



Basic Design Research: Parameters Of Visual Form

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ABSTRACT

Despite the fact that visual form is a precondition for visual communication, designers do not have established principles for the use of visual form in communication. If basic research is defined as investigation into the fundamental aspects of phenomena, then design needs the design equivalent of basic research in visual form.

This paper proposes a program of basic design research in visual form. Following a discussion of theoretical issues the paper describes a series of studies in visual form that may be considered basic design research. The preliminary studies seek to define parameters for preattentively processed visual form: form that 'pops-out' from its surroundings. The general research question is: can preattentive forms be defined and quantified through experimental research in such a way as to generate principles that are measurable and predictive that designers can apply to form-making decisions.

Keywords:

Basic Design Research
Visual Form
Perception / Perceptual Studies

THE NEED

Visual form is the visually perceived shape and configuration of something, including line, shape, color, and texture. Visual form is a precondition for visual communication, yet we designers don't know much about it. Fortunately for mankind, one does not have to have a PhD in perception to be able to gain meaning from visual form. Fortunately for designers, one does not need to understand *how* we see in order to create visual form. We have gotten along suitably with a natural and intuitive understanding of visual form based on the ability to see that we share with the rest of humanity. Unfortunately for designers, because we've based our knowledge of visual form on common experience we don't really know much more about the function of visual form than non-designers. Whether designers are the creators of visual form, manipulators of visual form or evaluators of the effects of visual form, we don't know much more than anyone else about the interactions of visual form.

EVIDENCE

Lack of Vocabulary.

There's good circumstantial evidence to support the assertion that designers lack understanding of visual form. One is the relative lack of a defined vocabulary. Shape, a basic component of visual form, has little verbal definition. Round, square triangular and rectangular are examples of definitions, but beyond these four classes designers have very few agreed-upon terms to define innumerable shapes. Another example is color. Color has three sub classes: value, hue and saturation/chroma/intensity, depending on your school. Humans can perceive millions of colors, yet we only have reliable names for about eight hues and studies show that even these names apply to widely different wavelengths particularly in the blue-green region (Lindsey, 2006).

Lack of Knowledge.

In addition to circumstantial evidence there is the dearth of parameters for using visual form to do something so simple as control hierarchy. Edward Tufte has proposed some good rules of thumb such as elimination of extraneous 'chart junk' and 'smallest effective difference' (Tufte, 1983). However, Tufte does not suggest parameters for how, if one chooses value to control hierarchy, to make the values different enough in to make clear distinctions between several levels. Beyond general observationally-based principles such as Tufte's, the measurement and control of visual form does not seem to be widely studied by designers. We can't understand what we don't know. We can't improve what we don't understand. Designers need greater understanding, including measurable parameters, for using visual form.

BASIC RESEARCH

If basic research is defined as investigation into the fundamental aspects of phenomena, then design should undertake some basic research into the fundamental properties of visual form, starting with a deeper understanding of perceptual processes that underlie our experience of it. This raises a couple of questions: has this kind of research already been done and if not, is it possible?

BASIC RESEARCH

DEFINITION

Linguistic analysis of 19 definitions of Basic Research from leading universities such as Northwestern, Stanford and Tulane shows a pattern of key features. Basic research is:

- Systematic inquiry,
- To expand knowledge or discover fundamental aspects or principles,
- Not determined by a specific application.

Currently, most of this research is done in Engineering and Medical science, as affirmed by an article from Stanford (Stanford).

METHOD

As to method, basic research often involves systematic investigation into features of phenomena or the collecting and cataloging of data either in the field or in a lab. Beginning with observation, description and prediction, these activities often result in designed experimental studies that explore cause and effect through the deliberate manipulation of one variable or certainly a very limited number of variables at a time. This so called 'scientific method' is designed to test an existing theory or a new hypothesis with the ultimate aim being to expand knowledge (Wikipedia, "Scientific Method"). After the testing of the thesis or hypothesis the findings are reported often resulting in the modification or formulation of new theoretical constructs.

THE QUESTION OF BASIC DESIGN RESEARCH

Are there research activities in design, such as those described above, which could serve as basic design research? Should there be? If so, what does or should it look like? These are some of the issues this paper addresses. To answer the first question necessarily requires a quick look at what currently constitutes Design Research.

Design Research Profile

Based on a quick review of the available sources on the web such as the design Research Society as well as an unscientific survey of designers and design educators conducted by the author, current Design Research activities fall into a handful of broad categories:

Design research as part of design discovery process:

- discovery of user need: Human Factors, Ethnographics;
- discovery through study of content
- discovery through testing models/prototypes

Design research as discovery of an apt Technical/Media solution to fit defined need

Design research as study and selection of best methods and processes: Management

Design research as study of Theories

Comparison of basic research and existing design research definitions shows design has little or nothing that would qualify as Basic Research. Basic research, though common in science apparently is not in design. Applied Research: solving practical problems for the sake of improvement, has been more common in design. One possible explanation is that basic research is not appropriate for

design. In fact, on the surface there appear to be several incongruities between basic research in science and design research and practice.

APPARENT INCONGRUITIES

Because science and design are different fields, caution is warranted when bringing the methods and processes used in one field into another.

Natural vs. Artificial

For example, design is focused on invention and science is about discovery. Design has been called “the science of the artificial” because it is about human creation as opposed to creation as a given that surrounds us.

Method

Basic research methods in science focus on a single phenomenon or variable often in isolation. (Zender, Crutcher, 2007). Designers, creators of visual form, use variables too. Form-generating software tools such as Adobe Illustrator and Photoshop have large sets of well-defined variables. These variables help quantify visual form for designers and for that reason might help designers understand visual form. But unlike scientists, designers craft solutions by simultaneously changing a host of variables in an iterative process (Moggerdige, 2007). Designers seldom systematically explore one variable at a time. But, using software as an example once again, it is certainly common for designers to build form objects piece by piece and variable by variable.

Approach

As described by the author elsewhere, there is substantial common ground between science and design in their use of a problem solving approach (Zender, Crutcher, 2007). This suggests a common purpose which might use similar processes.

Incongruities Summary

From the brief review above it seems as though design research and scientific research methods are not conceptually incompatible. Basic research in design, similar to that practiced in science, may be possible.

EXPERIMENTAL RESEARCH

If basic research in design is possible, what would experimental design research look like? What phenomena do designers have that can be placed under the microscope? And what would the microscope look like? If anything akin to basic research in science is to take place in design these questions need answers.

TOWARD A BASIC DESIGN RESEARCH PARADIGM

The hypothesis underlying in this paper is that the definition of research and methods of science can be adapted to design. The following offers proposed definition of basic research in design, a topic for study and several examples of how research might be done on this topic.

DEFINITION

The proposed definition of basic research in design is: systematic inquiry, directed by no specific planned application, into fundamental properties of basic phenomena essential to design. The

example of a basic phenomena examined in this paper is the perception of visual form. This is a topic design researchers might put under their microscopes.

TOPIC: PERCEPTION

If we lack understanding of visual form, a logical starting point is the science of visual perception. Visual perception has a substantial theoretical base supported by a growing number of established facts. To pervert a cliché summarizing these facts: seeing is in the mind of the beholder.

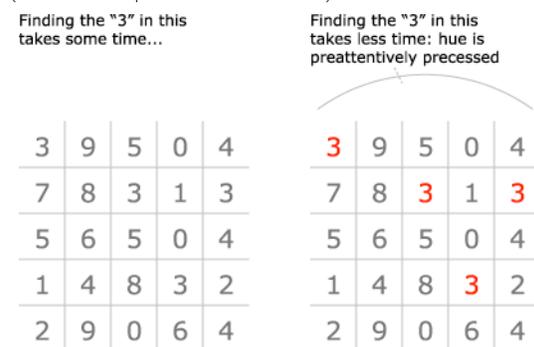
The eye is the window or the portal of vision to be sure, but the brain is where most of the work of visual perception proceeds (Livingstone, 2002). Seeing happens as much in the brain as the eye. In fact, the eye has been described as an outgrowth of the brain (Gregory, 1997). Since the groundbreaking work of David Hubel and Torstin Wiesel on perceptual regions in the cat brain, a perceptual processing model has developed describing how signals are passed in successive stages from the eye to the brain where specific cortical regions 'filter' the retinal 'image' for specific visual features such as a horizontal line. Visual perception is seen, in this model, as the building of recognizable objects from a combination of selected pattern features (Gregory, 1966 – 1997). Ann Marie Seward Barry goes so far as to propose that these perceptual processes are a form of 'pattern thought' that supports or is paralleled by creative thinking more generally (Barry, 1997).

