Hidden Knowledge in Aesthetic Judgments:

PREFERENCES FOR COLOR AND SPATIAL COMPOSITION

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Aesthetic science is intended to be an interdisciplinary enterprise in which people from a wide variety of fields—including art practice, design, philosophy, psychology, art criticism, neuroscience, art history, sociology, cultural anthropology, and others—engage in a meaningful scholarly exchange aimed at understanding aesthetics and its role in the human condition throughout history. A natural starting point would be to provide a working definition of aesthetics. Much has been written on this subject, but there seems to be surprisingly little agreement. For purposes of the present chapter, we take aesthetics to be the study of that dimension of human experience anchored at the positive end by feelings that would elicit verbal expressions such as, “Oh wow! That’s great! I love it!” and at the negative end by “Ugh! That’s awful! I hate it!”

Clearly, it would be preferable somehow to ground such a definition in the external world, but doing so is surprisingly difficult. In defining more “objective” experiential dimensions, such as redness, one can augment a subjective definition by pointing to easily identifiable, prototypical examples: Redness is that chromatic experience common to the visual appearance of ripe strawberries, fresh blood, Coca-Cola cans, fire hydrants, and so forth, when viewed under standard daylight conditions. Unfortunately, this strategy is not available for aesthetics simply because people’s aesthetic responses to such putative prototypes are too variable. If one were to claim, for instance, that aesthetics refers to the kind of experience that is common to one’s perceptions of Van Gogh’s Starry Night, Michelangelo’s David, Beethoven’s Ninth Symphony, Frank Lloyd Wright’s Fallingwater, a perfectly shaped rose, etc., at least two important problems arise. One is that people’s aesthetic responses differ so greatly that there may be some individuals who have strongly negative aesthetic experiences to all of the supposedly positive prototypes. The lack of agreement about aesthetic response even to such prototypes effectively derails the “exemplar” strategy.

Another problem is that aesthetic response, at least in our view, does not refer just to positive experiences or even just to extreme experiences. We assume that everyone has some sort of aesthetic response to everything he or she encounters
(see also Chapter 9). It may be embedded only in the “fringe” of consciousness, but it is there, nevertheless. Aesthetic response can come into focal consciousness in a variety of circumstances: when the aesthetic response is extreme (e.g., seeing something so wonderful or so terrible that it calls attention to itself purely on aesthetic grounds), when one’s attention is directed to aesthetic response by context (e.g., viewing paintings in a museum or shopping for home furnishings in a store), or when one is given explicit instructions to do so (e.g., in the aesthetic ratings tasks researchers give participants in laboratory experiments).

In this chapter we address two principal questions about human aesthetic experience: How are aesthetic responses related to stimulus dimensions, and what causes people to have them in the first place? We will address these issues as concrete, well-defined empirical problems that can be approached using the standard tools of scientific research: formulating hypotheses about how the visual system works and/or why it works that way, doing experiments designed to test these hypotheses, interpreting the results in light of them, and formulating further hypotheses to be tested in the next iteration of an ongoing hypothesis-testing cycle.

Although we find it fairly obvious that aesthetic response can be studied scientifically, others may not. Indeed, some would claim that aesthetic science is not only impossible but oxymoronic, presuming that science and aesthetics are somehow inherently contradictory and incompatible concepts. Science, for example, is supposedly lawful and objective, whereas aesthetics is claimed to be whimsical and subjective. We acknowledge that there is a logical possibility that aesthetic science might fail if there were no systematic commonalities among different people’s aesthetic preferences, but this is an empirical issue. Below we report several results that provide significant insights into aesthetic questions using rigorous experimental methods.

The two domains we have been studying are aesthetic preferences for color and spatial composition. Other than the fact that color and spatial structure are both visual features potentially relevant to aesthetic response, they seem to have little in common, being distinct aspects of vision that diverge within the visual nervous system right in the retina and appear to stay separated through much of early cortical processing. Nevertheless, aesthetic responses to chromatic and spatial structure seem to have a surprising high-level commonality in that both are strongly influenced by implicit statistical knowledge of the observer’s ecological niche. Below we review our reasons for coming to this conclusion.

