [sic] principle is compatible to Emphasis [sic] principle" [13, p. 376].

The dendrogram is weighted toward the left, suggesting that higher-level groupings in the dendrogram are less clear-cut, or that there was not much consensus on how larger groups of principles should be formed. At a distance of about 0.18, we might see five groups (Table 5). But this grouping, with one

Table 5. Hierarchical Cluster Analysis, 5 Groups

Framing	Focal Point	Context	Proximity	Space
Structure	Perspective	Emphasis	Similarity	Color
	Proportion	Dominance	Closure	Gradation
	Scale	Subordination	Continuation	Radiation
		Hierarchy	Gestalt	
		Chunking	Balance	
		Grouping	Symmetry	
		Comparison	Harmony	
			Unity	
			Simplicity	
			Consistency	
			Attraction	
			Variety	
			Rhythm	
			Repetition	
			Pattern	
			Alignment	
			Contrast	
			Figure/Ground	
			Movement	

very small group [*framing*, *structure*] and one very large group, isn't very satisfying. It's easy to understand the simple pairing [*framing*, *structure*], but it's more difficult to see what holds together the items in the large group.

At a slightly lower distance of around 0.15, we see more groups, but they might make more sense (Table 6). We still have the two-item grouping [*framing*, *structure*], but the large group from Table 5 is broken into several smaller groups.

Perhaps predictably, the group labels that participants provided were as idiosyncratic as the design principles in the raw list. One participant labeled each grouping with full sentences of explanation. Another labeled groups using only numbers; one used only letters; still another used only punctuation marks. Although individual participants' labels often made sense for the groups they formed themselves, it was difficult to see significant patterns in the labels over multiple users. In an everyday card sort for information architecture, the researcher would typically standardize the group labels subjectively. I attempted to do so, but found in such a variety of responses that it became a difficult if not impossible task. In the end, I felt it best to disregard the group labeling for the most part and focus on how participants grouped the principles.

So after seeing Table 6, I hazarded labeling some of the groups myself. Labels for groups one through six seem relatively natural. But labels for groups seven and eight are more difficult to imagine.

One potential difficulty revealed by this hierarchical cluster analysis is that participants seemed to group items for reasons other than inherent similarities. For example, participants clearly grouped together the Gestalt laws of *proximity*, *similarity*, *closure*, and *continuation*, as well as the term *Gestalt* itself (shaded in Table 6). In logical terms, however, it might have been as reasonable to split up the Gestalt laws among other categories—*similarity* going with *consistency*, for instance. By the same token, the common term "figure-ground contrast" might have encouraged participants to separate *figure/ground* from its association with Gestalt and link it to *contrast*.

K-Means Partitioning

Partitioning differs from hierarchical clustering in that the researcher specifies before the analysis how many clusters the items should be divided into, or *k*. Then the *k*-means algorithm, as described by Kaufman and Rousseeuw, "tries to find a 'good' partition in the sense that the objects of the same cluster should be closely related to each other, whereas objects of different clusters should be far apart" [70, p. 39]. The algorithm works by selecting *k* points as centroids, assigning each data point to the closest centroid, then re-computing the centroids, repeating the process until the centroids do not change [73]. The choice of *k* is subjective, so I was guided by Kaufman and Rousseeuw's advice: "Of course, not all values of *k* lead to 'natural' clusterings, so it is advisable to run the algorithm several times with different values of *k* and to select that *k* for which certain

Table 6. Hierarchical Cluster Analysis, 8 Groups

Structure	Viewpoint	Architecture	Gestalt	Aesthetics	Movement	?	?
Framing	Focal Point	Context	Proximity	Balance	Attraction	Alignment	Space
Structure	Perspective	Emphasis	Similarity	Symmetry	Variety	Contrast	Color
	Proportion	Dominance	Closure	Harmony	Rhythm	Figure/Ground	Gradation
	Scale	Subordination	Continuation	Unity	Repetition		Radiation
		Hierarchy	Gestalt	Simplicity	Pattern		
		Chunking		Consistency	Movement		
		Grouping					
		Comparison					

characteristics or graphics look best, or to retain the clustering that appears to give rise to the most meaningful interpretation" [70, p. 38].

