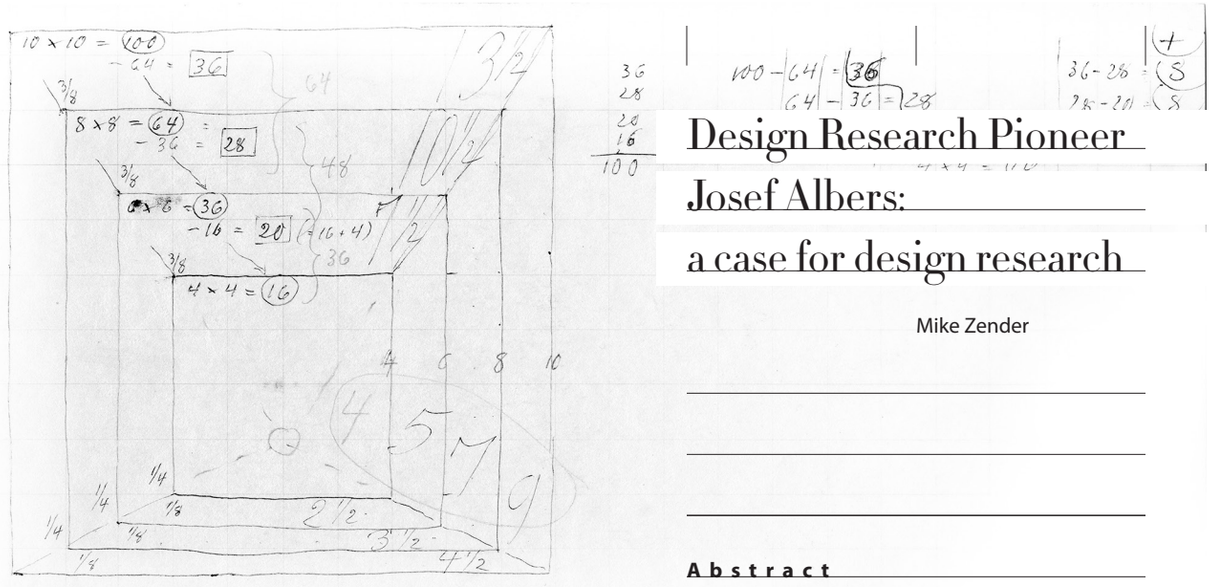


Design Research Pioneer Josef Albers: a case for design research

Mike Zender

Abstract

A lot of design has happened since Josef Albers produced his massive work *Interaction of Color* in 1963 (Albers, 1963). Communication design has grown from a toddling discipline full of confidence to an adolescent exploring new territory. Albers' color teaching in design school, articulated 52 years ago just as Graphic Design was emerging as a professional discipline, had a formative influence that has been as widespread as it continues to be lasting. Today, as design research is becoming normative in practice, this article revisits Albers not for his teaching, which is well understood, nor for his art, which is famous, but for his research. Josef Albers can be viewed as a pioneering design researcher of the first order and *Interaction of Color* can be read as the one of the earliest published records of a body of design research and principles derived from it. In this light, Albers' work might be worthy of emulation in its focus on a key topic explored through sustained, systematic, empirical study that produced generalizable knowledge and kept practice before theory. The article observes that design, far from building on Albers' research legacy, has largely failed to produce works of similar quality or influence to his groundbreaking work 50 years ago.

KEYWORDS

design research, visual perception, color, design foundations, science, scientific method, design teaching, communication design, graphic design

Mere distribution and accumulation of facts,

and many more so-called facts,

I consider possessive teaching and learning,

challenging memory more than imagination,

placing theory before practice,

and retrospection before creation,

and thus "re-search" before search.

Josef Albers, *Search Versus Re-Search*
(Albers, 1969, p. 13)

Josef Albers - design searcher/re-searcher?

To make a vast understatement, Josef Albers was a talented individual. His art is world renown. But far from being a narrow specialist, he succeeded in multiple roles: teacher, artist, designer, and as this paper will argue - researcher.

When viewed from a career perspective, Albers' CV would say he was foremost a teacher. Indeed, most of his life was spent teaching first in elementary school, then art and design at the Bauhaus, at Black Mountain College, and finally at Yale University (Horowitz & Danilowitz, 2006). *Interaction of Color* (abbreviated here *IC*) was his most comprehensive record of his teaching. More than a history, it is clearly a teaching manual, a primer for how to teach color. In it he wrote about classroom activities,
"On the blackboard and in our notebooks we write…
then the class is invited to produce similar effects but is not given the reasons…
Soon, these first trials are collected and separated into groups…
The class will become aware…
A second class exhibition of more advanced results should clarify…" (Albers, 2009, p. 11). Note how many times on a single page (p. 11) the word "class" was used. Albers described *IC* as "a report on a logical sequence of class exercises aiming at the development of color-sensitive eyes" (Holloway & Weil, 1970). *IC* offered instructions from a master teacher to instruct other teachers in his methods. In the last chapter of *IC,* Albers wrote, "This book presents the results of search, not what is academically called research. As it is not a compilation from books, it does not end with a list of books – either books read, or books not read." Although Albers called it search rather than re-search, from within *IC*'s descriptions of teaching emerge the methods of a researcher,

"It starts on a trial and error basis…
Because of the laboratory character of these studies…
successful studies present a demonstration." (Albers, 2009, p. 11).
The research orientation of Albers' teaching is clear from the very first line of the *IC* Introduction,
"The book "Interaction of Color" is a record of an experimental way of studying color and of teaching color."

Albers made clear in his lecture series titled "Search Versus Re-Search" that when he spoke against re-search he had in mind students' "memorization and redistribution" of theories that others had previously discovered (RE-search). Albers was not opposed to research. In fact he vocally advocated an experimental teaching method using trial and error and doing laboratory studies. What Albers opposed was students' learning by reading about experiences rather than having experiences of their own. This is clear because Albers used the language of the research laboratory to prescribe his classroom activity.

It's not at all novel to use the classroom as a laboratory as multitudes of good professors know. That Albers primary laboratory space was the classroom does not disqualify Albers' work from being scientifically valid; otherwise, much of past and current science across many fields would be removed from the corpus. Yet it would be an injustice to the truth to say that science was Albers primary aim. He made his aim unmistakably clear,
"The aim of such study is to develop–through experience
–by trial and error–an eye for color."
Yet even this clearly stated aim integrates teaching and research, theory and practice, but in a reversed order.
"This book therefore does not follow the academic conception of "theory and practice."
It reverses this order and places practice before theory,
which, after all, is the conclusion of practice."
(Albers, 2009, p. 1)

While Albers principal aim was not to do re-search, he at times certainly acted like a researcher. "This way of searching will lead from… to…" (*IC* p. 2) are words that describe an empirical process founded on a cause and effect epistemology that is the foundation of scientific inquiry. Others took note of the degree to which Albers used scientific methods in his teaching. In 1969 two scientists interviewed Albers for the art and science journal *Leonardo* and asked (I – interviewers; A – Albers),

> I. It has occurred to us that in your work there appears to be considerable application of scientific method.
> A. I do not know. I should tell you that recently I received articles on my work which are related to your question. One from Paris has the title 'Three important mathematical steps in Albers' work'. And another article from Rome saying 'Albers works scientifically.' Whether this is right or wrong, I enjoy mak-

> ing line constructions and color instrumentations which seem to work, that is, by inviting the spectator to attain an aesthetic experience and/or a new visual insight (cf. Fig. 1). My main concern is to remain a student looking for further problems to be solved and working for my own development.
> (Holloway & Weil, 1970)

In his response Albers did not reject the label "scientific" while being careful to qualify or add to it the concept of aesthetic insights. The descriptions of Albers' methods as "scientific" were made at a time when a single scientific method was more commonly envisioned than today. Today's scholars would be more nuanced. The National Academy of Sciences has recognized that there is not a single "scientific method" but a "body of methods" particular to scientists' work such as formation of a hypothesis, careful and thorough examination of the hypothesis using relevant data, and reporting of results (Committee on Science & Public, 2009). The Stanford Encyclopedia of Philosophy entry on "Scientific Method", while obviously philosophical in orientation, has also noted the devolution of a clearly defined, single scientific method while at the same time observing that science education at all levels continues to teach a scientific method of roughly five steps: observation, hypothesis formation, examination of evidence to test the hypothesis, analysis of test results, and presentation of findings (Anderson & Hepburn, 2015). Lately, some have noted that in their most general form scientific methods are the methods used to formulate knowledge of any kind. What the Stanford Encyclopedia entry concludes is that what distinguishes methods as scientific is the rigor and care with which knowledge is formed: the systematic examination of relevant data, the care in excluding alternative explanations, the rigor in reducing error, and the reasoned connections to other data. Thus scientific methods may be seen as a subset of epistemology that focuses on answering questions through methodical study. For purpose of this paper, methods will be considered scientific which include systematic exploration, examination, and demonstration of a hypothesis through empirical data with reported results. This paper will argue that over time Albers developed and used scientific methods in his teaching and in his personal work to do research.