Color Preferences

Most people have relatively strong and pervasive aesthetic preferences among colors. Although such preferences can differ quite dramatically across individuals, there do appear to be regularities. In modern Western cultures, for example, more
people name blue as their favorite color than any other. A century of scientific
investigation has taught us a great deal about which colors people like, on aver-
age, but there has been surprisingly little work on why people like the colors they
do. In the first half of this chapter, we describe our attempt to fill this gap. The
answer we propose, which we call the ecological valence theory (or EVT), is
relatively straightforward: people like colors to the degree that they like the
environmental objects that are that color. If true, the EVT implies that the human
brain contains statistical information about the overall affective valence (liking to
disliking) of interactions with colored objects. Some of this knowledge may come
genetically through the evolutionary history of the species, but some of it is surely
specific to the autobiographical history of the individual. We first describe the
EVT in the context of other theories of color preference. We then present experi-
mental results that measure color preferences. Finally, we present data that test the
theories, and we argue that the data strongly favor the EVT.

THEORIES OF COLOR PREFERENCE

Given the importance of the question, surprisingly little has been written about
why people like the colors they do. Most of the literature on color preference
consists of psychophysical experiments that simply describe preferences without
explaining them. This is, of course, an essential first step in understanding color
preferences, but going on to answer the why question is the important next step,
which has seldom been taken.

One approach was suggested by Nicholas Humphrey, who proposed that color
preferences arise because of the different signals that colors convey to organisms
in nature. He argues that colors can send “approach” signals, such as the colors of
flowers that attract pollinating bees, or “avoid” signals, such as the colors of poiso-

The physiological aspects
of their theory are based on well-understood mechanisms in the first few synapses
of the human color vision system (see Palmer, pp. 107–121, for a summary). Hurlbert and Ling found that 70 percent of the variance in their preference data
could be explained by contrasts between the outputs of these cone-based systems
in response to a color relative to its surrounding color. Among their findings was
a gender difference on which they based their evolutionary hypothesis: females
tended to prefer redder colors, whereas males tended to prefer colors that were
more blue-green.\textsuperscript{14}

Hurlbert and Ling\textsuperscript{15} attributed this gender difference to evolutionary adapta-
tion within prehistoric hunter-gather societies. They conjectured that females like
redder colors because their visual systems were selected for finding ripe red fruit.
They mentioned only this one example, however, and did not speculate on why
males might prefer colors that appear more blue-green or why both genders prefer
colors that are more blue-violet than those that are more yellow-green. By extrap-
olation, there should be evolutionarily good reasons for these other preferences as
well, depending on which colors are most adaptive for members of the species,
but the authors did not elaborate on such matters. Genetic modifications would
presumably have accrued over an evolutionary time scale such that the members
of the species came to be tuned to the most adaptive color preferences, whatever
those might be.

There is a variant of this theory that has the same conceptual foundation but is
based on a higher-level set of color dimensions. At some (as yet unknown) level of
the visual nervous system, the representation of color in humans appears to
undergo a transformation into a different set of three dimensions: hue (consisting
of red-versus-green and blue-versus-yellow), brightness (how light or dark colors
are), and saturation (how intense or vivid colors are). This set of dimensions is
historically associated with the color theory of Ewald Hering\textsuperscript{16} and is most closely
aligned in modern times with the Natural Color System specified by Hård and
Sivik.\textsuperscript{17} We call this theory the “color appearance theory” simply because its
dimensions correspond more closely to people’s conscious experiences of color
appearance than the outputs of the cone systems.\textsuperscript{8}

Another approach to answering the why question is based on the emotional
content of colors. Ou and associates\textsuperscript{18,19} proposed and studied a set of “color-
emotions,” which they defined as “feelings evoked by either colors or color combi-
nations.” They did not actually propose it as a theory of why people prefer the
colors they do, but it can readily be interpreted containing such a theory with a few
additional assumptions. They proposed that people’s experiences of colors include
nine emotion-like dimensions: warm–cool, heavy–light, modern–classical, clean–dirty,
active–passive, hard–soft, tense–relaxed, fresh–stale, masculine–feminine. They
measured people’s responses to colors in terms of these color-emotion dimensions
and performed a factor analysis of these data. Sixty-seven percent of the variance in
their color preference data could be explained by three factor-analytic dimensions:
active–passive (active preferred), heavy–light (light preferred), and warm–cool
(cool preferred). They did not speculate on how color-emotions arise nor why
some color-emotions predict preferences better than others. It is unclear, for
example, why happy–sad was not included as a color-emotional dimension; as per-
haps the most evaluatively polarized emotion of all, it would seem to be relevant,
but it does not seem to fit the obvious prediction that happy colors should be well
liked and sad colors poorly liked. Our own data show that most shades of yellow are rated as happy colors and many shades of blue as sad colors, yet blues are among the most preferred colors and yellows among the least preferred (see Fig. 8.1C).