Based on non-invasive brain imaging techniques, much has been learned in the past 20 years about these stages of visual processing. Colin Ware describes three Stages, with Stage 1 providing rapid parallel processing of basic visual features (Ware, 2004). Associated with this massive rapid processing are particular visual features that 'pop-out' from their surroundings. Ware calls these 'preattentively processed' features and defines them as being perceived very rapidly, in under 10msec, despite the quantity of distractors. Ware offers an example like the following (Figure PreAtten):

Figure: PreAtten

Preattentively Processed Feature Example: Hue

(illustration adapted from Ware, 2004)



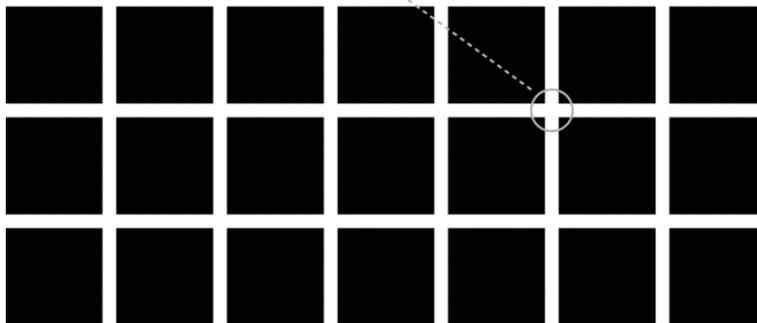
Because preattentive processing affects the hierarchy of what we see, Ware believes "An understanding of what is processed preattentively is probably the most important contribution that vision science can make to data visualization." (Ibid.) The physiological

nature of these findings suggests that this level of visual perception is 'hard-wired' into the human brain and is therefore shared by humans generally (Livingstone, 2002). These processes are only moderately affected by learning and experience. If the theories that support a physiological process of perception were true, then theories of making visual form based upon those physiological processes would hold true for all people regardless of age, experience or culture. As Ware states, "With sensory representations, we can also make claims that transcend cultural and racial boundaries. Claims based on a generalized processing system will apply to all humans, with obvious exceptions such as color blindness." (Ware, 2004). A simple example will suffice to support this: optical illusions (Gregory, 1997). Everyone with normal vision sees them (Figure Illusion).

Figure: Illusion

Hermann Grid Illusion

illusion: gray spot between corners



METHOD

The methods proposed here for basic research in design are similar to those in science. To start with, the studies were based on existing theories or knowledge, in this case scientific research in visual perception. From this, questions were defined and hypotheses were stated. To test the hypotheses experiments were designed, conducted, and the results analyzed. The aim was to define basic parameters of preattentively processed visual features leading to principles of visual form that could provide a foundation for form-making decisions in design practice.

EXPERIMENTAL STUDIES IN VISUAL FORM

Following the method just outlined, from 2003 - 2007 approximately 90 experimental studies have been designed and conducted to study the parameters of preattentively processed visual form. The studies were conducted as part of a Junior level Digital Design Seminar in the School of Design at the University of Cincinnati: Digital Design Seminar VI. The course presents perceptually based principles for information visualization and includes exploration of how such principles are formed and how research studies are designed. Because this was a classroom context and not a laboratory, the first priority was a learning experience including learning how to design and conduct a research study. This is not altogether bad, using the classroom as a laboratory has a long tradition, but it does mean that all the rigor that might accompany a research laboratory did not exist. While an IRB

protocol was not in place for these studies, principles for human subjects in the social sciences were taught and observed including: informed consent, respect for persons, beneficence and justice. From the outset, student researchers experienced firsthand the dearth of knowledge about visual form described previously in this paper.

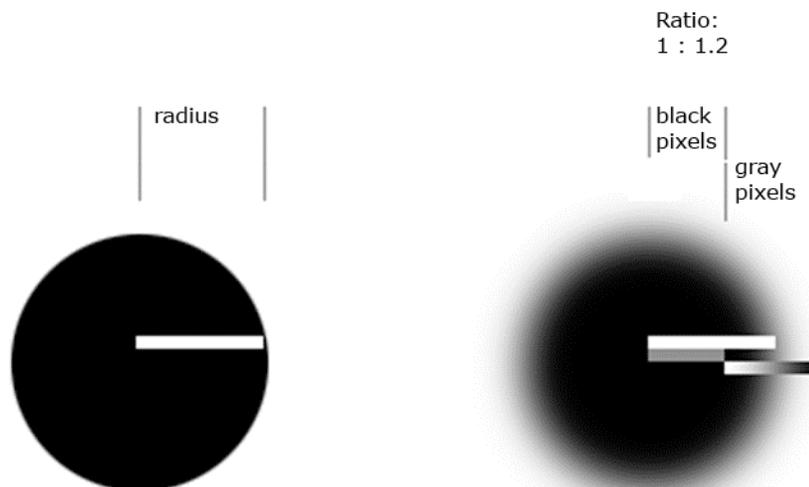
BLURRINESS

One of the earliest studies designed by Chrissie Talkington examined the preattentively processed attribute of blurriness. The first issue was to define blurriness. Definitions including fixed and variable parameters are a necessary first step in empirical inquiry. As noted previously here, many attributes of visual form have no real definition nor do designers have a vocabulary to describe them. To overcome this a definition for blurriness was developed as follows: a black circle was taken as the starting point, the radius was measured, then the circle was blurred using the Gaussian blur filter in Photoshop. Using the radius as the starting point, the ratio of black to gray pixels was measured and described as a Ratio. Circles were blurred by successively larger amounts, placed in a field of blurred and non-blurred circles and tested following an experimental design similar to that described below for value. As reported previously, the Blurriness Ratio required for a circle to be preattentively processed was determined to be 1 : 1.2 (Zender, 2007).

Figure, C. Talkington I

Blur Definition

Amount of blurriness was measured and quantified as a Ratio of Black (solid) to Gray (tinted) pixels.



While not all aspects of visual form lack definition in the same way blurriness does, a similar lack of parameters for understanding visual form was also encountered in better defined areas such as value.

GRAY VALUE

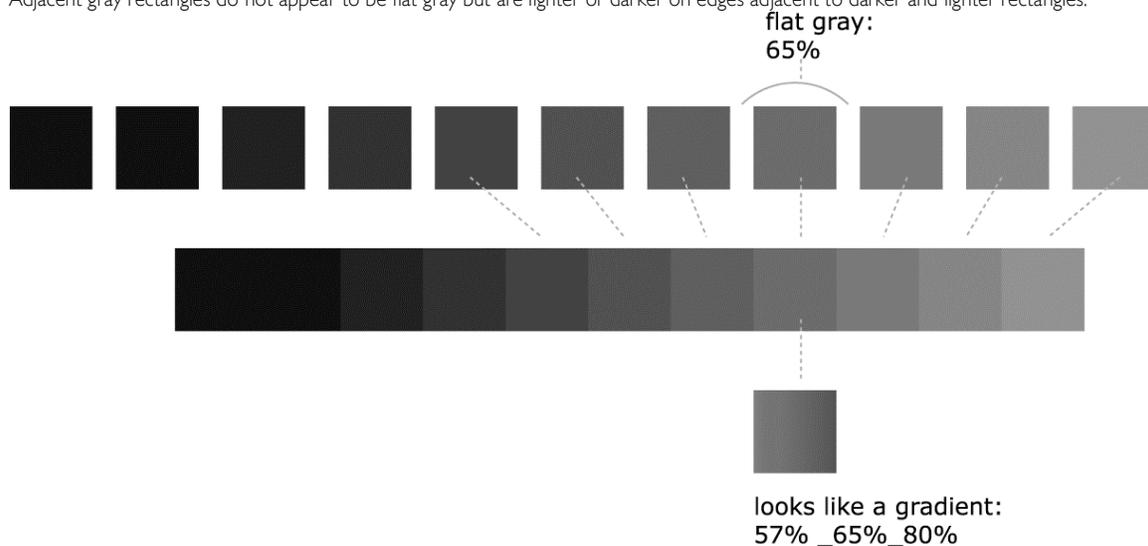
Problem Definition

Martha Rowe designed a study to determine “what amount of gray value difference is preattentively processed.” Following an initial study it was established that a good deal more information exists about gray value than for blurriness. Several factors were significant. One has to do with edge detection, which is itself a result of the center/surround organization of retinal ganglion cells discovered by Setven Kuffler in 1953 (Livingstone, 2002). This strong propensity for our perception to emphasize edges effects our perception of gray values. When a successively darker series of gray patches are arranged so that they touch, the illusion is formed that the gray patches appear not as a single flat gray value but rather each patch appears to be lighter where it touches the adjacent darker gray patch. This has been called the Chevreul Illusion (Ware, 2004).

Figure Chevreul

The Chevreul Illusion

Adjacent gray rectangles do not appear to be flat gray but are lighter or darker on edges adjacent to darker and lighter rectangles.



This illusion and the perceptual processes that drive it suggest that gray values will preattentively pop-out less when they are surrounded by white than when they touch. Martha’s hypothesis was that, depending on the surrounding value, at a certain degree of gray value difference, a threshold, a gray value would be preattentively processed or ‘pop-out’ from its lighter or darker neighbors. Conversely, everything below that threshold would not ‘pop out’. Martha defined the value differences as a percent of gray.