Accordingly, I ran *k*-means with $k = 1, 2, 3, \ldots 9$. Of these, I have represented here only $k = 5$, 6, and 7, which seem to form the most meaningful groupings (see Tables 7, 8, and 9).

The first observation we should note is that just as with hierarchical cluster analysis (Table 6), *k*-means clustering shows that users tended to group the Gestalt principles together (see the shaded areas in Tables 7, 8, and 9). That this grouping persists over different clustering techniques suggests a very strong association between these ideas.

A related association probably derives from Williams' [44] CRAP principles: *contrast*, *repetition*, *alignment*, and *proximity* (in bold). In both the 5-group and 6-group clusters, *contrast*, *repetition*, and *alignment* appear in the same cluster.

Table 7. *K*-Means Clustering, 5 Groups

Contrast	Framing	Space	Context	**Proximity**
Repetition	Structure	Gradation	Emphasis	Gestalt
Alignment	Focal Point	Color	Subordination	Closure
Consistency	Perspective	Radiation	Hierarchy	Continuation
Variety	Scale	Movement	Dominance	Similarity
Rhythm	Proportion	Pattern	Attraction	Chunking
Symmetry	Figure/Ground			Grouping
Harmony	Balance			Comparison
Unity				
Simplicity				

Table 8. *K*-Means Clustering, 6 Groups

Contrast	Scale	Gradation	Focal Point	**Proximity**	Framing
Repetition	Proportion	Color	Perspective	Gestalt	Structure
Alignment	Space	Radiation	Context	Closure	Chunking
Consistency	Figure/Ground	Movement	Emphasis	Continuation	Grouping
Variety	Symmetry	Simplicity	Subordination	Similarity	Comparison
Rhythm	Balance		Hierarchy	Attraction	Pattern
Harmony			Dominance		
Unity					

Table 9. *K*-Means Clustering, 7 Groups

Alignment	**Contrast**	Framing	Context	**Proximity**	Chunking	Scale
Consistency	**Repetition**	Structure	Emphasis	Gestalt	Grouping	Proportion
Symmetry	Variety	Focal Point	Subordination	Closure	Comparison	Space
Harmony	Rhythm	Perspective	Hierarchy	Continuation	Pattern	Figure/Ground
Unity	Gradation	Movement	Dominance	Similarity		Balance
Simplicity	Color			Attraction		
	Radiation					

Only *proximity* is separated from this familiar grouping, perhaps because it is more strongly tied to the concept of Gestalt. In the 7-group clusters, *contrast* and *repetition* still remain together, while *alignment* as well as *proximity* is relegated to a different group.

This pattern suggests that the lore of design principles, as represented by a very popular book or by a very popular theory, can have a profound influence on the way people see the relationship between design principles. Moreover, these patterns reveal a kind of natural ecology: in this case, Gestalt seems to have a stronger influence on how people group design principles than does CRAP, essentially stealing proximity from Williams' [44] list.

To my mind, the *k*-means clustering into seven groups yields the most stable and logical groupings. I have tentatively labeled these groups in Table 10 as Likeness, Difference, Composition, Architecture, Gestalt, Grouping, and Space:

- *Likeness* principles help create coherence over a whole design.
- *Difference* principles help mark the distinction between design elements.
- *Composition* principles help organize designs to influence our viewpoint.
- *Architecture* principles focus on visual organization and hierarchy.
- *Gestalt* principles govern perception of two-dimensional design objects.
- *Grouping* principles organize individual design objects into larger groups and patterns.
- *Space* principles guide the design of the two-dimensional field.

Likeness, Architecture, Gestalt, Grouping, and Space seem to be particularly fitting categories with few odd members. The categories Difference and Composition, however, seem less natural. *Contrast*, *variety*, *rhythm*, and *gradation* go together nicely, but *repetition* and *color* don't seem to fit as well. (Is *color* really a principle, or just a quality of design objects?) Composition describes *framing*, *structure*, *focal point*, and *perspective* pretty well, but to my mind it doesn't work as well with *movement*. At best, even the more natural of the categories include ambiguities—for example, *structure* might belong better under Architecture (with *hierarchy*), and *movement* might belong better under Difference (with *rhythm* and *repetition*).