Albers search/re-search impact on design

Albers integration of scientific methodology into his classes was not pioneering, but he was a pioneer in bringing a scientific approach to teaching Graphic Design while it was still in its infancy as a discipline. Many identify the Bauhaus (1919-1933) as a guiding influence for Graphic Design as a twentieth century discipline (Meggs, 1991, p. 288). While the Bauhaus started as an integration of art and crafts, it quickly embraced the scientific methods that were part of the spirit of the age. There were numerous lectures on Gestalt theory at the Bauhaus "typical of the tendency that dominated the

Bauhaus from 1928 on, to introduce system and scientific methods into the curriculum." (Wingler & Stein, 1976, p. 159). Scientific methods are defined above as being characterized by reliance on empirical data, and empirical is defined in the Oxford English Dictionary as based on observation and experience often involving experimentation. Albers applied scientific methods early in his Bauhaus teaching through his emphasis on students' direct experience with data. For the Sixth International for Drawing, Art Education, and Applied Art in Prague in 1928, Albers wrote, "The best education is one's own experience." (Wingler & Stein, 1976, p. 142). Albers advanced the use of scientific methods at the Bauhaus when he turned the fundamentals course away from the artistic direction of his predecessor Itten and toward a more empirical approach.

> When Albers himself began teaching what became known as the Bauhaus *Vorkurs* (Preliminary Course) in 1923, he build on Itten's course, stripping away its more esoteric and expressionist aspects and concentrating on the concrete experience of the investigation of materials and visual training…. Rooted in a fascination with how seeing occurs, Albers believed it was an outwardly directed endeavor (Horowitz & Danilowitz, 2006, p. 20). (underline added)

Albers fascination with seeing was fed by findings in vision science. His exact links to vision science will be detailed below, and it will show he was deeply engaged. He not only employed scientific findings in the design of his course content, but he also applied scientific methods in students' activities that used direct observations to build empirical evidence. His faculty position at the Bauhaus placed his methods at the center of the emergence of the Graphic Design discipline.

It was natural for Albers to teach design, as Albers was himself an occasional graphic designer. In his Introduction to the 2009 edition of *Interaction of Color*, Nicholas Fox Weber wrote, "In 1921 his (Albers) first project at the Weimar Bauhaus had been to make a speculative binding for a portfolio of artists prints, and a few years later when Gropius's pioneering art school had moved to Dessau, Albers made alphabets; graphic design was one of his passions" (Albers, 2009, p. xi). Noted art historian T. G. Rosenthal concludes simply, "Albers like other Bauhaus masters was a superb and innovative designer." (Albers & Rosenthal, 2006). Albers design orientation certainly found a receptive audience in design students who embraced his scientific methods. Albers teaching using scientific methods certainly helped train designers whose subsequent practice distinguished Graphic Design from craft and commercial art in part due to the scientific approach those designers utilized. It could be argued that it was Albers' research approach that helped distinguish Graphic Design from Fine Art.

Albers honed his teaching methods at the Bauhaus, and after a brief interruption for the war he brought them in a more advanced form to teach at Yale from 1950-1960. At this time Yale was at the forefront of

the impulse to establish Graphic Design as a discipline distinct from Fine or Commercial Art. Then-dean Charles Sawyer had just reorganized the Yale Division of the Arts "into three Departments: Architecture (which included city planning), Design (which combined painting, sculpture, and graphic arts), and somewhat incongruously, Drama" (Horowitz & Danilowitz, 2006, p. 46). The change raised a furor among painting and sculpture faculties "who resented, sometimes vocally and vociferously, the about-turn their hallowed art school was taking" (ibid. p. 49). When in 1950 Sawyer invited Albers to be the Chairman of the newly formed Department of Design where Albers was to introduce his research-oriented teaching methods, Albers faced the opposition deftly. "Albers strategy was simply to ignore the old guard and allow them to continue their classes, which attracted increasingly dwindling student numbers" (ibid. p. 49). Design historian Lorraine Wild in noting the impact that Bauhaus emigrés had on the creation and growth of design curricula in the U.S.A., credits Albers with establishing "one of the nation's first formal graphic design programs" at Yale (Giovannini & Walker Art, 1989). Though priority is important, it is not the same as prominence. In this case however, Yale was not only one of the first, but one of the most influential Graphic Design programs. Beginning at the time of Albers arrival, the Graphic Design Program at Yale was to become for nearly 30 years, under Alvin Eisenman's leadership, one of the premier Graphic Design programs in the world with a deep and far ranging impact on both academic study - with many alumni becoming future faculty in Graphic Design - and the profession – with many alumni such as Chermayeff and Geismar becoming principals in prominent Graphic Design firms. Since Albers' color course was required for Graphic Design majors at Yale, it is hardly surprising that the students who produced the studies that formed the core of *Interaction of Color* were graphic designers. Indeed, T. Geismar, of Chermayeff and Geismar mentioned above, is credited as author of Plate VII-4(L) in *Interaction of Color*. This book, first published in 1963, was almost immediately adopted into Graphic Design education well beyond Yale. Color studies from *Interaction of Color* were used to teach graphic design starting in 1969 at the University of Cincinnati's newly re-named Graphic Design Department headed by Yale alumnus Gordon Salchow. UC remains a leading design school and continues to teach Albers' color studies. In 1974 *IC* was published as a paperback book which, as Brenda Danilowitz reported in "A Brief history of Josef Albers *Interaction of Color*,"

> …(*IC*) was used frequently as a textbook in schools, where students often had access to the original publication in their libraries, and sales soared. Editions in Japanese, French, Spanish, Swedish, and Italian followed German and Finnish paperback editions. With the exception of the Japanese and Swedish editions, all remain in print (Malloy, 2015).

Albers' color studies became a staple of foundation and similar courses in Graphic Design in the U.S.A. and have remained a staple of foundational design education all over the world until today.

Perhaps because Graphic Design began to emerge from a craft into a discipline during a century reaping the fruit of scientific methodology it was inevitable that scientific methods would help form Graphic Design. Or it may be that Albers and a few others particularly interested in science at the Bauhaus skewed Design into a more scientific mindset than it might otherwise have had. Whether it was Albers' interests or the irresistible sweep of technology or perhaps some of both, as a result of this teaching Graphic Design had scientific methodologies integrated into its core teaching from the start; there is little doubt this foundation helped shape the subsequent nature of Design toward science and research.

But was Albers' use of scientific methods research? There is a difference between borrowing a method and using a method to produce research. If Albers did research, then Albers' work can be seen as one of the earliest, most extensive, most repeated, and most influential design research programs yet recorded. If it was research, it was a research-orientation that helped define the Graphic Design discipline and that still informs it today. Without perverting Albers' instructional intent or taking away from his many artistic accomplishments, this paper examines Albers work as research and if found to be so, to draw from his research important qualities to inform the future of Graphic Design research.

Research

The definition of research that will be used here to examine Albers' work is a simple one: systematic investigation that aims to produce generalizable knowledge. This research definition is used by The University of Cincinnati (UC) and 1,400 other institutions across the USA who utilize the CITI training website to prepare researchers to conduct government funded research studies. The definition's core tenets are exploration or examination in a rigorous way that includes carefully controlled observation, collection, and analysis of data (in short, scientific methods defined above) the aim of which is broadly applicable principles that others can employ to reliably address problems or on which to construct new knowledge. Emphasis is on empirical study rather than pure logic with public reporting of findings so that others can verify them, refute them, and when suitable build on them. Based on the CITI definition, this paper defines research as

> a hypothesis,
> systematically explored, examined, and/or demonstrated using empirical data,
> with links to other knowledge (scientific methods),
> and reported results.

Many have argued that design research is different from other research, or that it should be. Herb Simon is often quoted in this regard

describing design as the science of the artificial (Simon, 1996) as opposed to the science of the natural. The key distinction many make is that science seeks to explain the nature of things that exist like physical phenomena while design involves the human creation of the not yet and that this significant difference necessarily affects not just the aims of inquiry but also the methods of inquiry. Others suggest that design involves aesthetics and connects beauty to intangible qualities not considered the purview of science. Donald Norman has written convincingly on the critical role of aesthetics and emotion in *Emotional Design: why we love or hate everyday things* (Norman, 2004). Citing research findings, on page 19 Norman wrote, "attractive things make people feel good, which in turn makes them think more creatively… making it easier to find solutions to problems they encounter." Still others point to the practice-based practical nature of design as distinguishing it from scientific research. Yet even allowing for these differences, design research still shares many features of the general research definition. Most design research employs observation or experience, the definition of empirical study. Most design researchers report their findings for others to consider. Both design and general research hope to identify principles and knowledge that others can use, and certainly many branches of science such as medicine are extremely practice focused.

This paper suggests that Albers' work fulfills this definition of research, as will be detailed below. Albers investigated a hypothesis he called the interaction of color. He studied this for more than 40 years. Albers investigated systematically. He produced and supervised the production of numerous systematic, carefully controlled, and rigorously supervised studies. The data Albers collected was carefully analyzed, annotated, and stored. Conclusions reached were based on empirical observation. Albers' results produced generalizable knowledge. The results were categorized and formulated into a structured framework. They were published and adopted broadly making them subject to scrutiny and repeated examination for verification and amplification.