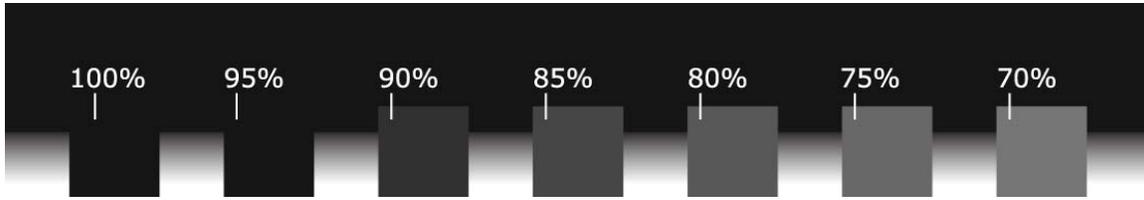
Experiment Design

An experimental study was designed consisting of a field of 25 gray squares of two values. Subjects were asked to count the number of lighter (or darker) squares, in each case a random number between 3 and 7. Responses were measured for accuracy and speed. Based on observations from preliminary trials, Martha noted that background value and darkness of square gray value might have an impact on the threshold. Therefore, the final experiment consisted of three sets of gray squares: dark gray on white, middle gray on white and light gray on black.

Figure, M. Rowe 1

Dark Gray Test:

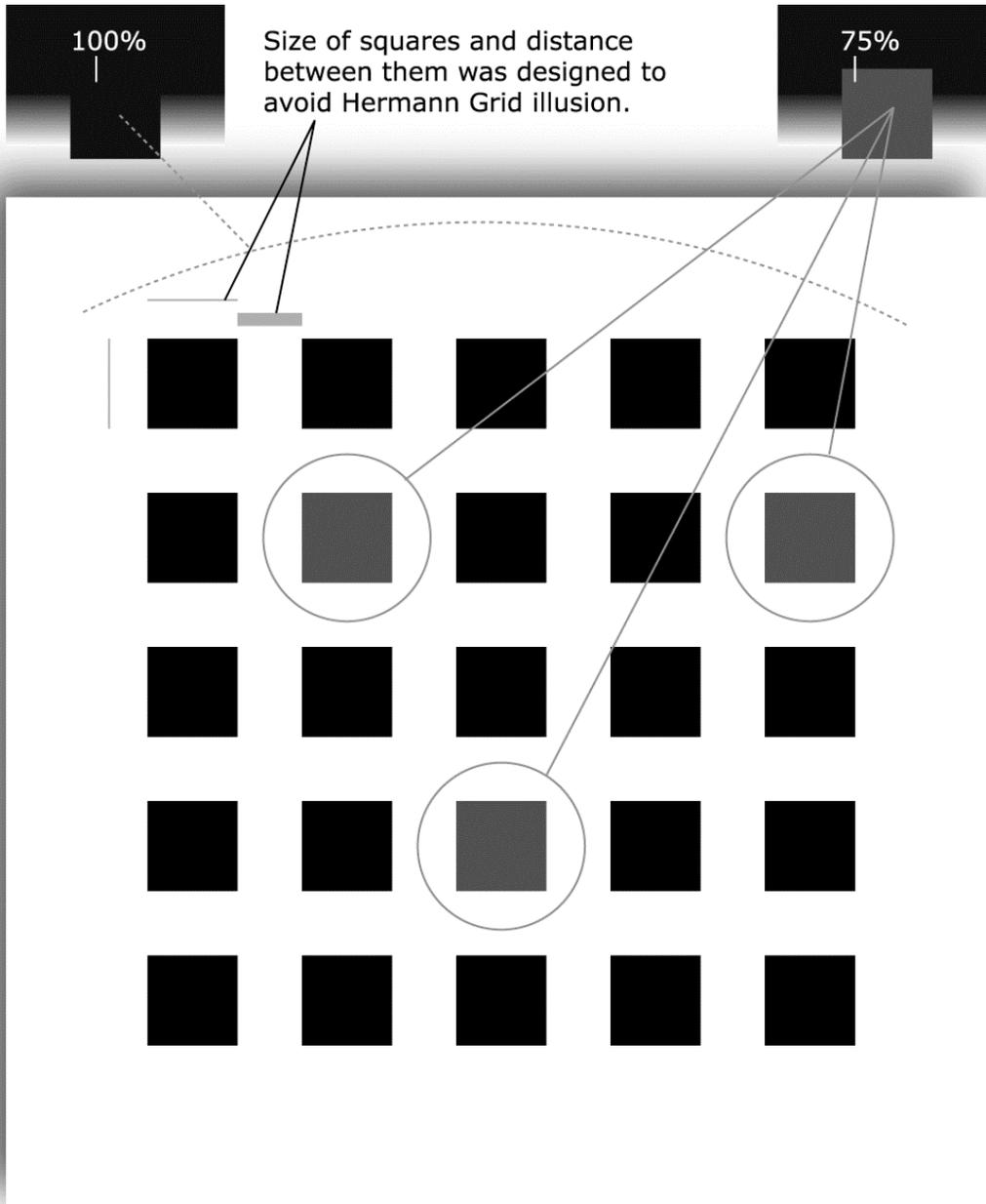
Dark Gray/Black 100% _ plus 6 lighter gray values _ 95% to 70%



Figure, M. Rowe 2

Dark Gray on White Test Display:

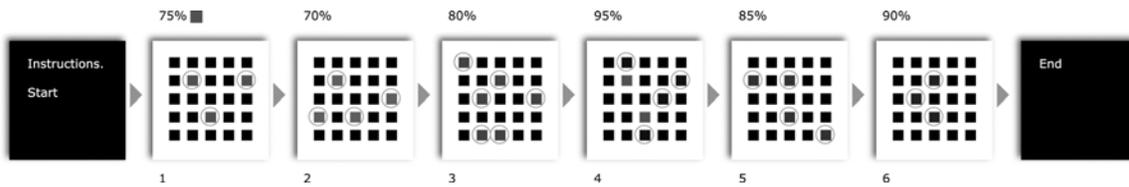
A field of 25 black squares, 100% of black, with 3 to 7 randomly placed lighter squares, 75% in this example, on a white field. *Note: circles and lines indicate values for purposes of illustration but were NOT part of the display.*



Figure, M. Rowe 3

Dark Gray on White Test Display Process:

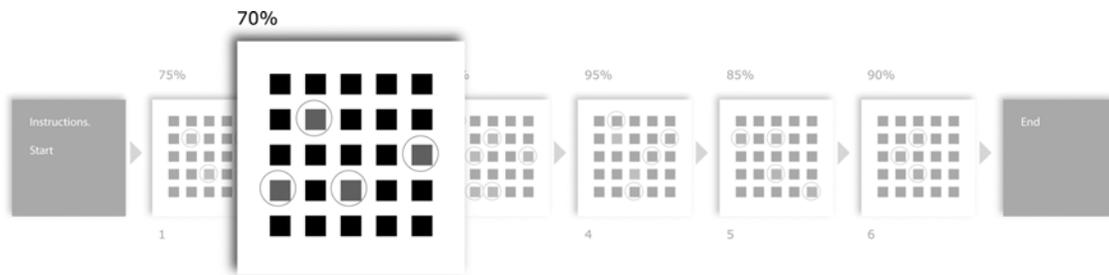
After instructions, a subject viewed a test display, counted the number of lighter squares, and time and accuracy were measured. A subject went onto the next display, through six displays, each a different combination of black and a dark gray value. The order of the values is random for displays 1 to 6. Note: Circles indicate correct choices for illustration purposes but were NOT part of the Display Test.



Figure, M. Rowe 4

Dark Gray on White Test Display Results:

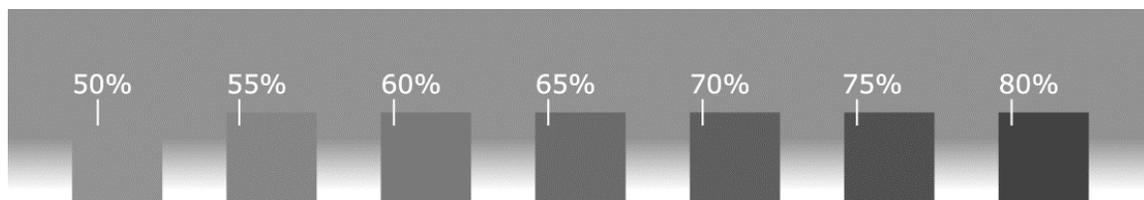
For black on white ground, the improvements in speed and accuracy were nearly continuous to 70% gray, a 30% difference between the 100% black and the 70% gray. For this example, 30% may be the Threshold of necessary dark gray value difference to be preattentively processed or 'pop-out' with black.