SURVEY RESULTS AND DISCUSSION

The cluster analysis gives us a better sense of how participants thought design principles might relate to one another. But I was also interested to find out what participants thought and felt about design principles more generally. Accordingly, aside from the basic questions about positions, training, and design

Table 10. Design Principles Categorized

Likeness	Difference	Composition	Architecture	Gestalt	Grouping	Space
Alignment	Gradation	Framing	Context	Proximity	Chunking	Scale
Consistency	Color	Structure	Emphasis	Gestalt	Grouping	Proportion
Symmetry	Radiation	Focal Point	Subordination	Closure	Comparison	Space
Harmony	Contrast	Perspective	Hierarchy	Continuation	Pattern	Figure/Ground
Unity	Variety	Movement	Dominance	Similarity		Balance
Simplicity	Rhythm			Attraction		
	Repetition					

activities I have already discussed, the pre- and post-survey questions asked participants to talk about:

- What design principles they had read or learned about, what principles they use in design, and what principles they think it's important for new designers to learn
- How they would define "design principle"
- When and how design principles should be used in practice

Responses to these questions show interesting dynamics, some of which reinforce the cluster analysis findings.

What Design Principles?

Before participants saw the list of 38 design principles in the exercise, I gauged their experiences with and attitudes toward design principles by asking four questions beginning with "what . . . design principles":

- What (if any) visual design principles did you learn about in your design education or training?
- What (if any) visual design principles have you learned about through your own reading?
- What (if any) visual design principles do you use consciously in your design practice?
- What visual design principles do you think are important for new designers to learn?

I asked these questions before the card sorting exercise so as not to bias any responses. Most participants answered these questions with a short list of principles, most of which also appeared on the raw list of 198 principles gleaned from published texts on design. A few new principles cropped up, such as dynamics, expression, texture, and grammar—but not many. Ironically, responses to the post-survey question "Were any of the visual design principles you use consciously in practice missing from the sorting exercise?" listed a considerable number of unique principles that did not appear in the responses to question 7, such as inspiration, humor, gravity, vectors, embodiment, ecological, logic, staging, and salience. Perhaps the card sorting exercise prompted some thinking.

These four "what principles" questions also reiterated the strong influence of Gestalt and Williams' CRAP principles we saw in the cluster analysis. Ten participants referred to Gestalt as a set of design principles they had learned about in their education or training; four reported having learned about Gestalt through their reading; three reported thinking about Gestalt in their own design practice; and four said that Gestalt was important for students to learn about. Even more participants cited Williams' CRAP, whether by name, by acronym, or by listing the four principles together. Nine mentioned learning about Williams through formal education or training; seven reported learning about Williams

through their own reading; six said they consciously used CRAP in their own design practice; and six said that students should learn about these principles. Summing up this tendency, one participant said in responding to question one, "I took Robin Williams' contrast, repetition, alignment, and proximity advice to heart." This adherence to Williams suggests that her simple set of principles might have an even stronger influence than Gestalt.

On the other hand, grouping CRAP was not always a compliment. One participant who created a category for CRAP labeled it "A handy, oversimplified, arhetorial [sic], and now overused set of principles that involve only logos and that do not address the affective elements of design at all." But for good or ill, CRAP is strongly embedded in the lore of design education and practice.

Several participants made comments that suggested that they had outgrown design principles as they gained experience or had so deeply absorbed principles that they didn't need to think about them consciously. For example, one design educator commented, "I believe that a solid understanding of design principles negates the need to consciously apply them. I am aware of these concerns in others' design and my own, and I no longer have to think specifically about applying alignment or closure." Another design educator said, "More than anything, my fundamental design principle is to trust myself to effectively use all of the principles I have internalized over the past 40 years." A graphic designer commented, "I was lucky to have an innate 'design sense' that was further developed through education. I don't consciously use particular principles, but sometimes things 'just don't look right' and that's most likely from an integrated, 'organic' use of design principles." These comments suggest that some participants think design principles are most useful for beginners, but that practiced designers develop a more holistic sensibility that helps them make design decisions.