In addition to Albers' work fitting the definition of research, two contemporary witnesses described Albers as a researcher. To publish the book *Interaction of Color* Albers sought and was awarded a $6,000 grant from the Rockefeller Foundation Division of Humanities. In his April 11, 1956 letter requesting the grant, Yale Provost E. S. Furniss wrote that the grant was "…to enable Josef Albers, Professor of Art and Chairman of the Department of Design at Yale University, to complete his research and prepare for publication of a manuscript of his color studies and their application to the field of design." The receipt for one of the $1,500 quarterly payments was labeled simply "research" (letter and receipt Albers Foundation, Box 73, Folder 14). Albers clearly acted like a researcher, was funded as a researcher, and was recognized as a researcher by knowledgeable peers.

One measure of authentic research is the impact it has on others working in the same field. The fact that Albers' experiments have been reproduced widely and influenced the development of Design was noted above. Yet the impact of Albers' research went well beyond his students. Albers' work laid a foundation for others' work in color. Karl Gerstner worked initially as a graphic designer and founder of a design agency Gerstner+Kutter and later as an artist deeply interested in color. Grace Glueck in her essay "Perceiving Karl Gerstner" in the book *The Spirit of Colors: The Art of Karl Gerstner* wrote that as Gerstner's interest in the phenomena of color grew, he contacted Albers to learn of Albers' work and made it "a departure point for his own work." (Sterlin, 1981, p. 15). Glueck quotes Gerstner as saying, "Albers was one of the first to explore colors in a precise and rational way, describing them as phenomena with an intriguing life of interactions" (Sterlin, 1981). Gerstner recognized in Albers a scientific approach "precise and rational" and a novel research hypothesis "intriguing life of interactions." Clearly this is the description of Albers as a researcher made by a colleague building upon his work.

At first look Albers' work certainly seems to fit the general definition of research. Gerstner's observation suggests that Albers was indeed a design research pioneer, and the lasting effect of *Interaction of Color* suggests Albers was a pioneer of the first order that others continue to follow. If Albers was a researcher with significant influence, then we might benefit from a look at the characteristics of his research: what he did, how he did it.

Characteristics of Albers' Search/Re-Search

Albers' work was based on findings in vision science, particularly color. This is evident from the chapter titles of *Interaction of Color*. Chapter XIII is titled "The Bezold Effect" and chapter XX "The Weber-Fechner Law."[1] Albers' foundation in vision science is also evident in his notes for *IC*,

> The physio-psychological phenomena of the so-called after-image is the reason why we don't see neighboring colors as what they actually are, that is, physically. (HANDWRITTEN NOTE "wavelengths")" ¶4 "This effect can be understood two ways. ~~First~~ (HAND STRIKETHROUGH) One, as it is usually, in an additive direction as any outspoken hue adds its complementary hue to its neighbor. But it is just as important to see this as a subtractive influence in absorbing from its neighbor its own hue, or (HAND ADDED its own) light.
>
> Albers Archive, Box 74, Folder 12.2

Albers had significant work to build upon. Vanja Malloy wrote recently in the "Introduction" to *Intersecting Colors*,

> It is not a coincidence that Albers's concern with the deceptiveness of visual perception developed during a momentous period in vision science. During his lifetime great advances were

[1] The Weber-Fechner Law is about perception generally not just visual perception, but it was applied by Albers to visual perception.

made in improving our knowledge of how the brain interprets the information it receives from the eye. The American physiologist Ida Henrietta Hyde (1857–1945) invented the microelectrode in the 1930s, enabling scientists to record the activity of single cells in the brain (Malloy, 2015).

Vision science had been developing for 100s of years from Newton's discoveries of the properties of the spectrum through Chevreul in the 19th century, and as Malloy notes this science got a boost from the use of single neuron probes. However, the most important results of electron probe visual research largely came after Albers had completed his work. About 1950 Stephen Kuffler began to identify the important center-surround structure of the cat eye using such probes, followed in the 1958 by discoveries from David Hubel's lab about the functional structure of the visual cortex in the cat brain (Hubel, 1988, p. 69). The published results of these groundbreaking discoveries did not appear for some time after Albers had largely finished his teaching career. Knowledge of the process of visual perception would develop even more rapidly at the end of the 20th century with the development of non-invasive forms of brain imaging to monitor physiological brain activity in response to visual stimuli in humans.

While Malloy may have overstated the influence of the single electrode probe on Albers, the essential point is correct: vision science certainly was advancing during the time Albers was exploring color in his classes, and there is ample evidence he was aware of it. Albers had in his library the 1868 English translation of M. E. Chevreul, *The Laws of Contrast of Colour*; indeed, Albers cited page 5, paragraph 11 of Chevreul's book on page 51 of *Interaction of Color.* He also owned Carrie van Biema's *Farben und Formen als Liebendige Krafte* 1930, Bruno Petermann's *Das Gestaltproblem in der Psychologie,* and Goethes' *Natur wissenschaftliche schriften band I and II,* Verlag, Leipzig, 1925, and other similar books.

Albers stayed current with his knowledge of vision science as is evident from his personal interaction and communication with vision scientists. During Albers's tenure at Yale Dr. Walter Miles, noted international researcher doing night vision research, and Dr. Thomas Cornsweet, a widely recognized expert in vision science and definer of the Cornsweet Illusion, were serving as faculty in the Psychology Department at Yale. Albers apparently discussed particular problems in vision science with those in the Psychology Department at Yale. In a November 20 typewritten note on Department of Psychology letterhead either Tom Cornsweet or his predecessor Walter Miles wrote,

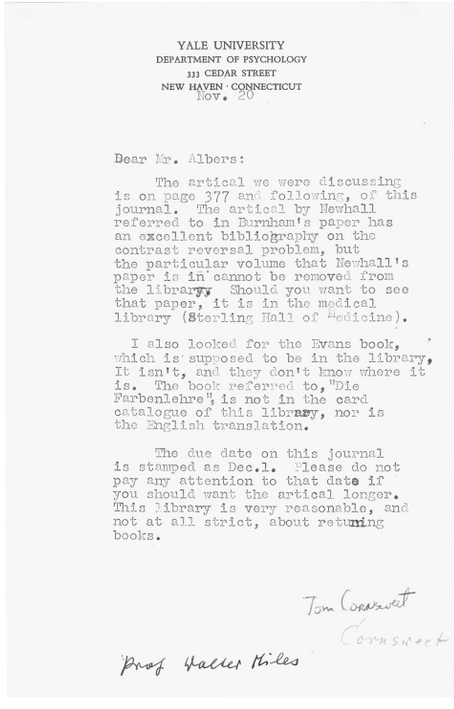
> The article we were discussing is on page 377 and following, of this journal. The article by Newhall referred to in Burnham's paper has an excellent bibliography on the contrast reversal problem, but the particular volume that Newhall's paper is in cannot be removed from the library. Should you want to see that paper, it is in the medical library (Sterling Hall of Medicine). (Albers Archive, Box 73, Folder 9)

FIGURE 1

Note from Psychology Department colleagues. Note Albers' annotations of "Cornsweet" and "Prof. Walter Miles" at the bottom.

JAAF Archive Box 73, Folder 9

Courtesy of the Josef and Anni Albers Foundation



YALE UNIVERSITY
DEPARTMENT OF PSYCHOLOGY
333 CEDAR STREET
NEW HAVEN · CONNECTICUT
Nov. 20

Dear Mr. Albers:

The artical we were discussing is on page 377 and following, of this journal. The artical by Newhall referred to in Burnham's paper has an excellent bibliography on the contrast reversal problem, but the particular volume that Newhall's paper is in cannot be removed from the library. Should you want to see that paper, it is in the medical library (Sterling Hall of Medicine).

I also looked for the Evans book, which is supposed to be in the library, It isn't, and they don't know where it is. The book referred to, "Die Farbenlehre" is not in the card catalogue of this library, nor is the English translation.

The due date on this journal is stamped as Dec.1. Please do not pay any attention to that date if you should want the artical longer. This library is very reasonable, and not at all strict, about returning books.

Tom Cornsweet
Cornsweet

Prof Walter Miles

As Albers was preparing *IC* for publication he sent a draft of the manuscript to Dr. Walter Miles noted above for review for technical accuracy. In Albers' letter of April 20, 1958 to Dr. Miles, Albers wrote:

> I remember with pleasure meeting you in my office in Street Hall about 2 years ago when you gave me a reprint on the Bezold effect. I probably mentioned at the time I was planning a book on color… Now, I am looking for someone competent who could check my formulations, particularly in regard to psychology, I thought of you and was repeatedly referred to you. Thus I dare to ask you whether you would be willing to read and check my manuscript.

The reprint Albers mentioned may have been the one described in the Psychology Department note in Figure 1 suggesting that this note was from Miles. Regardless, the correspondence shows Albers was aware of the Bezold effect, discussed it in a cross-disciplinary way with relevant colleague(s), and took steps to insure that vision science was accurately represented in *Interaction of Color*. Albers likewise communicated with noted psychologist of art, Rudolf Arnheim, and invited Arnheim to come to Yale to make a presentation (Horowitz & Danilowitz, 2006, p. 262).