Figure, M. Rowe 5

Middle Gray Test:

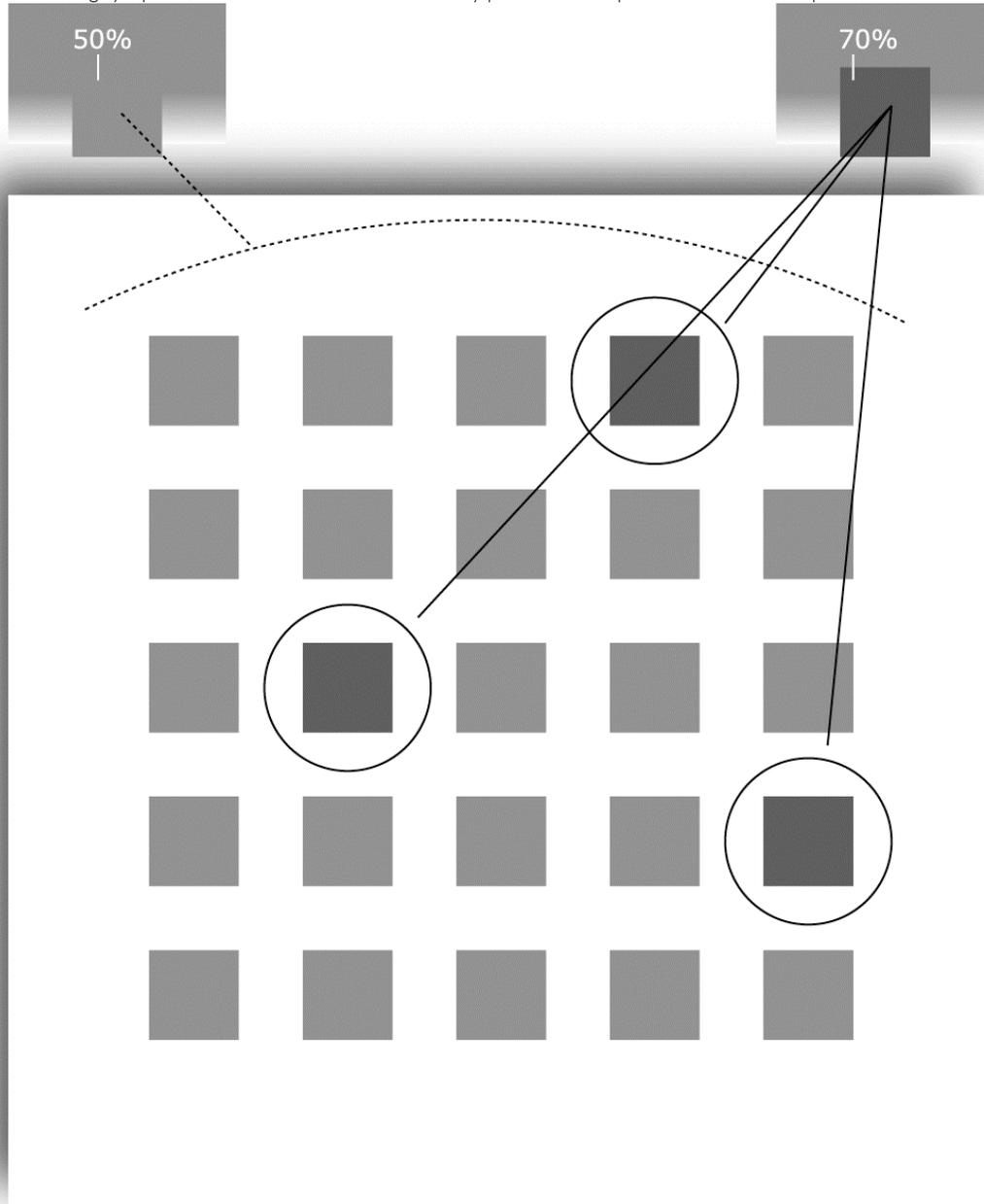
Middle Gray 50% _ plus 6 darker gray values _ 55% to 80%



Figure, M. Rowe 6

Middle Gray on White Test Display:

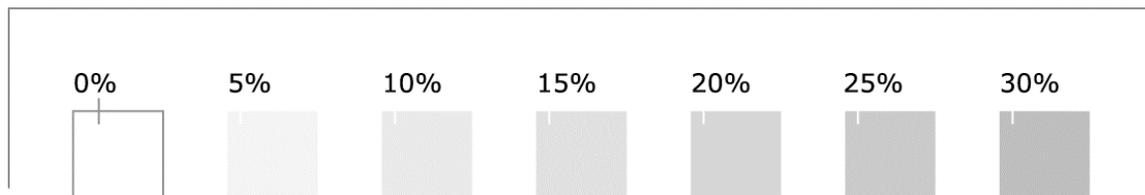
A field of 25 middle gray squares, 50% of black, with 3 to 7 randomly placed darker squares, 70% in this example, on a white field



Figure, M. Rowe 7

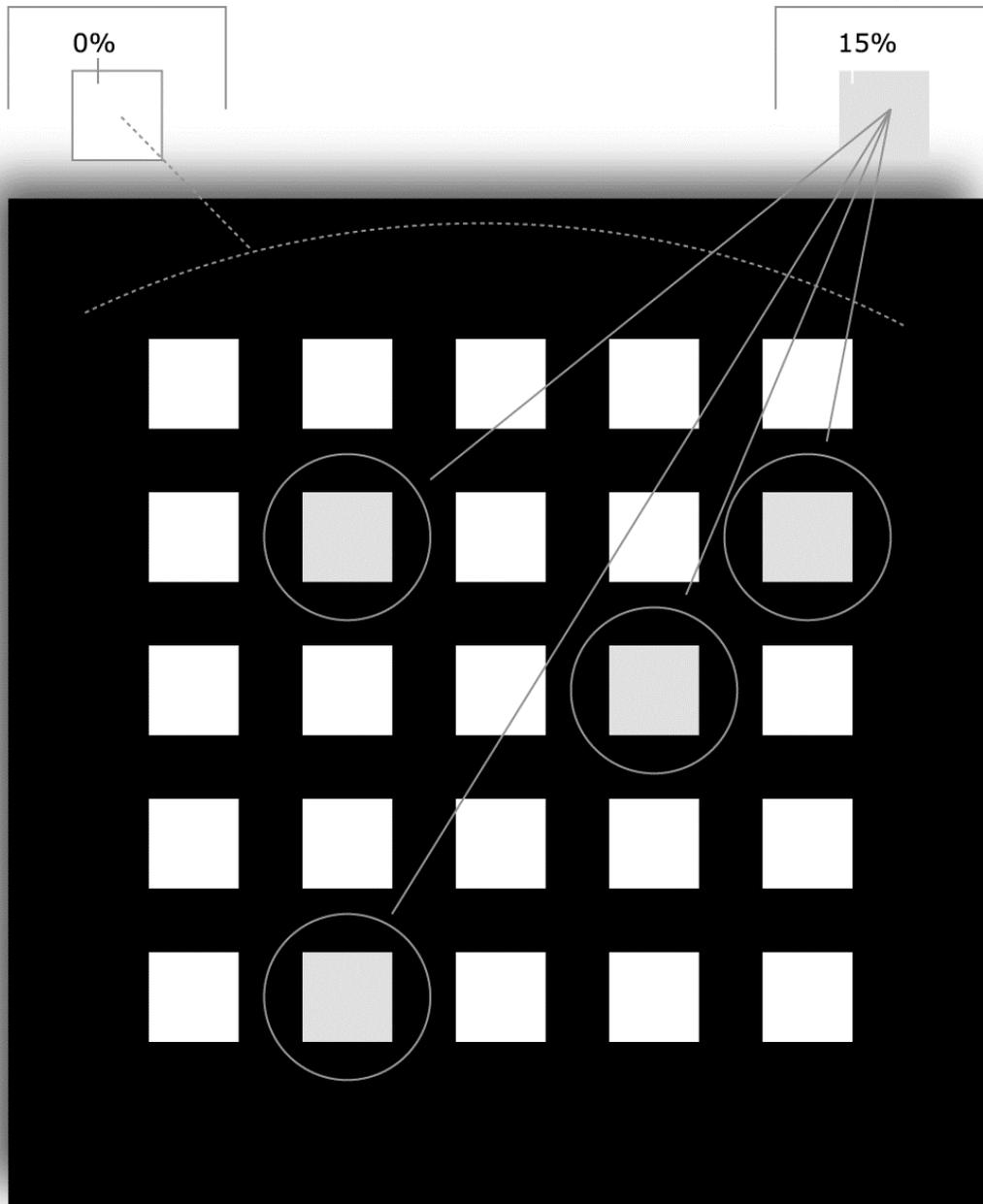
White - Light Gray Test:

White (0%) _ plus 6 darker gray values _ 5% to 30%



Figure, M. Rowe 8

Light Gray on Black Test Display:



A field of 25 white squares, with 3 to 7 randomly placed darker gray squares, 15% in this example, on a black field

Test Scope and Results

Five subjects participated: three male, two female; all college students: three design majors and two English Literature majors. While the number of subjects for this study was less than others, Ware has defended the concept of using relatively few subjects, as few as two to four, when studies are

investigating "low-level machinery of vision." (Ware, 2004). There were no significant differences in individual subjects' performance. Both speed and accuracy increased with an increase in gray value difference as noted in the accompanying Figures: Rowe I-8.