However, other participants stressed that while beginners should learn about design principles, they should also learn how to apply them intelligently, not by rote. One design educator commented that new designers should learn "all of [the design principles], but they have to be intuitively felt, not learned in the sense of memorizing a list." Similarly, another design educator said, "just about any vocabulary will do, as long as there is some vocabulary with which a beginner can begin to think—with the caveat that all principles be rhetorically contextualized."

Though a minority, some participants used these questions to express that they did not think that design principles are useful or desirable in education or practice. Most strongly, one design educator said, "You only have to look at some of the best designs to see that design prescriptions are for fools." Others stressed the importance of a good eye. For example, a design educator said, "It is imperative for designers to trust their eye and design sense over the influences provided by precise measurement, well-meaning computer algorithms and 'hard-n-fast' rules."

Defining Design Principles

Although participants offered diverse definitions, a number of the responses used some form of one of the following terms:

- guideline;
- concept;
- rule of thumb, heuristic, or strategy;
- rule or prescription; or
- tips and tricks, technique.

By far the most common response centered on terms like "guideline," "guide," "guiding thought," "practice that guides," "idea which provides guidance," and so forth. Two respondents specifically distinguished between "guideline" and "rule," both saying that situation has an impact on how a design principle should be applied. One elaborated by saying that "Principles are contingent generalizations; . . . their application depends on the particulars of a given situation." This suggests that designers believe design principles should not fully determine specific design decisions, but can provide a systematic way of thinking about those decisions. Five participants focused on the word "concept" to define design principles. These participants seemed to think of design principles less as prescriptions than as general or in one case localized ideas that govern a design. The four participants who described design principles as a rule of thumb, heuristic, or strategy similarly focused on the contingent nature of design principles. They expressed this contingency by using qualifying words or phrases, for example, "a *general* rule of thumb" or "a systematic heuristic leading to a particular perceptual outcome *for most people most of the time in a given context*."

In this sense, "guideline," "concept," "rule of thumb," "heuristic," and "strategy" seem to be related. Together, they provide the most common response to "what is a design principle?"

However, four participants expressed precisely the opposite idea by describing a design principle as a "rule" or "prescriptive guide." These responses indicated that design principles were concrete and universal. One respondent described design principles as "rules that concretize what we mean when we say 'aesthetically pleasing'." Another described them as "a universal standard." Still another used this terminology: "a concept, rule, or other observable pattern that is recognizable and replicable." However, some of even these responses allowed room for flexibility. One participant described a design principle as "a prescriptive guide to help a designer choose among a range of possible arrangements"; although the participant used the word "prescriptive," this description sounds considerably like those using the terms "guideline" or "rule of thumb."

Three participants described design principles as tips, tricks, or techniques. These participants seemed to suggest that design principles are ephemeral or superficial approaches to design; one even used the phrase "bag of tricks."

However, another used the phrase "fundamental technique," which suggests that design principles might have a deeper relationship with design practice.

This question also elicited a couple of dissenting voices. One claimed, "There is no such thing as a visual design principle. You could pretend there is and make some up but you would be limiting creativity. This is the wrong way to think about it." Similarly, another participant said

> I don't think in terms of "visual design principles," so I wouldn't be inclined to define the term. Design, much like music or art, is largely intuitive. I suppose an analysis of design might yield some principles, like balance, rhythm, contrast, etc., but I don't consciously think about them anymore than I think about the mechanics of locomotion as I walk.

These comments suggest that despite the common discussion of design principles in literature on design, some people find the very idea of design principles constraining.

Using Design Principles

The final two post-survey questions asked participants to discuss when and how they use design principles in design projects.

In response to the question about when they rely on design principles and when they use empirical research such as usability testing or focus groups, the most common response placed design principles and design research in a dynamic relationship. One participant specifically mentioned multiple cycles of iterative design: "I teach my students to use a combination, following iterative design principles: make a choice, test it, revise it, test again." Another described parallel iterations: "I use the principles to create a variety of design then use focus groups and interviews to find the best ones." But most in this group put design principles at the start of the design process and design research at the end—for example, "They go hand-in-hand most of the time, but I probably lean toward design principles first draft and empirical research to finish"; "I think of design principles as valuable for invention and initial design decision; research comes into play when considering use/interaction"; "I use design principles first to create the piece, then go back and look at it from a usability standpoint, making changes where needed"; "Start with design principles, refine with research. Personal to social."