Albers' dialogue with vision scientists continued after publication of *Interaction of Color*. In a December 11, 1964 letter, Leo M. Hurvich,

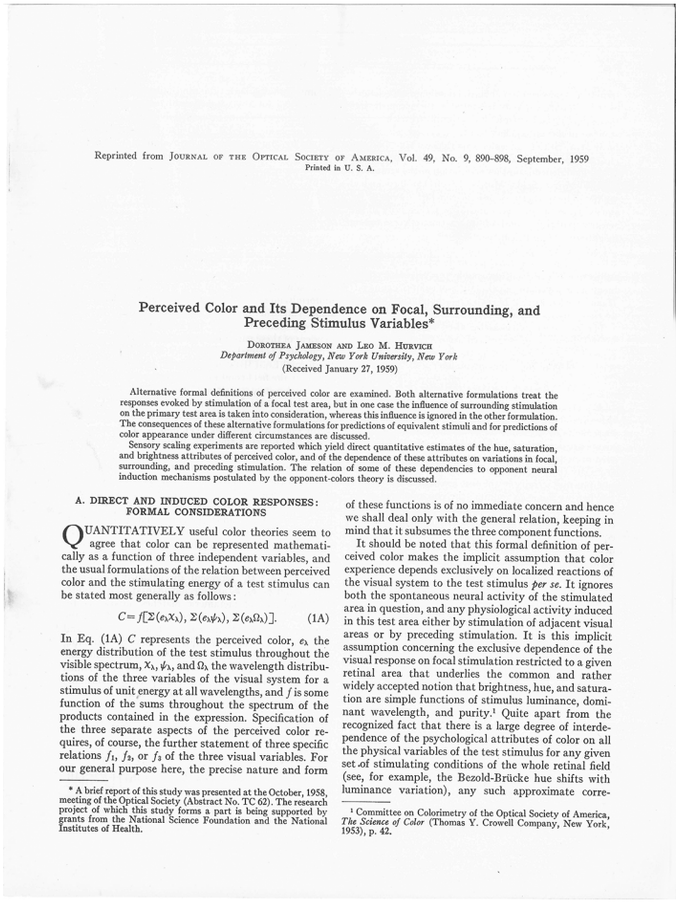
a perceptual scientist, noted having seen and read *Interaction of Color* and observed great similarities between his research interests and Albers' work. Attached to the letter was an article reprint (See *Figure 2*) that he had co-written with Dorothea Jameson titled "Perceived Color and Its Dependence on Focal, Surrounding, and Preceding Stimulus Variables," vol 49 No 9, 1959, *Journal of the Optical Society of America*. The article builds a mathematical formula to describe the "relation between perceived color and the stimulating energy of a test stimulus" (Jameson & Hurvich, 1959, p. 890). Hurvich observed that existing formulae ignored adjacent visual areas, and proposed a way to accommodate the Bezold effect. Jameson and Hurvich asked in their article, "Can we validly ignore the influence of adjacent stimulation on perceived color, or dismiss it as 'purely subjective effect'…?" (correspondence and article Albers Archive, Box 73, Folder 9). Albers who had long preached the difference between "physical fact and psychic effect" must have nodded

FIGURE 2.

Essay on perceived color by Dorothea Jameson and Leo M. Hurvich, 1959 sent to Albers after publication of *Interaction of Color.*

JAAF Archive Box 73, Folder 9

Courtesy of the Josef and Anni Albers Foundation



Reprinted from JOURNAL OF THE OPTICAL SOCIETY OF AMERICA, Vol. 49, No. 9, 890–898, September, 1959
Printed in U. S. A.

Perceived Color and Its Dependence on Focal, Surrounding, and Preceding Stimulus Variables*

DOROTHEA JAMESON AND LEO M. HURVICH
Department of Psychology, New York University, New York
(Received January 27, 1959)

Alternative formal definitions of perceived color are examined. Both alternative formulations treat the responses evoked by stimulation of a focal test area, but in one case the influence of surrounding stimulation on the primary test area is taken into consideration, whereas this influence is ignored in the other formulation. The consequences of these alternative formulations for predictions of equivalent stimuli and for predictions of color appearance under different circumstances are discussed.

Sensory scaling experiments are reported which yield direct quantitative estimates of the hue, saturation, and brightness attributes of perceived color, and of the dependence of these attributes on variations in focal, surrounding, and preceding stimulation. The relation of some of these dependencies to opponent neural induction mechanisms postulated by the opponent-colors theory is discussed.

A. DIRECT AND INDUCED COLOR RESPONSES: FORMAL CONSIDERATIONS

QUANTITATIVELY useful color theories seem to agree that color can be represented mathematically as a function of three independent variables, and the usual formulations of the relation between perceived color and the stimulating energy of a test stimulus can be stated most generally as follows:

$$C = f[\Sigma(e_\lambda x_\lambda), \Sigma(e_\lambda \psi_\lambda), \Sigma(e_\lambda \Omega_\lambda)]. \quad (1A)$$

In Eq. (1A) C represents the perceived color, e_λ the energy distribution of the test stimulus throughout the visible spectrum, x_λ, ψ_λ, and Ω_λ the wavelength distributions of the three variables of the visual system for a stimulus of unit energy at all wavelengths, and f is some function of the sums throughout the spectrum of the products contained in the expression. Specification of the three separate aspects of the perceived color requires, of course, the further statement of three specific relations f_1, f_2, or f_3 of the three visual variables. For our general purpose here, the precise nature and form of these functions is of no immediate concern and hence we shall deal only with the general relation, keeping in mind that it subsumes the three component functions.

It should be noted that this formal definition of perceived color makes the implicit assumption that color experience depends exclusively on localized reactions of the visual system to the test stimulus *per se*. It ignores both the spontaneous neural activity of the stimulated area in question, and any physiological activity induced in this test area either by stimulation of adjacent visual areas or by preceding stimulation. It is this implicit assumption concerning the exclusive dependence of the visual response on focal stimulation restricted to a given retinal area that underlies the common and rather widely accepted notion that brightness, hue, and saturation are simple functions of stimulus luminance, dominant wavelength, and purity.[1] Quite apart from the recognized fact that there is a large degree of interdependence of the psychological attributes of color on all the physical variables of the test stimulus for any given set of stimulating conditions of the whole retinal field (see, for example, the Bezold-Brücke hue shifts with luminance variation), any such approximate corre-

* A brief report of this study was presented at the October, 1958, meeting of the Optical Society (Abstract No. TC 62). The research project of which this study forms a part is being supported by grants from the National Science Foundation and the National Institutes of Health.

[1] Committee on Colorimetry of the Optical Society of America, *The Science of Color* (Thomas Y. Crowell Company, New York, 1953), p. 42.

in agreement and satisfaction even if Hurvich's mathematical formulae were not part of his vocabulary. However, Albers response to another scientist's comment on *Interaction of Color* was decidedly unappreciative. Writing in response to a letter from Mr. Robert Allen Mitchell correcting Albers' use of primaries "red, yellow, and blue" Albers wrote,

> As any understanding of acoustics has nothing to do with the production or appreciation of music, so, similarly no knowledge of wavelength of color or theories or rules about color will lead to imagining or seeing meaningful color – or art. Because (to quote myself) the source of art is the discrepancy of physical fact on psychic effect. (Albers Archive, Box 73, Folder 9)

Albers' response to Mr. Mitchell reveals Albers peculiar relationship to science: on the one hand he built his work upon it; on the other hand he looked beyond scientific definitions of color and focused instead on people's experience. Due to his commitment to giving students experience before forming theory Albers would not generally explain the scientific basis of classroom experience until after the students' work on a project was finished (Horowitz & Danilowitz, 2006, p. 203). This suited Albers' prioritization of direct experience over theory as a starting point.

Empirical: experiential, based on observation

Albers' work was built on findings in vision science as noted above, but Albers did not just build on others' knowledge: he extended their empirical methods. Albers' entire focus was on direct observation. In the "Introduction" to *Interaction of Color* he wrote, "The aim of such study is to develop– through experience–by trial and error," that is, by observation. Albers' students performed experimental studies under his supervision, they observed the data they collected through class critiques, and they analyzed the results. The instrument of measure was the human eye because the purpose of the experiments was ultimately to open the eyes of students to see color, to appreciate it, and as professionals to use it effectively. Horowitz affirmed the empirical quality of these methods writing that "Albers course built on earlier empirical attempts to understand the nature of color" observing that "even though Albers was more narrowly concerned with color as it is observed in normal conditions, the experiments (of Goethe) provided a model for systematic investigation" (Horowitz & Danilowitz, 2006, p. 195). Albers whole process placed practice/experience before theory, as quoted previously.