To extend the color-emotion theory to account for why people like the colors they do, one simply needs to assume that people like colors to the degree that they like the color-emotions produced by or consistent with viewing those colors. Because people like active, light, and cool colors better than passive, heavy, and warm ones, this hypothesis predicts that they should also tend to find active, light, and cool feelings more desirable than passive, heavy, and warm feelings. In a small study, we found that the first two dimensions of their three-factor model are appropriately aligned with this prediction, because people do rate active and light feelings as more desirable than passive and heavy ones, but we also found they generally rate warm feelings as more desirable than cool ones, which is inconsistent with the prediction.

The EVT that we propose as a framework for understanding color preferences in some sense unites and extends these previous approaches. It is based on both an evolutionary premise that color preferences are fundamentally adaptive and an emotional premise that affective valences (positive to negative evaluations of experiences) underlie them. The primary difference is that the EVT proposes it is not people’s responses to the colors themselves that determine preferences, but their affective responses to the objects that are those colors.

In general, the EVT posits that people’s health and well-being are likely to be improved if they are attracted to things whose colors “look good” to them and avoid things whose colors “look bad” to them. We thus view color preferences as providing a kind of steering mechanism roughly analogous to that provided by taste preferences in eating. Generally speaking, people’s health and well-being are likely to be improved if they eat things that “taste good” to them and avoid eating things that “taste bad” to them. The rationale is that the tastes people tend to like (e.g., sweet fatty substances) are correlated with high-calorie content and those they tend not to like (e.g., bitter sour substances) are correlated with toxic content. The analogous ecological heuristic underlying the EVT will be similarly adaptive if how “good” versus “bad” colors look to people correlates with the degree to which things that characteristically are those colors are advantageous versus disadvantageous to their health and well-being.

The EVT makes a clear empirical prediction: average preferences for any given color over a representative sample of people should be highly predictable from average emotional responses (positive to negative) of similar people to the set of correspondingly colored objects. In other words, people should generally like colors associated with objects that tend to elicit positive affective reactions (e.g., blues and cyans with positively valued clear sky and clean water) and dislike colors associated with objects that tend to elicit negative reactions (e.g., brown and olive colors with negatively valued biological waste products and rotting food). We test
this central prediction of the EVT in Experiment 2 and compare its predictions for
color preferences with the predictions of theories based on cone contrasts, color
appearances, and color-emotions.

Feedback from color-relevant experiences can influence color preferences in at
least two ways. First, it could shape genetically based preferences for evolutionarily
advantageous colors over evolutionarily disadvantageous ones, as Humphrey
(1976) and Hurlbert and Ling (2007) suggest. These preferences would presumably
reflect universal biases in the ecological statistics of color within the human eco-
logical niche (e.g., blue skies and brown feces). Similar principles might also hold
for other species, but we will restrict our attention to people, who are much easier
to study. Second, learning mechanisms could tune an organism’s color preferences
during its own lifetime based on environmental feedback such that it comes to like
the colors it has found to be associated with advantageous outcomes and dislike
colors it has found to be associated with disadvantageous outcomes. To the extent
that people prefer more advantageous outcomes, they should learn to prefer the
colors associated with those outcomes.

The best evidence for innate color preferences in humans comes from measure-
ments of looking preferences in infants. Researchers measure either how much
time infants spent looking at each color in comparison with white during a series
of fixed-duration trials or the percentage of trials on which infants look first at
each color in comparison with white. Figure 8.1A shows data adapted from Teller,
Civan, and Bronson-Castain for the first-look preferences of 12-week-old infants
viewing pairs of six colors. The general shape of this function, with a peak at blue
and valley around yellow-green, is surprisingly similar to the average hue prefer-
ences we find in adults (Fig. 8.1B,C). Although the infant preference function may
of course reflect learning during the first 12 weeks of life, it may also include a
strong innate component.

The EVT assumes that learning mechanisms modify color preferences from the
inborn starting point, leading eventually to adult preference functions that reflect
many diverse influences. Through interactions with objects in the environment,
people learn valences for particular objects depending on the pleasantness/un-
pleasantness of their experiences with them. For example, biting into a delicious
red apple or diving into a refreshing blue lake should produce an increment of
positive affect to corresponding red and blue colors, whereas smelling feces or
tasting rotten fruit should produce a decrement in positive affect to the corre-
sponding brown and olive colors. Colors thus accumulate increments and decre-
ments in aesthetic valence by association with the corresponding objects, such that
color preferences come to reflect the overall desirability of things associated with
that color.