30% Threshold? Dark Gray on White

For black on white ground, the improvement was nearly continuous to 70% gray, a 30% difference between the 100% black and the 70% gray. For this example, 30% may be the Threshold of necessary gray value difference to be preattentively processed or 'pop-out' but it is impossible to say because the study stopped at 70% and improvement may have continued.

20 - 25% Threshold Middle Gray on White

For middle gray on white ground both speed and accuracy improved nearly continuously to 70% to 75% gray. At this difference the improvement leveled off. This suggests that a 20% to 25% difference between the 50% gray and the 70% to 75% gray is necessary for middle gray values to 'pop-out'. For this example, between 20% and 25% may be the Threshold. This difference is less than the 30% Threshold for dark values.

15% Threshold Light Gray on Black

For light gray on black ground both speed and accuracy improved nearly continuously to 15% gray, however, the time went up slightly from 20 - 25% gray. At 30% the speed returned to 15% level. This suggests that a 15% difference is necessary for light gray values to 'pop-out' from a black ground but that the differences between light values of 15% to 30% may be difficult to distinguish on a black background. For this test 15% may be the Threshold but an additional 15% difference may be necessary to distinguish between one light gray and another, on a black ground. The light value Threshold is less than both the 30% Threshold for dark values and the 20% Threshold for middle values.

Problems and Issues

Differences in time to count the lighter squares were not weighted for quantity of squares. The number of squares to be counted was too broad making it difficult to measure true differences. Martha noted in her write-up that, "If I were to run this experiment again, I would probably use fewer squares (perhaps 16 instead of 25) and probably cut the number to be counted from 3-7 to 2-5." Three to five would probably be better, only a 66% quantity increase compared to 233% increase.

Conclusions

These studies suggest that there may be measurable parameters for guiding how much gray value difference is needed for grays to 'pop-out' from a surrounding field of similarly sized darker or lighter grays. Further, these studies suggest that less gray value difference is needed for light values on a black field than black or dark gray on a light field and that middle gray values also may be distinguishable with less difference than dark values. However, this is a long way from being proven or even from being particularly useful knowledge for design practice. For example, the study did not measure the effect of a middle gray ground on the pop-out of darker or lighter grays. Neither did it measure the effect of several gray values in combination. Finally, the role of proximity, how close the gray patches are to each other, was not investigated.

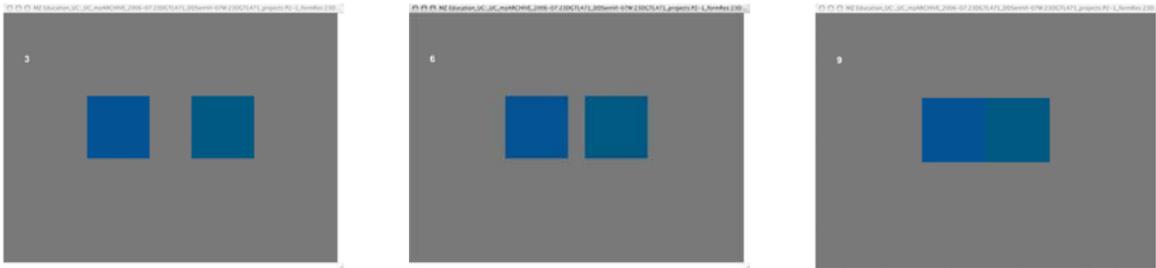
HUE

It was precisely the issue of proximity that another study investigated. Based on other studies in hue differences, a preattentively-processed feature, it was recognized that the proximity of two different hue or saturation patches affected the ability to distinguish between them. Patches touching have much more edge contrast than those that are separated.

Problem Definition

Tony Trucco designed a study to evaluate the effect of distance on the recognition of hue differences. Subjects moved two hue patches closer together until they could identify whether the two patches were different hues or not. Not surprisingly the difference was most apparent when the two were touching. Beyond a minimal distance there was little change in ability to perceive color difference once the two patches were significantly separated.

Figure, T. Trucco 1



Another student researcher, Paul Dehmer, designed an experiment to measure hue difference with a modest but fixed amount of separation. Dehmer's hypothesis was "There needs to be a certain amount of change in hue (to be preattentively processed). Proximity to other colors plays a large roll in this."

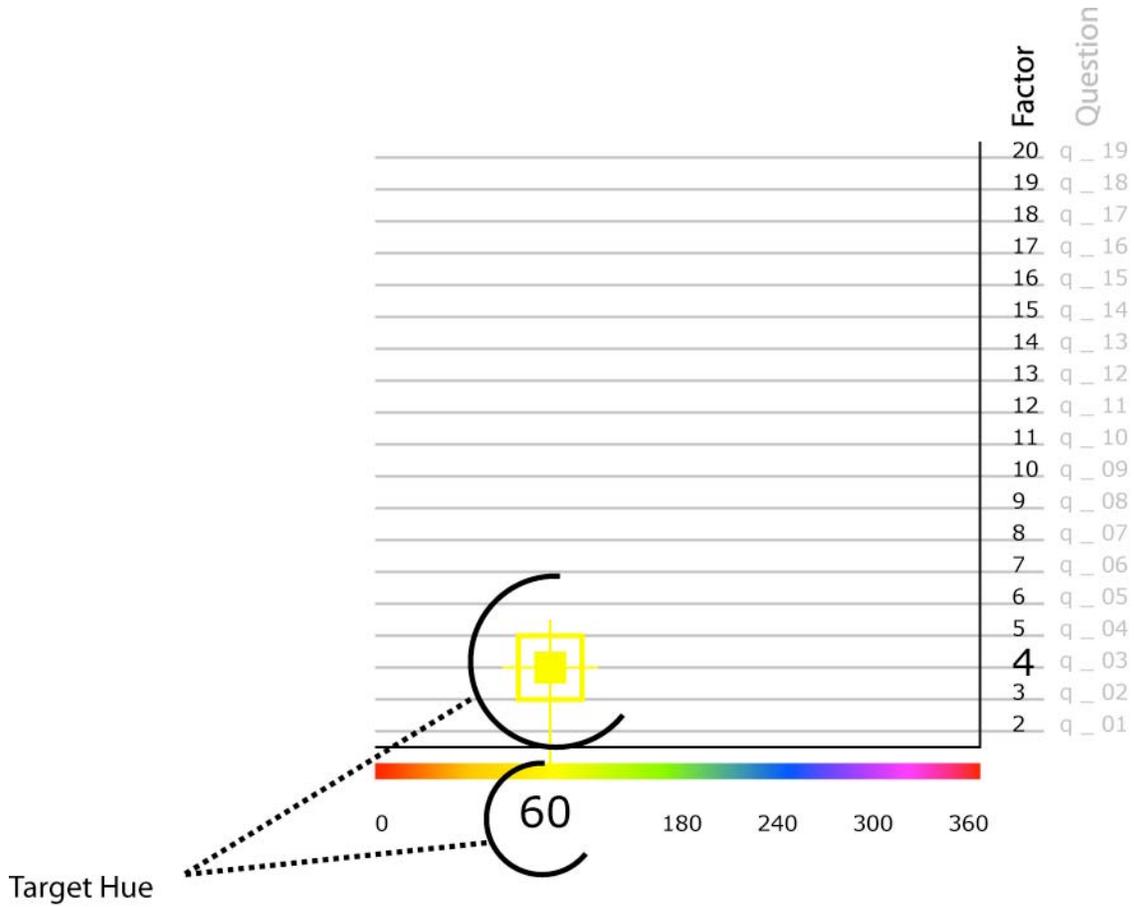
Experiment Design

Dehmer designed an experiment consisting of a square Target Hue separated by a fixed space from a column of five adjacent hues, one of which was the Target Hue and four of which were Distractor Hues. Nineteen different Hue Sets were generated, each set with a greater or degree of difference of the Distractor Hues from the Target Hues. Responses were shown each of the nineteen Hue sets and asked to identify the Target Hue. Responses were measured for accuracy.