Integration of science and imagination

Though empirically grounded, Albers' laboratory was not a sterile scientific lab disconnected from reality but united observation with imagination. In the "Introduction" to Interaction of Color Albers wrote "Seeing here… is coupled with fantasy, with imagination. This way of searching will lead from a visual realization… to an awareness… ." In Albers' use, "realization" was

word for making objects or physical demonstrations; hence he is speaking of converting the experience of making things into explicit knowledge through imagination. He seemed delighted to note that the Weber-Fechner Law "demonstrates that, perceptually, multiplication appears as addition" (Albers, 2009, p. 111). Albers' students appreciated Albers' statement that you can do in art what you can't do in banking. One plus one could add up to three or more. Albers distinguished between "factual facts" such as data on wavelength and "actual facts" of perceptual experience where 2 colors look like 3 or 4 colors can look like 3. He reveled in exploring the experience of reality and sharing this exploration with his students. They were fascinated. Horowitz quotes one student as saying "You were always looking forward to the next wonderful surprise, it was like going to a magic show" (P. 200). A magic show founded on science.

Albers' laboratories

Albers explored color using empirical research methods in two different laboratories: the classroom and the studio.

Classroom laboratory

Productive research inquiry is well focused, and Albers focused his research effort on an essential topic: color. This was strategic choice. Color is experienced everywhere and is used everywhere in design. Color was a foundation or core course topic everywhere Albers taught. While color had and still has near universal applicability, it was nevertheless a narrowly focused field with clearly defined properties: value, hue, and saturation are the key features of color from a designer/artist perspective, wavelengths of light are key from a physicists perspective, cones and color opponent pairs are key from a perceptual scientist's perspective.

Because Albers was primarily a teacher, he explored his chosen topic largely in the classroom. In reality, there was little choice since none of his study was funded because design had few if any funding sources at that time. If the classroom required that Albers' primary aim was helping students see, we might say his secondary aim was to conduct "an experimental way of studying color" (p. 2). As noted above, in 1963 Albers gathered and recorded his teaching methods and results in *Interaction of Color* (Albers, 1963). Albers designed and produced *IC* with the help of two of his former students and fellow faculty at Yale, Norman Ives and Sewell Sillman. *IC* was a massive (22 lb) and massively expensive ($200 in 1963) boxed set, the largest and most expensive book then undertaken by Yale University Press. It included Text, color Plates mostly screen printed to precisely control color, and Commentary on the color Plates. Due to *IC*'s size, expense, limited number of copies, and the fame of its author, *IC* soon found its way into the rare book archives of many libraries with corresponding carefully controlled access. *IC* was subsequently reproduced in English in paperback with a very limited

number of color Plates in 1971, 2006, and a 50th anniversary edition in 2013. In 2009 *IC* was also reproduced as an oversized book with all the color Plates reproduced offset rather than silkscreen, providing the most complete and accurate facsimile of the original to date (Albers, 2009). To facilitate reference and examination, this paper references the 2009 re-publication of *IC* in the following analysis.

IC was overwhelmingly visual. The 2009 edition was spit into two oversize hardbound volumes. One had over 150 pages of color Plates showing over 170 color studies and demonstrations; the other contained 118 written pages: 72 pages of Text and 46 pages of Commentary on the Plates. Pages showing color studies contained no written copy other than Plate numbers. The Text, Plates, and Commentary shared a system of Roman numerals (I through XXVII) to link them. The Text was divided into 27 brief topics or chapters, each presented in poetic format with individual typographic lines carefully broken by Albers in the manuscript. Despite the oversized page there were only about 350 words per page due to the font size and hand-broken lines. Each Text topic, the equivalent of a chapter, occupied just 1 to 5 pages. The color Plates dominated the book numerically, visually, and conceptually.

IC color studies were chosen from student projects completed in the classroom whose authors are credited on Text page 71, the last chapter titled "In lieu of a bibliography – my first collaborators." The Text makes clear that these student color studies were driven by research questions: "The question is, What color relatedness makes 3 colors look like 2" (2009, p. 85)? They were directed: "The task: one and the same color, placed equally on 2 grounds of different colors, is to lose its identity entirely…" (2009, p. 84). They were systematic: "these first trials are collected and separated into groups," and they were repetitious, "a second class exhibition of more advanced results" (2009, p. 11). In some cases "the laboratory character of these studies" (2009, p.11) required a level of repetition that tested student researchers' patience, "for a number of Albers's former students the mention of the Weber-Fechner project summoned up memories of drudgery, prompting laughs or groans." Even so, careful data collection and analysis were required: "To illustrate the difference between the mathematical and geometric progressions, students graphed both systems" (Horowitz & Danilowitz, 2006, p. 209). As Brenda Danilowitz wrote in her contribution to *Intersecting Colors*, "The goal of the exercises was not to elicit a single correct answer but to engage students in active experimentation that would yield many and varying solutions—that would extend the question or investigation at hand and suggest new ones" (Malloy, 2015, p. 19).

Reliability is a characteristic of research, and Albers observed this by repeating classroom exercises year after year, always collecting, analyzing, and critiquing the results. Yet it was an evolving inquiry "in which solutions were not conclusions but steps on an endless path. Those who repeated the course–and many did–reported that it (the course) was never

the same twice" (Horowitz & Danilowitz, 2006, p. 195).

Students were not only co-PIs with Albers in his study, they were subjects also. "We have students test themselves," Albers wrote (Albers 2009, p. 14). Albers recorded that only a minority of students "can distinguish the lighter from the darker within close intervals" (2009, p. 13). Whereas current standards call for a "n" number when reporting this kind of finding, Albers was content to summarize roughly, suggesting his interest was on color phenomena rather than sociology.

As a result of this study, color principles were identified and verified. Albers reported that "one is able to push light and / or hue, by use of contrasts, away from their first appearance… any ground subtracts its own hue from colors which it carries…"(Albers, 2009, p. 20). Some effects, such as making different colors look alike, were apparently discovered by Albers and his students "in order to present these unusual and little-known effects…" (Albers, 2009, p. 86). Functional properties of principles were identified: "Hue mattered–mixtures could be changed more easily than purer colors. Intensity mattered–dull colors could be changed more easily than brighter colors. Amount mattered… Shape mattered… Placement mattered…" (Horowitz & Danilowitz, 2006, p. 203). Although Albers wrote of his resistance to color theory, it is clear that *IC* conveyed at least numerous related principles of color interaction, if not a well-formulated theory. Albers' opposition to theory may be partly a matter of semantics. What Albers called color theory we would today call "color systems" as he himself suggested with the title of *IC* chapter XXIV "Color theories–color systems." It may also be partly a matter of sequence, as Albers was interested in theory so long as it came from practice. Art historian T. G. Rosenthal regarding *IC* stated, "the book has become a key work of color theory" (Rosenthal 2006, p. 21). This shows that even if Albers did not intend theory, that at least some thought theory was the result. These operational principles, or this theory, of color interaction could be used to make engaging color relationships in color compositions, which was what Albers did in his personal work.

Studio laboratory

In addition to the classroom laboratory, Albers continued his research in his studio where his production of paintings and graphic constructions has been well documented. *Homage to the Square* is perhaps the best known of these with scores of examples in museums around the world. Toward the end of his career Albers published the full range of his work spanning 40 years as a series of two silkscreened portfolios titled *Formulation : Articulation* (here simply *F:A*). Designed and produced with the help of the same two collaborators that helped with *IC*, Norman Ives and Sewell Sillman, the portfolios were not a retrospective, which Albers disdained, but in Albers own words "These are visual realizations here presented outspoken in silkscreen" (Albers & Rosenthal, 2006, p. 20). *F:A* was a re-articulation of Albers' work in many media: painting, drawing, sandblasting, re-realized in a new media – silkscreen print. As such it provided a convenient and consistent summary of his studio work and thus provides for this article a focal point and easy reference source for discussion of Albers' studio work. Specifically, this paper cites the 2006 re-publication of *Formulation : Articulation* by Thames and Hudson. Numbers separated by a colon (II:1 for example) refer to portfolio prints in *F:A*.

The first thing apparent in *F:A* is that when Albers entered his studio, he seldom lacked a starting point because he nearly always worked in series. In addition to the *Homage* paintings, he produced a number of compositions using short thick lines for sandblast technique (*F:A* I:8 for example), a number of compositions with thin concentric lines he called the *Graphic Tectonic* series (*F:A* I:31 for example), and a number of drawings that implied 3D shapes in often perplexing ways that he would call simply "constructions" (*F:A* I:8 through I:10 and I:12 for example). Albers noted in *F:A* I:17 commentary that he had made "nearly twenty" of these on the same underlying grid. Rosenthal noted in *F:A* that Albers produced more than 1,000 *Homage to a Square* paintings (Albers & Rosenthal, 2006, p. 24), at least 38 of which are represented in the two *F:A* portfolios. *F:A* is the chronicle of Albers' serial focus on visual interaction that unified many hundreds of studio projects over 40 years.

The title of one of his series, *Variants* (*F:A* I:11 for example), suggests the reason for this sustained repetition. Albers was using repetition to show the variation possible within a limited number of broadly applicable principles. As Norman Ives and Sewell Sillman wrote in "Preface" to *F:A*,

> We have tried to show how he continually worked in series, for example in one folder the same image will be developed several times, the only difference being that the same color (or similar colors) is distributed in different quantities and therefore assumes new characteristics (Albers & Rosenthal, 2006).