The EVT implies several levels at which environmental factors might influence
color preferences. First, average color preferences from large, diverse samples of
people across the world should reflect universal trends in colored object valences.
Presumably nearly everyone in every culture likes clear sky and clean water, but dislikes feces and rotten food. If similar trends hold for the valences of other objects of these colors, there should be a general liking of blues and cyans and a disliking of browns and olives that largely transcend culture. Second, systematic differences between color preferences in different cultures should co-vary with corresponding cross-cultural differences. There could be differences in color-object associations (e.g., Japanese observers may associate a certain shade of reddish orange with Shinto shrines, whereas observers from the United States would not) and/or differences in object valences (e.g., people in Japan may like eel, where...
it is considered a culinary delicacy, much more than people in the United States
do). Third, systematic sub-cultural influences should also arise from individuals'
associations with various societal groups with strong color associations, such as
sports teams, universities, religions, and/or gangs. Other sub-cultural effects could
arise from beliefs about what colors complement (versus clash) with one's eye,
skin, and hair color. Fourth, truly idiosyncratic effects should also be present. The
color of grandmother’s rocking chair, for example, might have a positive effect on
an individual’s aesthetic response to that color if he or she loved sitting on grand-
mother's lap in that chair as a child, but a negative impact if he or she loathed and
dreaded those experiences with grandma. It would be impossible to tease apart all
such idiosyncratic influences for any single individual, but some of them can be
effectively isolated and studied, as we will explain later in this chapter.

We should also note that color preferences may change systematically over time
on a scale from weeks to years within individuals and from years to centuries
within cultures. Color fashions in the modern clothing industry change seasonally
in fairly consistent ways and annually in less predictable ways. Even more dra-
matic are cultural sea-changes in color preferences that have occurred over peri-
ods of decades or longer, such as the ones Pastoureau has documented for blue.
Surprisingly, blue was the least favored color in ancient Rome, probably because
blue was so prized by their arch-enemies, particularly the Celts and Germans, who
painted themselves in blue for battle. Pastoureau posits that blue rose to favor in
part via its association with the Virgin Mary within the increasingly dominant
Catholic church.

One of the great virtues of the EVT is that all of these factors—universal,
cultural, sub-cultural, idiosyncratic, and even dynamic—can potentially be accom-
modated within its scope. That is not to say that it is so amorphous that it fails to
make testable predictions: as we will show, numerous tests are possible, not only
of its basic predictions across large samples of people, but also of more specific
predictions that should hold with carefully selected subsets of individuals who
share specific cultural and even personal experiences.

AVERAGE COLOR PREFERENCES IN THE UNITED STATES

The 32 colors we studied were systematically sampled over the three most salient
dimensions of color appearance: hue, saturation, and brightness (Fig. 8.2). We
effectively based our sampling on the structure of the Natural Color System. We
began by choosing highly saturated colors of the four Hering primaries (approx-
imating the unique hues of red [R], green [G], blue [B], and yellow [Y]) and four
well-balanced binary hues (orange [O], purple [P], cyan [C], and chartreuse [H]).
We then defined four “cuts” through color space that differed in their saturation
and lightness levels, as follows. Colors in the “saturated” (s) cut were defined as the
most saturated color of each of the eight hues that could be produced on our mon-
itor. The eight colors in the “muted” (m) cut were those about halfway between the
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Figure 8.2 (A) The 32 colors of the Berkeley Color Project. (B) The projections of these colors onto an isoluminant plane in CIELAB color-space.

$s$ color and neutral gray, those in the “light” ($l$) cut were those about halfway between each $s$ color and white, and those in the “dark” ($d$) cut were those about halfway between each $s$ cut and black. This set comprised the 32 chromatic colors that were studied. We also included five achromatic (A) colors—white, black, and the three grays whose luminance was the average luminance of the eight hues in the $l$, $m$, and $d$ cuts—but we report results just for the 32 chromatic colors in this chapter. Colors within cuts were not constant in saturation or luminance, because we wanted to include highly saturated unique colors, which are not equivalent in either luminance or saturation. Unique yellow and blue, for example, vary dramatically in luminance, with unique saturated yellow being much lighter than unique saturated blue.

Forty-eight individuals from the San Francisco Bay area with normal color vision participated in 30 different tasks as part of the Berkeley Color Project. We will discuss only a small subset of these results here: preference ratings of individual colors, ratings of color appearance dimensions (red–green, blue–yellow, light–dark, and high–low saturation), and ratings of the three factor-analytic dimensions of color-emotions (active–passive, heavy–light, and warm–cool). All ratings were made using a continuous line-mark scale with explicit points at the middle and both ends.