Figure, P. Dehmer I

Hue Test: Generate Target Color

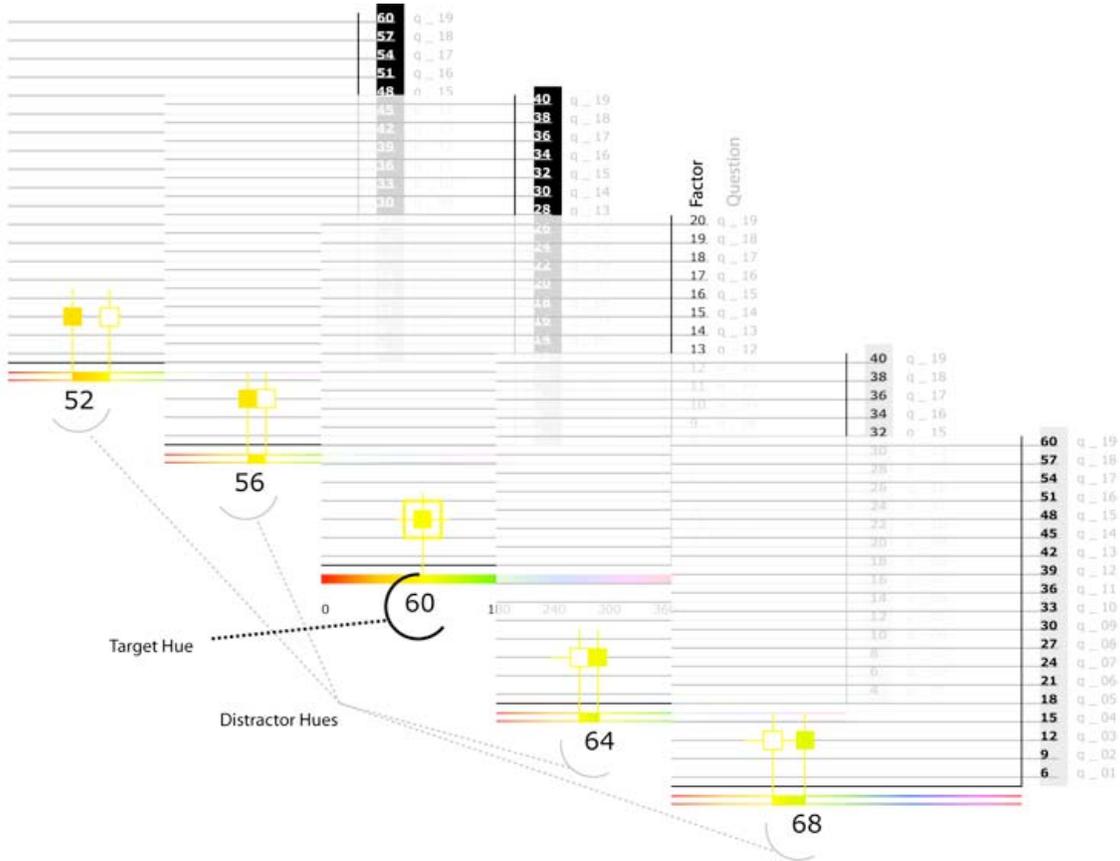
For each question, the student-designed application randomly generates a Target Hue from 0° to 360° on the hue scale of the HSB color system: in this example 60° = yellow. Saturation and brightness remain constant throughout at 100%. A factor from 2 - 20 is associated with each question: in this example 4. The factor is used to generate four Distractor Hues (see Figure, P. Dehmer 2).



Figure, P. Dehmer 2

Hue Test: Generate Distractor Hues

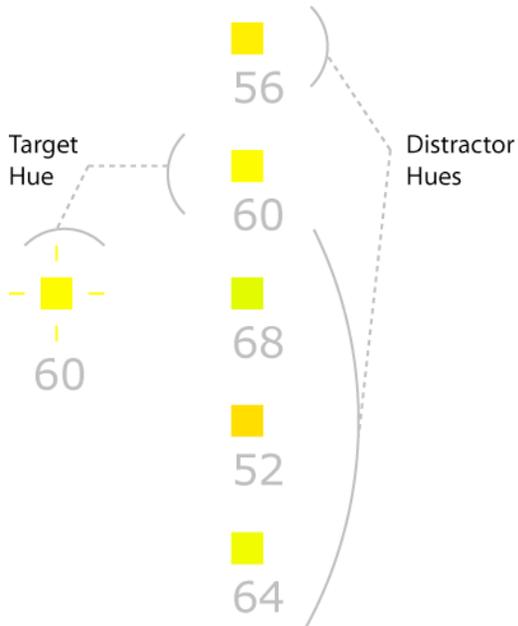
Based on the generated Target Hue, the application generates two additional Distractor hues each an order of magnitude *greater* than the Target Hue. In this example, because the Factor for Question Three is 4, the two greater Distractor Hues are 64° and 68°. At the same time, the application generates two additional Distractor Hues each an order of magnitude *less* than the Target Hue. In this example, the two Lesser Distractor hues are 56° and 52°.



Figure, P. Dehmer 3

Hue Test: Arrange Hues for Display

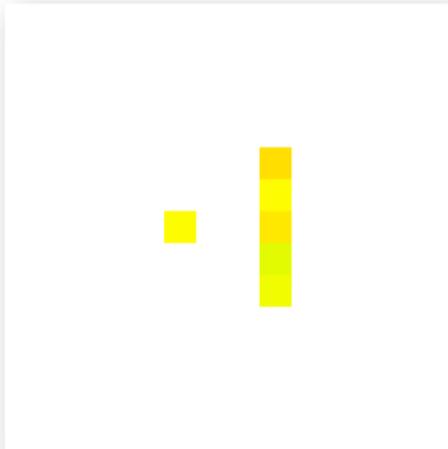
The five hues, the Target Hue plus four Distractor Hues, all equal in saturation and brightness, are placed in a generated display, adjacent to the Target Hue. The five hues are arranged randomly vertically. *Note: the target hue is identified with cross-hairs for illustration purposes only; the arcs, lines and the numbers were not part of the display.*



Figure, P. Dehmer 4

Hue Test: Generate Display

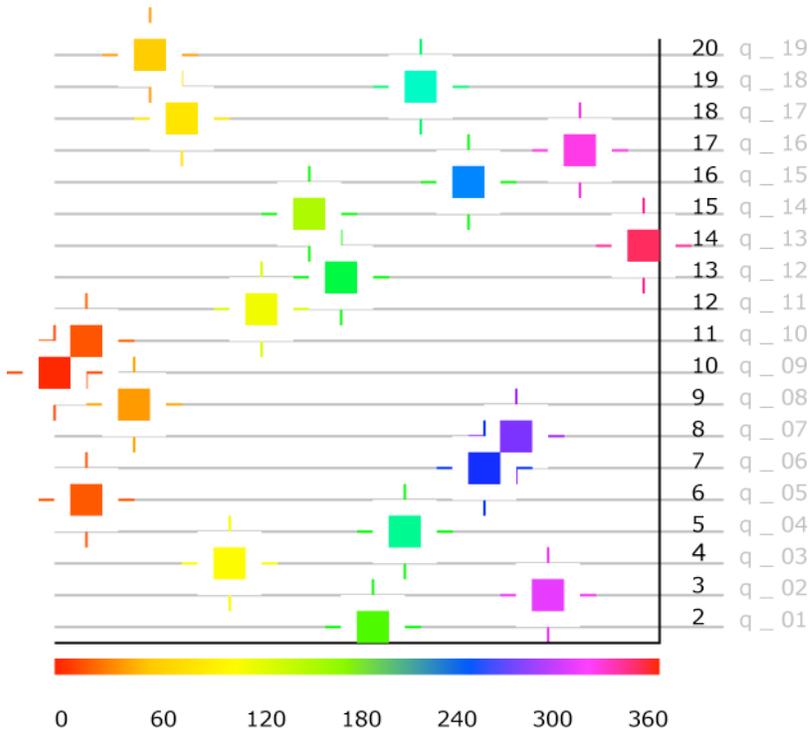
The five hues, the Target Hue plus four Distractor Hues, are arranged adjacent to the Target Hue comprising a Hue Set for the test. The subject is asked to identify the target hue from the five choices in the Set.



Figure, P. Dehmer 5

Hue Test: 19 Display Combinations

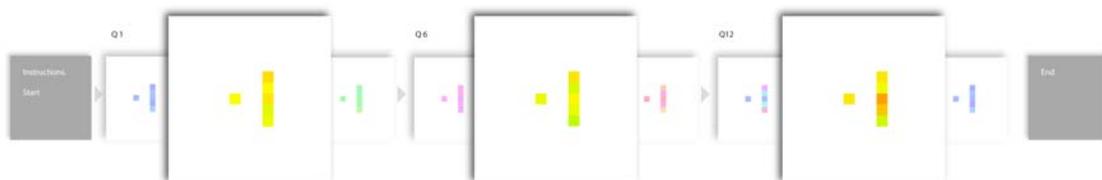
Nineteen (19) Hue Sets are generated for each test. Each Target Hue is randomly selected as the starting point from which Distractor Hues are generated. A different factor, ranging from 2 to 20, is used to generate each Display Target Hue / Distractor Hue Set. Thus, question 2, using a factor of 2 to generate the Hue Set, will have the least difference in hues while question 19, having a factor of 20, will have the greatest difference in hues.