Albers' repetition was not due to lack of imagination or for commercial gain but again quoting Ives and Sillman, "the artist has placed the folders in a sequential order so that they may be seen and examined for their visual interaction" (ibid, 2006). The sequence and organization of work in *F:A* were designed to make interactive relationships apparent and make the overall principles evident. Albers said in the Preface to *F:A* that the aim was not a retrospective report but "visual realizations." I take this to mean that *F:A* was not organized as a typical chronological retrospective, nor was its aim to glorify the development of the artist but rather that the aim was to arrange the work so that the principles that they "realized"–Albers code word for "made manifest"– would be made clear for the viewer. As *Interaction of Color* was the record of his students' exploration, *F:A* was the record of Albers' search of the same visual interactivity using his own hands.

Albers worked in series in order to make apparent subtle variations on his favorite theme, color interactivity. Many of Albers color projects in the *F:A* portfolio share the same colors used different ways. The

two *Homages* in I:5 use the same four blue/green colors but in reverse order: small square to large, large square to small. Then those same four blue/green colors form the background of four new compositions I:6 which have thick gray bars from the sandblast series to demonstrate the value change in the blues/greens and their impact on the apparent value of the gray. Others used similar colors in different arrangements and quantities such as the eight Homages in I:27 and I:28, "all only in reds" as Albers said. Ives and Sillman called attention to desired impact of this in the "Preface" to *F:A* writing that "we will consider the visual dialogue between versions of the same painting in the same hue: reds, greens, grays" (Albers & Rosenthal, 2006). The repetition and organization of these works are designed to show the interaction of color and how color changes in changing contexts.

Like an experiment designed to control variables to make the intervention effects obvious, Albers designed formats for his series to control changes across the multiple variations he made. *Variants* used a "checkerboard" grid "in order to measure the exact quantity of each color used"(Albers notes to *F:A* I:11 and I:17). After noting that the underlying unit of the two *Variants* in *F:A* I:11 was one half-inch square, 32 X 23 units, a total of 736 units per *Variant*, Albers noted the precise quantities of each of the five colors in *Variants* I:11 as 92, 92, 93, 91 equaling 368 units or half of the composition area, leaving the other half of the composition to the remaining color. Not all Variants were the same proportion. *Variants* I:17 were a 30 X 15 double-square proportion totaling 450 units for example, but all used the same checkerboard grid and similar layout. *Homage to the Square* works were all produced from the same grid of four nested squares. While some *Homage*s only used 3 of the 4 squares, this grid was strictly followed no matter the number of colors (see *Figure 4*). The square grid was not strictly symmetric but was designed to create 3 distinctly different sized bands of each different color. Format measurement was not always mathematical. Albers constructed I:27 *Biconjugate* on a horizontal axis with an even-width unit in a 2-3-2/3-3-2 pattern. Of a similar even–unit pattern for I:8 *Fugue*, Albers said it "recalls a beat (as measured by a metronome) in its vertical, static order…". Together these reveal a man working with thoughtful consistency determined to control variables to better clarify his purpose.

Though consistent in purpose, Albers was rigorous in exploration of alternatives. Many developmental sketches for the *Variants* and *Homage to the Square* paintings exist showing how Albers tried first one color combination then another, seeking the most intriguing demonstration of color effect. Around 70 of these exploratory sketches, many containing Albers' handwritten notations, were the focus of the 2011 exhibition *Painting on Paper – Josef Albers in America* at the Kunstmuseum Basel, in Basel, Switzerland. The notes and numerous sketched alternatives were often all on one piece of paper and exhibited Albers' rigorous process. The website artdaily.org reported on the Basel exhibition and described why Albers worked on paper: "He worked on sheets of highly absorbent blotting paper;

FIGURE 3.

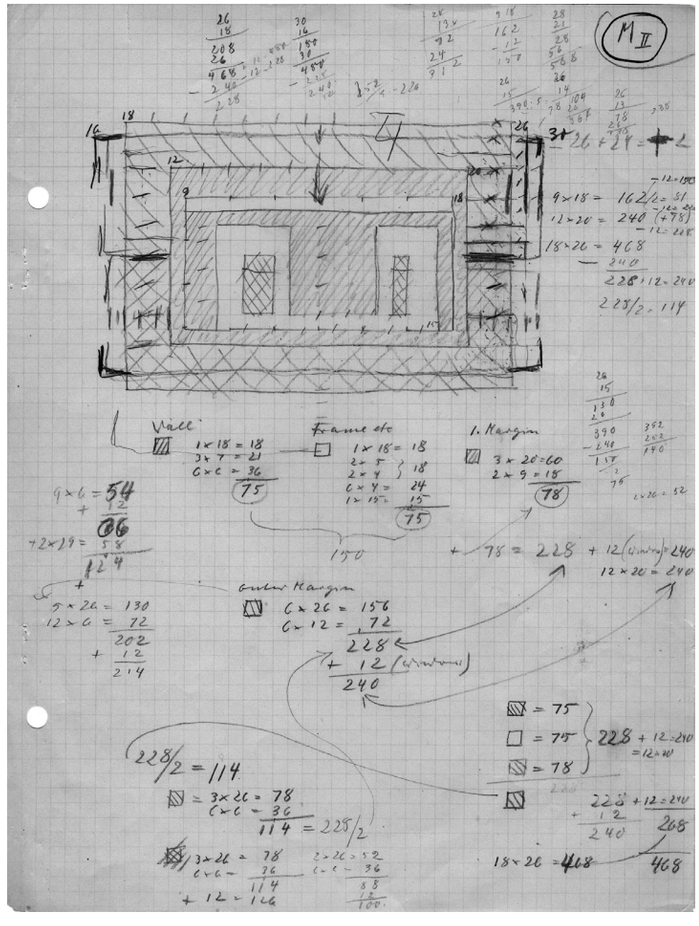
Josef Albers

Sketch of an Adobe/Variant, Scheme M II, ca. 1947

graphite and colored pencil on graph paper

26.7 x 20.3 cm

JAAF 1976.40.95; Archive Box 118, Folder 4



their limited size encouraged his penchant for experimentation and accommodated his serial method, which had been a defining feature of Albers's art from the very outset"(from http://artdaily.com/news/52759/Painting-on-Paper--Josef-Albers-in-America-exhibition-on-view-at-Kunstmuseum-Basel#.Vqfgfsd-nAU, accessed 01.26.2016). The absorbent paper made for rapid drying and rapid iteration. An image for a sketch of a *Variant* that accompanied the website showed Albers' notation of both the colors explored and the half-inch grid (noted above) used to explore them. It's been reported that Albers generally used only paint colors straight out of tube, no mixtures, to increase his level of control and that he also wrote the names of the individual paint colors used on the backs of his completed *Homage to the Square* paintings.

There is no doubt about his purpose in producing so many variants of the same painting, as Albers said in *F:A* I:15, "in my paintings *Homage to the Square* the interaction of color caused by juxtaposition is one of my

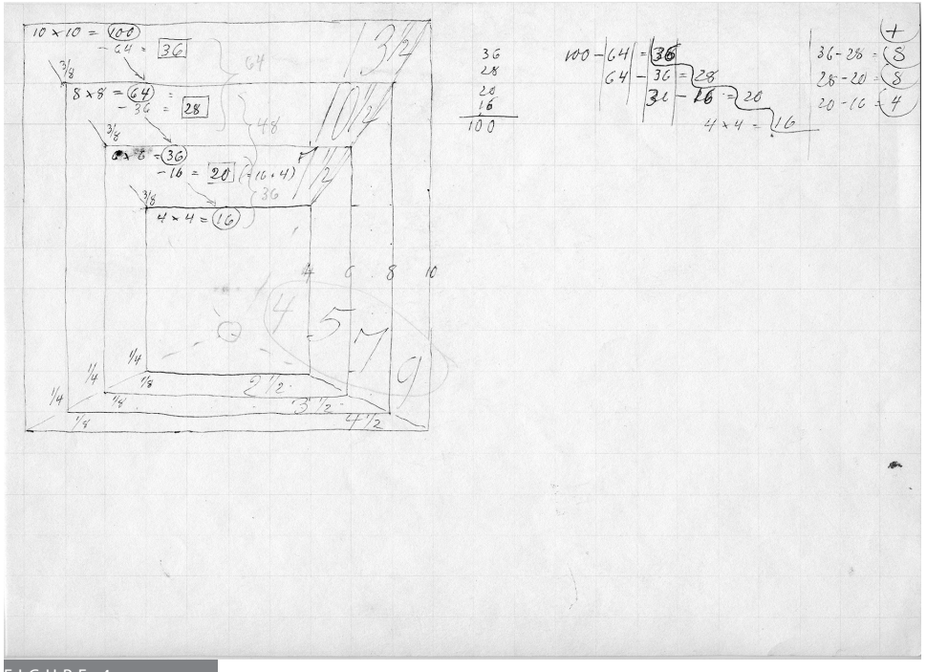


FIGURE 4.