However, a surprising number of participants (11) claimed that they use design principles almost exclusively to help them make decisions. For some, the reason was practical and economic: "In my current line of work, it's all design principles. We don't have the resources, including time, for usability testing." Others expressed a distrust of design research altogether: "I find design principles outrank usability studies, which I find limited and subject to style"; "Design principles always trump empirical research"; "Designing by committee can be dangerous."

Finally and perhaps most broadly, the survey asked participants "how do you think design principles should be used in design projects?" This elicited several general responses. One of the most common responses emphasized that design principles were contingent on audience, situation, and rhetoric. Examples of this position include the following:

- "They should be used in the context of meaning making, not style copying."
- "They must be used for the design to communicate effectively."
- "The same way invention strategies and rhetorical principles are used in writing."
- "As guides within a larger framework of common sense and analysis of purpose, audience and point."

Another common response emphasized the importance of principles. One participant called design principles "the prime standard." Another said that design principles should be used "as often as possible," and still another said, "design principle should be 99.9% of the time. If you don't know the 'rules' and how to apply them, you can't break them effectively." One participant described design principles as "articulating in language what an artist or designer does intuitively," adding that "if the project is to be discussed, then the 'language of design principles' or another language will have to be used. Better use it knowledgeably!!" Three participants discussed at length the importance of design principles for students, one commenting that "school design projects should be based on learning the basic principles and how to apply them."

The participants who as we have seen did not approve of design principles voiced that opinion on this question as well. One commented, "there are no principles only learning how to observe and feel." Another said "if one has to think of a design principle checklist in order to design, one has not yet gained an intuitive understanding of design." Finally, one participant conceded that "Principles are tools. They should be used to train new designers, they should be used to help resolve uncertainty when choices need to be made, they should guide testing and revision. But I don't think they should be followed as 'rules'."

CONCLUSION

What have we learned about design principles through this study?

Exploring Lore

First, while lore is inevitably idiosyncratic and hazy, we can see some patterns in the lore of design principles. The cluster analysis reveals that designers do think some principles belong together, although for different reasons. Some of the groupings in Table 10 seem natural and functional, like *context*,

emphasis, *subordination*, *hierarchy*, and *dominance*. Others seem reasonably so, like *chunking*, *grouping*, *comparison*, and *pattern*. These groupings reveal the interplay of visual perception and communication dynamics that designers must make decisions about every day.

But the consistent grouping of the Gestalt laws and Williams' CRAP suggest other dynamics at play: social convention and familiarity. Though Gestalt is for the most part outdated as a school of cognitive psychology, Gestalt laws apply so conveniently to two-dimensional design and have been such a foundational part of design curricula that designers with any training or even reading in design see these laws as belonging together. Similarly, the integrity of Williams' [44] CRAP principles both in the card sorting and in the survey responses testifies to the powerful influence of this small and unassuming book. Granted, her principles are incomplete and limited, but Williams provides a memorable way for new, perhaps self-taught designers—"non-designers," to use her own term—to demystify design.

In addition, the frequency study from the literature review suggests that despite a large array of unique or idiosyncratic principles, a few principles—the top ten or a dozen in Table 2, perhaps—have a higher level of visibility than most. The frequency of their use suggests that these principles have at least a certain amount of social currency and therefore perhaps even effectiveness. These are the principles that most designers probably know about through their education, training, and reading. If we wished to build a coherent and consistent set of design principles to use in design education, the most common principles would be a good place to start.

However, the picture of the communal lore on design principles that emerges from this study is not entirely in focus; given the nature of lore, perhaps it never can be. The cluster analysis reveals not only patterns but a considerable amount of disagreement and ambiguity. This haziness might be the result of idiosyncrasies in the participants' viewpoints or training, or of the considerable differences in how they see or define design principles—after all, some even denied their existence. And admittedly, some of the ambiguity undoubtedly arises because asking 38 chefs to combine 46 recipes doesn't always make a good bowl of soup.