Figure, P. Dehmer 6

Hue Test:

These represent 19 Hue Sets from one Hue Test. Though the full hue spectrum was included in the test, as illustrated in Figure, P. Dehmer 5, yellows are highlighted here to facilitate comparison. Lower Factor on the left, higher Factor on the right.



Test Scope and Results

Nineteen subjects completed the on-line test. As expected, greater hue difference was easier to detect than smaller one. Beyond that, the conclusions from this study were unclear. The sophisticated design of this study was both a strength and a weakness. It provided a large number of

options with high randomness within an ordered structure. Yet using the full hue spectrum as a basis clouded the results ignoring the fact that perceptually some hues are easier to distinguish than others. Yellow, at 100% saturation and brightness is always light in value and any variants from yellow are therefore likely to change also in value. The large number of participants combined with the large number of randomly generated variants also created a problem of data analysis.

APPLY KNOWLEDGE: VISUALIZATION

Although basic research is defined in part by its indifference to a specific application, and the foregoing has been proposed as a model of basic research in design, it was also an aim of these studies to produce principles for visual form that can provide a foundation for form-making decisions in design practice. To that end, student researchers tested the applicability of the principles uncovered in the experimental studies by applying them to an information design project: redesigning a weather map.

M A P

Minimum effective difference

Students were assigned the task of taking an existing weather map visualizing information such as temperature or rainfall and redesign that map integrating principles of preattentively processed visual form with principles of effective design. One principle students were assigned to apply was the principle proposed by Edward Tufte: smallest effective difference, “visual elements that make a clear difference and no more – contrasts that are definite, effective and minimal.” (Tufte, 1997). Students applied specific principles gained from their experimental studies to implement this general principle.

Value

One example used value to suggest rain density in a map of Florida. The original map used hue to distinguish between different rainfall amounts (Figure: D. Stull 1). However, because hue is not perceptually ordered except in narrow ranges, its use to convey successively ordered amounts of rainfall creates confusion. Student David Stull used values of blue to convey increasing amounts of rainfall (Figure: D. Stull 2). Value is perceptually ordered. Testing indicated that this improved the communication of the data. In the process of choosing the blue values his choices reflected Martha Rowe’s value difference principle by using a greater value difference to distinguish in dark values, 11% difference here, and less value difference to distinguish between lighter values, 7% here.

Figure: D. Stull 1

Map Prior to Redesign Using Principles

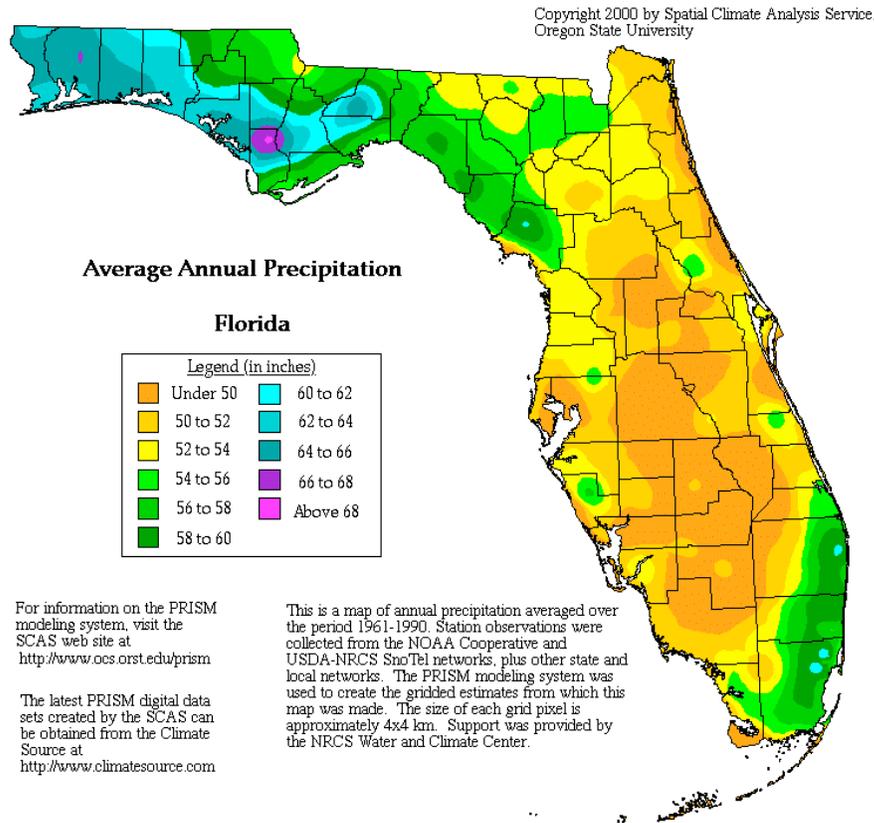
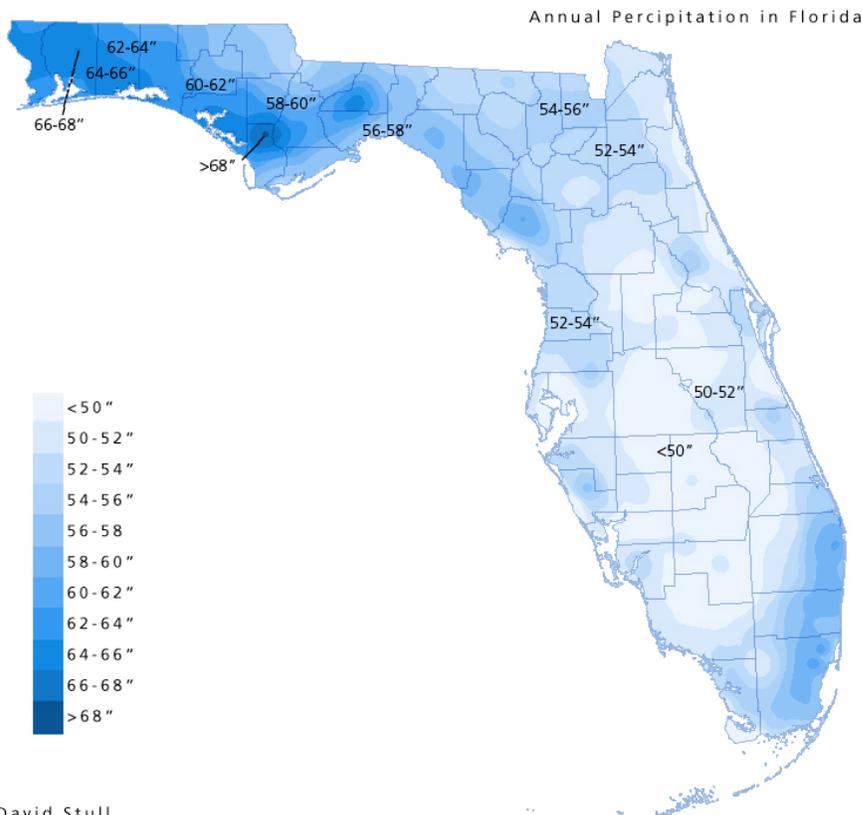


Figure: D. Stull 2

Map After Redesign Using Gray Value Principles



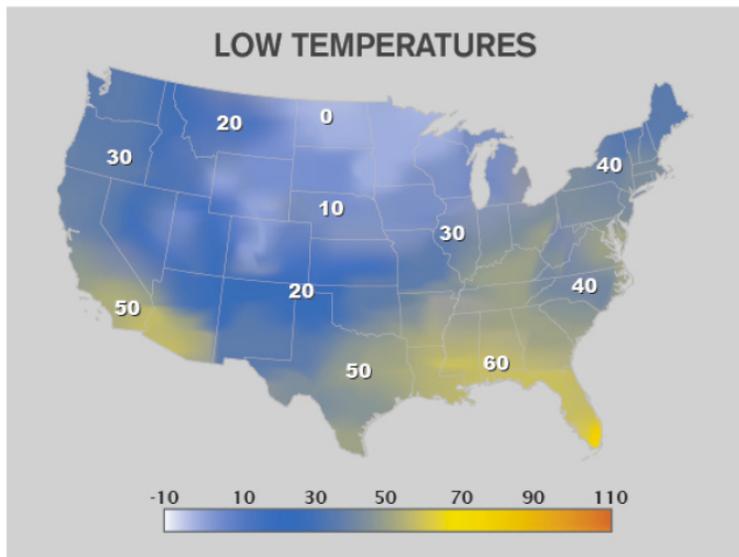
Hue

Another example used hue to distinguish between temperatures. Again, the original used the full spectrum of hue inappropriately to convey conceptually ordered data. Student Tom Wise applied principles from the study of hue to first select a narrow range of hues (Figure: T. Wise 1), and then to select hues from a narrower range that had a minimum effective difference as defined by studies such as Paul Dehmer's (Figure: T. Wise 2). Note that in the legend hues exhibit the Chevreul illusion which, while it emphasizes the edges, also distorts the data by implying that as the color representing 60° F gets closer to 70° F, it in fact gets less like the 70° color block. In evaluation, this illusion was seen as negatively impacting the communication of the data.