Josef Albers

Sketch of dimensions of an *Homage to the Square*

pen and pencil on graph paper

20.3 x 28.6 cm

JAAF Archive Box 118, Folder 3

main concerns." As Albers noted in *F:A*, some *Homage* paintings and prints demonstrate transparency – the principle in *IC* XI; some *Homage* sequences are designed to make the same color look different – the principle in *IC* VI; or different colors look alike – the principle in *IC* VII (see Albers notes in *F:A* II:32 for example). Thus Albers himself demonstrated the principles he articulated in *IC*. He said in his *Search Versus Re-Search* lecture, "We have no right to demand from our students what we are unable or unwilling to do ourselves." The same purpose driving students' explorations presented in *Interaction of Color* were represented in Albers' *Formulation : Articulation* portfolio showing how perfectly aligned were Albers' studio and classroom work.

Without taking anything away from Albers as an artist, from a compositional point of view *Homage* was one composition painted more than 1,000 times. Except for the number of paintings produced, the same could be said of *Variants*. While such extreme repetition may be unusual in art, it is not unusual in research. Without taking anything away from *Homage* and *Variants* as art, their repetition is more easily understood when viewed from a research perspective. This apparently also occurred to the two *Leonardo* interviewers who asked Albers about this.

> I. May we talk specifically about your 'Homage to a Square' series, where you seem to have removed every kind of obvious symbolism and you have simplified things so that it seems almost that you are looking for effect from color only-this is like a scientific treatment. One would concentrate on the single aim with everything else removed. We wondered whether you were doing this consciously so that you could investigate color alone or whether you were doing it intuitively and emotionally or, in the way you were just suggesting, for fun without conscious intellectual effort. What is the history of the squares you make? How did you begin? Was it by deciding to take some simple forms to see what they will do or did you begin with something less tangible?
>
> A. I know my interest in color comes from handling color for years. I know when and where I painted my first 'Homage to the Square', but how I got into it I do not remember. I like to believe that in playing with color combinations I came across a promising accident (as happens sometimes) and I did not overlook it but tried to articulate it.
>
> (Holloway & Weil, 1970, p. 462)

It seems clear from this that Albers was not self-consciously trying to conduct a new kind of research program in his studio. But that does not mean that he did not. His work speaks for itself, in 2016 as loudly as in 1969, of research work done for the simple joy of discovery. The fact that intuition and play inspired the work does not disqualify it as research. In fact, intuition as a source for hypothesis exploration has more in common with current conceptions of how scientists work than it did in Albers day.

In Comparison

To reveal the sparkle of a particular diamond cut a wise jeweler often places the gem on black velvet because the contrast highlights differences. In a similar way, the particular characteristics of Albers' research approaches may become clearer if we place them in the context of similar research in a different domain. In the preceding description of Albers' foundations in vision science I noted the quite similar work done by perceptual scientist Leo M. Hurvich (Jameson & Hurvich, 1959) who, like Albers, was interested in the effect of one color surrounded by another. Jameson and Hurvich's paper for the *Journal of the Optical Society of America* provides an interesting point of comparison with Albers' *Interaction of Color* and *Formulation : Articulation* because Hurvich's paper covers the same topic, explored in the same timeframe, but in the context of optical science.

Hurvich and Albers shared more than just subject matter. Hurvich and Albers were both concerned with subjective experience, as Hurvich argued, "Can we validly ignore the influence of adjacent stimulation on perceived color, or dismiss it as a 'purely subjective effect' not amenable to systematic treatment in the psychophysical analysis of color phenomena" (Jameson & Hurvich, 1959, p. 891)? Hurvich and Albers each tested his own hypothesis using the subjective observations of human research subjects as Hurvich reported "the observer is asked to report, in numerical terms, on

a particular attribute of perceived color" (p. 893). Hurvich and Albers both conducted research in conjunction with students, as Hurvich noted on page 893, "A preliminary evaluation of the saturation scaling technique was made by Mr. Robert Kestenbaum in an undergraduate research project." But Hurvich and Albers also differed significantly. Albers' first English words about teaching expressed the abiding purpose of his color research: "to open eyes." By comparison, the first words in Hurvich's article are "Quantitatively useful color theories…". A glance at the Jamison/Hurvich paper in Figure 2 shows that they used algebra to express their hypothesis of what was happening physiologically whereas Albers made color demonstrations. In the quote above Hurvich noted that subjects reported "in numerical terms" while Albers required his students to report almost exclusively in color terms. In the Rosenthal quote above he went on to say "The plates in this book are, for the most part, works of art (and design)…". If *F:A* was a demonstration of theory expressed in the language of art, Hurvich's article was a work of theory expressed in the language of math. Where Albers used color Plates, Hurvich used Greek letters as mathematical signs; where Albers used lines to suggest ambiguous 3D space, Hurvich used graphs with plot lines to illustrate specific data. Hurvich analyzed in a mathematical language to form or refute a theory whereas Albers through line and color formed and informed his students. He explored perception in order to arouse emotion, saying in *F:A* II 11-12 art is "constant in its task to reveal and arouse emotion." He wrote of his graphic compositions in *F:A* I:31, "They oppose the belief… that mechanical construction is antigraphic or unable to arouse emotion." That same note reveals that Albers enjoyed "inducing several interpretations" or "multiple readings" and directions that "are imaginary" rather than offering definitive explanations. Rather than define and quantify nature, Albers wanted to demonstrate color experience. In fact, Albers showed delight in producing work that defied nature saying of *F:A* I:32 that light seemed to be simultaneously coming from opposite sides of a Graphic Tectonic: "Thus art is trying anew to do more than nature: two polar lighting directions at the same time." Albers traded in ambiguity and fantasy while Hurvich described with precision our reality. Albers made clear he was not creating "a report on nature…" (*F:A* II:17) but was opening eyes, hearts, and minds.

Whereas Hurvich wrote up his work in the specialized language of science, writing, "wavelength distributions of the metametric stimuli *e* and é remain unchanged but the stimulus energies are uniformly increased or decreased at all wavelengths by some constant factor *q* throughout the "normal" photopic luminance range…", Albers described the experienced effect of his work using common metaphors, "they move forth and back, in and out, and grow up and down and near and far, enlarged and diminished".

[2] The shift from referring to the discipline as Communication Design here, whereas it has been called Graphic Design previously, reflects the historic evolution of what the discipline calls itself. What was Graphic Design in Albers' day is with increasing frequency being called Communication Design today.

Albers also described his work with imaginative narratives as in his description of *F:A* I:22: "we then follow a few small steps of the same light red as it leads up a colossal building of many stories which ends broader than high at the top" (see *Figure 9*. I:22), and through poetry as he wrote in poetic form breaking each line of type in *IC* by hand (see the quotes at the beginning and end of this article). Albers often described color in terms of human relationships: "Color in my opinion behaves like man – in two distinctive ways: first in self-realization and then in realizations of relationships with others" in *F:A* II:17. By this I believe Albers meant that a specific red is first itself; then in combination with other colors it both changes itself and changes others and thus it forms relationships of sympathy with some colors and opposition to others. Albers cultivated some of his own specialized language. He used "constellation" to mean a group of related elements (following Gestalt laws); he used "constructed" to indicate forms created by mechanical means (rulers) (*F:A* I:31); "instrumentation" to mean the color collection or palette used to create an effect (*F:A* II:8); "climate" to describe the environmental effects of a color composition (*F:A* II:8). While specialized like Hurvich, Albers' language is poetic

The conclusion Jamison and Hurvich reached in their paper was that "Surrounds of given hues reduce the perceived saturations of test wavelengths that evoke similar hues when the surrounds are not present" (Jameson & Hurvich, 1959, p. 897). In short, a green surround makes a small greenish patch look less green. Thus they independently confirmed Albers' color subtraction principle. Hurvich and Albers differed not in outcome but in the language used to describe the phenomena observed: math and graph versus paper and ink; the nature of their purpose: explanatory theory versus experienced life; and the scope of their discovery: specialized precision versus relational expansion. A description of Albers the man by T. G. Rosenthal, who wrote the text for the 2006 edition of *F:A*, also summarizes Albers' research well: "deeply cerebral, highly intellectualized… also sensual" (p. 20).

Summary Characteristics of Albers' Research

Albers' research demonstrated. It did not explain, and it did not discover, at least not much. He made some slight claim to discovery of principles like 3 colors looking like 2 for example, but his work mostly demonstrated the interaction of color and identified principles related to that, color subtraction for example. Albers' work employed scientific methods to produce generalizable knowledge. His hypothesis was the interaction of color, his systematic exploration occurred through repeated class exercises and serial artistic works that empirically described color phenomena, his work was well connected to other knowledge, and he reported his results. Thus his work fulfills the definition of research offered here.

Just as use of scientific method does not make an activity research, so all research is not scientific. Albers demonstrated this. Albers'

research employed visual language rather than math and embraced, even focused on, poetic and aesthetic features not normally considered scientific.

Based on the above, this paper asserts that, without diminishing him as a teacher, artist, or designer, Josef Albers was a pioneering design researcher of the first order who had a lasting impact on Graphic Design.

Albers' Search/Research for Today

Assuming the view of Albers' work presented here is an accurate picture effectively drawn, thoughtful readers can draw their own inferences. Of course there are limitations to what can be concluded from one example no matter how outstanding. And we are wise to be cautious drawing lessons from the past because many things have changed.