But the disagreements and inconsistencies themselves also reveal interesting things about design and designers. The profusion of unique design principles in response to the post-survey question about principles missing from the sorting exercise suggests that every designer has his or her own way of explaining what he or she does. The lack of clear patterns in the category labels participants supplied also reflect this idiosyncrasy. That's probably a good thing; it would be a dull, Stalinesque world if nobody could make up their own principles. Though communities of practice might share wisdom through guiding principles, that collective wisdom should grow and breathe over time.

Design Principles: Helpful Guides or False Rules?

Second, although most participants claimed to know about and use design principles, many resisted thinking of principles as prescriptive rules. Repeatedly, they emphasized the limited and contingent nature of design principles as a method for making decisions or guiding actions. This skepticism seems entirely fitting: we must think about how and when to apply design principles, not follow them blindly.

However, a few participants rejected principles outright. This attitude echoes that expressed by the participant discussed earlier, whom I scrubbed from the card sorting because he or she created only two categories: "byproducts of nuclear decay" and "What an academic thinks of when he or she misinterprets design as the synthesis of a set of design principles." In the general comment field for the card sorting exercise, this participant said, "I haven't intentionally meant to be sarcastic, but this exercise shows a lack of understanding about the processes of design from a designer's point of view. Similarly, one might as well ask professional basketball players to dissect and define their court performance in terms of how they use and understand the mathematics and physics behind dribbling and shooting baskets."

In fact, some athletes have a very sophisticated understanding of the mathematics and physics behind their sport, and a whole discipline of sports physiology has risen to help athletes improve their performance through precise physical measurement. But the point remains that while most participants find design principles useful or even necessary starting points, a few expressed the view that design is an art best pursued by inspiration. (Interestingly, the fine artist who participated in the study was not among this group.) Those who felt this way reacted negatively to the very idea of regularizing or formalizing design with a set of rules, or even rules of thumb.

One participant who abandoned the sorting exercise responded at length in this vein:

> You need to spend time with some designers in an office or out in nature. Design just does not work this way. You are attempting to force a hypothesis and its [*sic*] just not going to work. People will try but this is missing the point. Imagine applying this to a piece of art for example. Art is no different than design in fact its the same thing just with a different outcome. You will then see the absurdity of this process you are trying to force. Visual designcomes [*sic*] from seeing or rather observing and feeling how a form, colur [*sic*], texture peaks [*sic*] your senses and it is then further developed through repetative [*sic*] experimentation. this [*sic*] process of understanding takes years to develop and you cannot just formulate rules—there are none. I would suggest you personally do something that removes you from the academic world for a moment and gets you out into the world where you can use your hands and mind and experience this for yourself. Take a pottery course or a wood working course, or an elementarygraphic [*sic*] design course

> etc.. [*sic*] and make something and experience how you create the visual aspects. Observe how a creation comes into being and I think this might help you. Hoep [*sic*] this helps- Good luck

This mixture of criticism, dismissal, and encouragement shows some fascinating tensions in the participant's attitude toward design principles, design education, and design itself. The participant clearly sees design principles as a product of the ivory tower, and design as an art which must be learned intuitively through years of feeling, experience, and observation. And yet generously the participant encourages me to take some design classes. In other words, the participant urges me to get out of the academy into the real world—by advocating that I go back to school.

This contradiction brings into question whether designers who hold this view believe design is something that can be taught at all. Is design a matter of art, inspiration, and genius, or of craft, research, and strategic decision-making? If the former, design principles are probably pointless and even misleading, because no number of principles can guide us to good design. But if the latter, it seems reasonable that over centuries of practice the community of designers would come up with some general guidelines that work in most situations—if only as a starting point for beginning a design project or for beginning a career. As the literature review showed, the fact is that design principles *are* out there in the long-term discourse on design. This alone suggests that despite claims to the contrary, most designers see some space for generalizing at least some rules of thumb. (I suspect that if I were to take an elementary graphic design course as the participant above suggests, it would include some design principles.)

Of course, the third answer to the question above is that design requires both art and craft. Just as in any endeavor, designers get better as they go; design becomes a matter of muscle memory, an unconscious application of lessons learned through both education and long practice. But new complications, new situations, and new audiences mean that designers must be willing to practice consciously, as well. And the ability to explain why a design works or why a particular design decision was made is the mark of a master.

Steps Forward

Finally, if design principles are here to stay, how should we define them and use them in design?