Figure: T. Wise 1

First Redesign Using Hue

Initial Revision



Least Difference

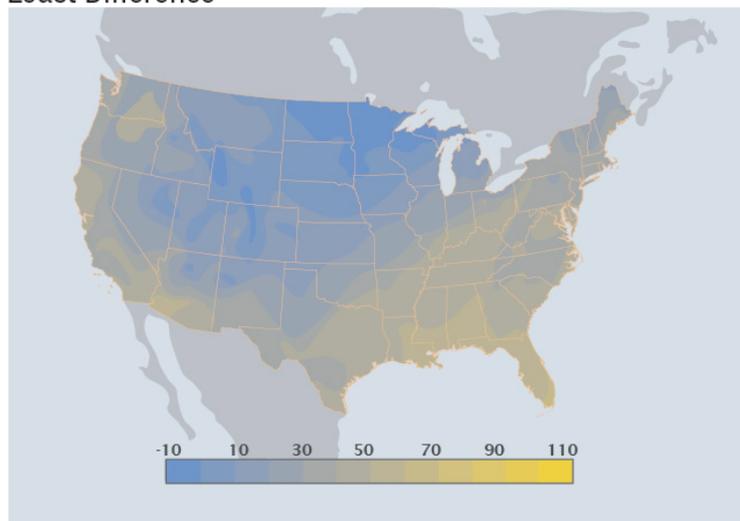
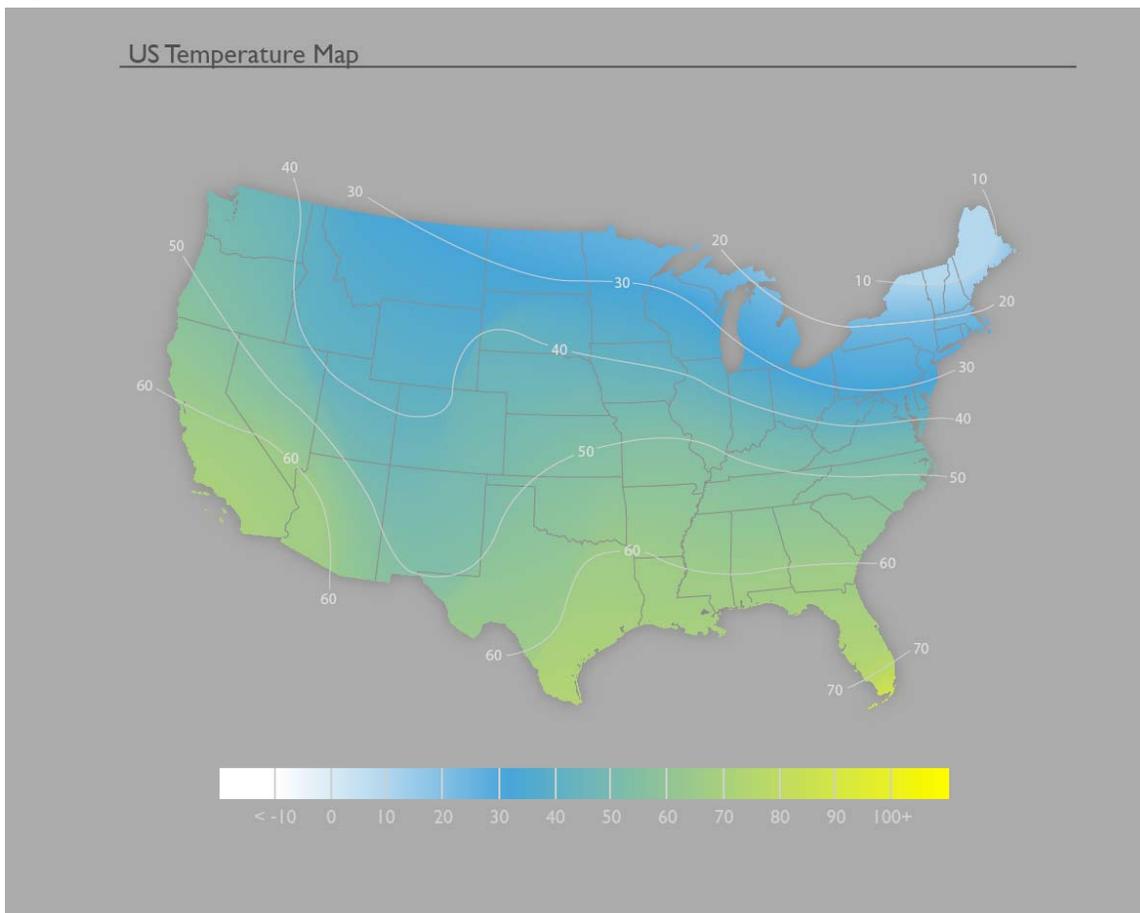


Figure: T. Wise 2

Second Redesign Using Hue and Minimum Effective Difference

In a final example, Student Ryan Devenish applied the principles of hue and edged contrast from the Chevreul illusion to develop a map that evaded the issues associated with edge contrast by using a smooth gradient of hues and overlaying lines on these to create zones of temperature. Evaluations deemed this a successful approach (Figure: R. Devenish 1).

Figure: R. Devenish 1



In each of these examples, students observed principles discovered in the experimental studies of visual form to inform their decisions and even in the last example to inspire a new solution. This does not mean that the principles were first fully developed and then applied to the map project. At this stage none of the principles are that well developed. Rather, experimental studies and the map were developed simultaneously so that the experimental studies formed a context for the map redesigns.

PROPOSED BASIC DESIGN RESEARCH PARADIGM

Based on just these preliminary studies it is too early to claim success for a basic research paradigm for design, but several observations are possible. First, it seems clear that something can be gained in understanding the functional parameters of certain visual form attributes in so far as they 'pop-out' from their surroundings. These parameters appear to be informative in when applied in design practice. What's more, the principles discovered have led to the formulation of new hypotheses and additional discoveries, such as Trucco and hue separation and Dehmer and hue distinction. Modest as it is, these seem to mimic the progression found in basic research in science where one study informs another in the expansion of knowledge.

Another thing that seems evident is that basing design research upon scientific findings seems to bear fruit. Using the theory of preattentively processed visual features as a foundation has provided at least a theoretical construct to inspire visual form investigation. And, as said above, if the science is accurate then design has an area of investigation open to it that is founded in human perception and therefore, within the limits of normal perception, not subject to variances in education or cultural experience. Of course this approach is mechanistic in that it does not touch upon the meaning of the visual form, only the potential to control hierarchy in perception.

Finally, the methods used for this study are roughly scientific and are therefore replicable. The results could therefore become predictable and may therefore, like science, become building blocks upon which theories may be built. If the parallel with science holds, as these results are reported and applied they can contribute to the formulation of broader theories of design for communication in teaching and practice.

PROBLEMS

There are many obstacles to developing principles of visual form through basic research that might be used by practitioners to predict results. Colin Ware notes that, "It is natural to ask which visual dimensions are preattentively stronger and therefore more salient. Unfortunately, this question cannot be answered, because it always depends on the strength of the particular feature and the context." (Ware, 2004). The author has discussed the critical role of context separately (Zender, 2006). Studying single variables is artificial and may be misleading. Paul Dehmer's study examined hue. Tony Trucco studied distance. Each study was done separately. Ware notes that studies have been done testing several preattentive features in combination and Ware for one proposed some generalizations based on these studies, but context and combination will likely always challenge every rule with an exception.

CONCLUSIONS

Returning to examine the key features of Basic Research proposed earlier:

- Systematic inquiry,

- Expand knowledge, discover fundamental aspects or principles,

- Not determined by a specific application,

suggests a fit between the studies outlined above and the proposed definition of Basic Research. The inquiry was systematic, at least to the degree possible with undergraduate students in a classroom setting. Having seen no published findings that correspond with the findings above, it does seem that knowledge was expanded. While the findings were applied to design projects, the application followed the formulation of form principles based on research that were then applied in a test scenario. The application was indirect because the research studies were not aimed at the design of maps but at the identification of basic principles that might inform any design project. Therefore the studies seem to fit into a basic research paradigm rather than an applied one.

Ultimately the definition one applies is less relevant than the conclusion about the meaningfulness and usefulness of the activities described, to which each reader will formulate their own answer.

One reviewer of this paper abstract suggested that if what this paper proposes were possible: establishing how visual form works, measuring and controlling form and using formal controls to predetermine results in the design process, then a 'holy grail' of contemporary design research will have been acquired. Far be it from the author to claim that level of success, but perhaps the work described herein is one step advancing that quest.

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