Yet not everything has changed. Vision still works just the same today as in 1950, and it still plays at least as important a role in human interpretation of the world. Empiricism still remains the dominant way of generating new knowledge despite reasonable challenges from postmodernism's recognition of the inescapability of personal experience when making observations. The enduring influence of Albers' work suggests that it was more than a passing fad. Emboldened by these lasting features, there are at least four qualities from Albers research that stand out as instructive and worthy of emulation in Communication Design[2] research today:

Key Topic,
Sustained, Systematic, Empirical study,
Generalizable Principles,
and
Practice Before Theory.

Key Topic

Albers' research built upon findings in a related field–vision science–and on a topic within that field–color–that was central to Communication Design. Communication Design is a synthetic operation that includes topics that connect to multiple disciplines: anthropology and user-centeredness; formmaking and visual perception; typography and readability; symbols and perceptual cognition. A lot of design scholars have little interest in math or science topics and thus don't appreciate the creative and intuitive aspects of science; they think it is all cut and dried. Only a little design research has built on these connections between science and Communication Design, a recent *Visible Language* article "Brainy Type" described the use of EEG to study how letterforms are processed in the brain is one recent example. But much more is possible because so much has been learned in fields like neuroscience since Albers' time. In recent years design has embraced humanities-informed work and methods such as those in sociology and anthropology. This is wonderful but strategic focus on findings in fields that apply universally, like visual perception, might yield even more broadly applicable principles. A focus on visual perception and cognition might help cultivate a language native to design: visual language. Communication Design would benefit from research on a few foundational research topics informed by findings in other disciplines strategically selected for their universal applicability: research like Albers'.

2 The shift from referring to the discipline as Communication Design here, whereas it has been called Graphic Design previously, reflects the historic evolution of what the discipline calls itself. What was Graphic Design in Albers' day is with increasing frequency being called Communication Design today.

Sustained, Systematic, Empirical study

Albers studied a single topic in a sustained, systematic, empirical way and then published it in design-friendly visual format that integrated fact with poetry and beauty. This is a unique and powerful combination. Yet too many scholarly design papers are opinion masquerading as fact and too many others look and read like science papers done without math or rigor. Scholars openly bemoan the poor quality of design research papers, even those in the most prestigious venues. It is not a question of the use of visual language versus math but of systematic rigor or the lack of it. Systematic study is the essential component of scientific methods described above and also key to the advancement of Communication Design. Repeated calls for more evidence-based design practice cry-out for sustained empirical design research programs. Albers proved that sustained research is possible even in the absence of funding and that empirical does not mean absence of emotion, aesthetics, poetry, and visual form. Communication Design needs many more sustained research programs systematically conducted, empirically grounded, and aesthetically expressed.

Generalizable Results

Albers work has been used and repeated for over 50 years. This will be commented on below.

Putting Practice Before Theory

When Albers so often said practice should come before theory, he probably did not mean design "practice" as we know it today but something simpler like practicing an instrument comes before making musical art. In that sense it is true that time spent practicing temporally precedes performing well: one before the other. But precedence is not just temporal; there is precedence of priority as well. Design is a practice-oriented discipline focused on creating interventions to make things better. With that in mind, Communication Design would be wise to adapt what Albers may have intended as temporal and apply it as priority in putting practice before theory. Albers avoided systems and laws of color; the growing Communication Design discipline should also be careful to avoid purely theoretical pursuits that

are disconnected from practical outcomes. What works for and with people should be the measure of design research programs and choice of topic areas. Albers' research was human-centered; ours should be too. Albers' research produced generalizable principles that others could use; ours should too.

There's a fifth quality from Albers research that stands out as instructive for today as something Communication Design should *not* emulate. Albers' research explored:

Basic Exercises.

Building on Basics

Albers taught color ABC's. Albers color ABC's are still taught today because they are still relevant, but they probably shouldn't be. Imagine 21st century physicists still primarily learning Newton's color spectrum. Communication Design should have added to Albers' lessons by now. Vision science has learned a tremendous amount since Albers drew upon their findings, but Communication Design has not kept up. Design should not just replicate Albers lessons but should build on them, advance them, and move beyond them using the same empirical research methods he used. I believe Albers would be appalled that we are still replicating his work, mindlessly repeating what he so adventurously discovered. Communication Design desperately needs to build new basic insights.

Observations

In the quote at the head of this article, Albers placed search before research. It should now be clear this formulation was Albers' way of saying he preferred carefully constructing direct experiences to gathering facts from others. He was not opposed to research, quite the opposite. His whole work was what he called search, here given the more familiar word research, that is the systematic exploration, examination, and demonstration of a hypothesis through empirical data with generalizable reported results.

Why hasn't anyone studied Albers as a researcher before? The sciences have been quick to identify pioneers like Newton and build on their work. Was there something about Albers' work that has made design slow to study his example, or was there something about the discipline that put a pause in Albers' field study? Did design exhaust color knowledge? In conversation with a colleague from the School of Art about this paper, she rightly said, "Albers was a great artist." To which I responded, "That's true, from your point of view. He was also a designer who taught at the Bauhaus, and he was a researcher." Perhaps Josef Albers was too many things for his own good, or perhaps design was too immature to claim a great pioneer or is just awakening to its roots, but clearly Josef Albers was a pioneering design researcher of the first order who had a lasting impact on Communication Design. Albers' methods were insightful, prescient, and appropriate for today.

Looking at Albers' work as researcher and *Interaction of Color* as his research report raises the question of whether similar work has been produced in and for Communication Design in the 52 years since *Interaction of Color*'s publication. As I scan my library, I find that Communication Design, far from building on Albers' research legacy, has largely failed to produce works of equivalent quality or influence. Emil Ruder's book *Typographie* is considered seminal work on typography in many designer's libraries as are Robert Bringhurst's *The Elements of Typographic* style and Jan Tschichold's *DIE NEUE TYPOGRAPHIE (The New Typography)*. Karl Gerstner, mentioned earlier, did research and wrote *Compendium for Literates* in 1974, but he did not continue in this line of research for long. None of these typographers are as widely taught as Albers' work. Wolfgang Weingart, Zuzano Licko, and David Carson each shook up the design status quo in the 1980's even as Paul Rand and Massimo Vignelli variously defined and defended it. None of these had the empirical basis of Albers. Paul Rand's reflections may have been well-informed personal opinion but they were never founded on an empirical research and years of patiently collected data like Albers. Nor have any of these had as much lasting influence as Albers' work continues to have. With a growing number of calls for evidence-based design, Albers' model research deserves emulation in areas strategic to Communication Design such as cognition and creativity, design of systems, the way symbols work, evaluation and outcome measurement, aesthetics and perceptual, empathy and emotion, and all of this designed with clear connections to practice. Practice first, then theory, but get to theory. Communication Design is not there yet.

Maybe Albers was fortunate to be in the right place at the right time, looking at something Communication Design needed just as the discipline was emerging. If so, he was looking in the right area, based on well-founded phenomena, conducting rigorously controlled repeated experiments, and reporting his findings vigorously in multiple forms. Maybe Albers was just lucky. I doubt it. But he was definitely fortunate to have done this work, and we are fortunate to have had him do it. I am bold enough to hope for more work like Albers' in the future.

Albers wrote,

In my own work

I am content to compete

with myself

and to search with simple palette

and with simple color

for manifold instrumentation

So I dare further variants

Albers, *F:A* II:18

Final note

This paper hopes to make the case that Josef Albers was a pioneering design researcher despite Albers' own statement that *Interaction of Color* was not an academic research report. I concede *IC* was not a typically structured academic research report. I wish that it had been. If Albers had included a Bibliography, "books read, or books not read," it would have saved me time at the Albers Archive identifying the books in his personal library that bore his personal mark or notation inside them trying to winnow what he had read from what he had not. Odd as it sounded to me some years ago when I read it, knowledge is a decidedly communal activity. It is undeniable that we, all of us, stand on the shoulders of those who have gone before as we each reach out to make our particular contribution to those around us and those who will surely follow us. As design finds its way from craft to discipline supported by a body of knowledge, my hope is that in just this one thing, the desire to do rigorous *academic* research, we will differ from the otherwise exemplary work of Josef Albers. We'll include a Bibliography.

Acknowledgements

I would like to thank my wife for her patience and the staff at the Albers Foundation, particularly Nicole Marino, for their generous patience and support. I also wish to thank Tom Cornsweet for helping clarify Albers' correspondence with the Psychology Department at Yale, the reviewers whose critical supportive comments helped sharpen the overall thrust of this article, and last but not least Laura Kilker copy-editor extraordinaire.

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Author

Mike Zender is Professor of Design at the University of Cincinnati. Professor Zender is a past president of Cincinnati AIGA (American Institute of Graphic Arts) and in 2009 was named a National Fellow of the AIGA for his contributions to design and design education. He has written two books on design, more than 25 journal articles, and in 2013 became editor of the 48 year-old communication design research journal *Visible Language*. Mike's research on communication through simple symbols such as icons and pictograms, specifically in the medical domain, and the application and testing of these in global cross-cultural communication, is uncovering principles for communication design and design research.