Based on my qualitative reading of many design principles and many people's thoughts about them in this study, a design principle is ideally:

- *Generalizable*: it can be applied to many situations;
- *Heuristic*: it helps guide decisions and determine paths of action;
- *Grounded*: it is more than simple preference; it is based on organized experience, whether developed through practice or research;

- *Meaningful*: it helps designers communicate ideas to real people in rhetorically effective ways; and
- *Contingent*: its application depends on local conditions.

For example, one of the more common principles is alignment. As a design principle, alignment fulfills all of the qualities outlined above:

- Alignment is generalizable, applying to many different design projects and situations from architecture to industrial design to document design.
- Alignment is heuristic, helping us decide how and where to place objects in a design space—whether that space be a computer screen or the pegboard in your garage.
- Alignment is grounded in our experience of reality. Human animals perceive that objects that line up belong together. Empirical justification for this quality of alignment arises from a variety of research and scholarship, including Gestalt theory (more specifically, the law of continuation), which was developed through the empirical studies of Kurt Koffka, Max Wertheimer, and Wolfgang Köhler.
- Alignment is meaningful, subtly communicating a larger system of values: order, regularity, system, rationality, and connection.
- And of course, how we use alignment is contingent on local audiences, purposes, and situations. It's possible to play against expectations of alignment for a particular effect.

Essentially, a design principle says, "here's something that works most of the time."

But we must be mindful of not only what design principles are, but how they should be used in design projects. Even if they fulfill the qualities listed above, design principles are inevitably designer-centric. If we use a "rule of thumb," whose thumb are we measuring against but our own? If we use only design principles, all of the decisions we make will be the designer's decisions. Even if the user is involved in the process—say in a usability test—it's arguably only patronistically, as the designer has already made decisions she hopes will be in the best interest of the user. Reconciling this designerly control with user-centered design is essential. At worst, the designer-centric aspect of design principles can lead to charges of mere individual aesthetic preference, or (dare I say it) art.

That's why I agree with participants who suggested that design principles must be used in conjunction with design research and iterative design—not just to shore up the weaknesses of design principles, but also because design research and iterative design are expensive and difficult. Done well, usability testing requires considerable money, time, and expertise throughout a design project. The dirty secret of usability testing is that companies rarely employ it except to justify a finished design. As a result, as Lane Becker put it, "90% Of All Usability Testing Is Useless" [74]. Even under the best of circumstances,

design research can become a meaningless task—after all, there's no end to what we might research, down to the tiniest feature of the design.

Design principles fill this gap. Though designer-centric, incomplete, and ambiguous, design principles are a very efficient method of making design decisions. Design principles may not be entirely accurate—they may be conradictory and even idiosyncratic—but they help us to get close to the target quickly, or at least to figure out quickly whether we're aiming at the right target. They also give an opportunity for designers to speak creatively, then to see how users respond to what the designers have to say.

In this regard, design principles work well alongside design research as a part of iterative design. When I teach document design classes, I advise students to listen to users first, then to use design principles as their first query in a conversation between designer and users. That is, after doing research into users' needs and situations, let design principles guide the development of initial low-fidelity prototypes, which we can then test with users. Through discount usability testing, users can then speak back to us, telling us what works and doesn't work for them. Design principles can also guide the development of subsequent prototypes. Sometimes the results from usability testing a prototype can give us only a hazy sense of direction; design principles allow us to explore that direction efficiently, by developing another prototype—or three—and testing them quickly.

My sense, not only from the survey responses but from my own experience, is that most designers do use design principles, although not always consciously. If you ask a good designer why she did something just so, she can usually give you a rationale, often sprinkled with the terms we have been calling design principles. Design principles provide a way to help designers get started on design projects, especially in terms of creating initial prototypes. Design principles also help designers make subtle iterative tweaks that improve designs alongside empirical research or in its absence. In this way, design principles and design research are the yin and yang, the chicken and egg of design projects. Designers need both to work efficiently.

Finally, design principles may find their most significant impact in design education. They form a common and usually successful way of helping neophytes make sense of what seems a mysterious activity. Design educators would do well to think more carefully about what design principles to teach their students and how those design principles work together to create a heuristic path.

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