Average preference ratings showed relatively strong effects of hue in the $s$, $l$, and $m$ colors, producing approximately parallel hue functions with peaks at blue and troughs at chartreuse (Fig. 8.3). $s$ colors were preferred to $l$ and $m$ colors, which did not differ from each other. Hue and cut did not interact across the $s$, $l$, and $m$ cuts, but they did interact for the $d$ cut versus the other three. In particular, dark-orange (brown) and dark-yellow (olive) were less preferred than other oranges and yellows, whereas dark-red and dark-green were more preferred than other reds and greens. (See Palmer and Schloss for statistical and methodological details.)
We used multiple regression techniques to fit the models from the previously described theories to these data. The predictors for the cone-contrast model were computed from the cone contrasts of the 32 tested colors against the gray background, plus CIELUV saturation, as specified by Ling and Hurlbert. These four predictors together accounted for just 37% of the variance in the preference data. The three predictors for the color appearance theory (our participants’ ratings of red-green, blue-yellow, light-dark, and low-high saturation) performed better, accounting for 60% of the variance in the preference data. The predictors for the color-emotion theory (our participants’ ratings of active-passive, heavy-light, and warm-cool) accounted for 55% of the variance. Clearly, the lower-level cone-contrast theory does not fit as well as the higher-level color-appearance and color-emotion theories, but the latter two are nearly indistinguishable in terms of their ability to account for the data. Next, we attempted to fit the data using a model from the EVT, but doing so required a much more complex experimental procedure to estimate the relevant predictor variable.

**Figure 8.3** Results of Experiment 1. Color preference ratings are plotted as a function of hue—red (R), orange (O), yellow (Y), chartreuse (H), green (G), cyan (C), blue (B), and purple (P)—for saturated, light, dark, and muted colors.
Object Association Task

We collected object associations for each of our 37 colors by showing them to a separate group of 74 observers and asking them to describe as many things of that color as they could in 20 seconds. They were asked to describe only things whose colors would be known by most other people from their verbal description. Responses were eliminated if they (a) could be any color (e.g., crayons, shirts), (b) were abstract concepts instead of objects (e.g., winter, Christmas), (c) were color names instead of objects (e.g., “Cal Blue,” “teal”), (d) were very dissimilar to the presented color (e.g., “grass at noon” for dark purple), or (e) were provided by only a single participant across all colors. The remaining descriptions were then categorized to reduce their number. Those that were judged to be essentially the same were combined into a single category (e.g., algae included the descriptions “algae,” “algae water,” “algal bloom,” “algae-filled fish bowl,” and “algae floating on top of water”). The net result was a list of 222 objects with diagnostic coloration.

Object Valence Ratings

The resulting 222 descriptive categories were then shown in black-on-white text to 98 different participants, who were asked to rate the affective value of the referent object (i.e., how positive or negative they felt about it) using the same line-mark rating scale as in Experiment 1. These ratings were averaged over participants, resulting in 222 object valence ratings.

Object–Color Match Ratings

Finally, we showed a third independent group of 31 participants each of the 222 object descriptions paired with each of the 32 colors for which it had previously been given as a description, one pair at a time. Participants were asked to rate how well the color of the described object category matched the color on the screen (e.g., strawberries together with a homogeneous square of saturated red) using the same line-mark rating scale. The average color–object match ratings were then used to weight the average affective valence rating for each object–color pair, such that the valences of the descriptions that better matched the color on the screen were weighted more heavily. We call this measure the “weighted affective valence estimate” (WAVE) of the color.

The fit of the WAVE to the preference data is impressive, producing a correlation of +0.89, which accounts for 80% of the variance. This level of fit to the data is considerably better than any of the other three theories tested, even though the WAVE model uses a single predictor variable, rather than the three or four used by the other three theories. Even the WAVE’s weighting factor based on the object–color match ratings (which is not a free parameter because it is taken directly from the ratings our participants made in this task) is relatively unimportant, because the unweighted average valence ratings are almost as highly correlated with preferences ($r = 0.83$) as the WAVES are.
The average WAVEs for our 32 chromatic colors are plotted in Figure 8.4, which the reader should compare with the average preference ratings shown in Figure 8.3. In addition to a better quantitative fit, the WAVEs also better capture the qualitative structure of the preference functions: the broad, pronounced peak at blue, the trough at chartreuse, higher preference for saturated colors, and the steep global minimum around dark yellow. Its main deficiencies lie in under-predicting the aversion to dark-orange (largely because chocolate is rated as quite appealing) and under-predicting the positive preference for dark-red (largely because blood is rated as unappealing).

Equally important is the fact that the EVT, from which the WAVE measure was derived, answers the why question: color preferences are caused by average affective responses to correspondingly colored objects. Although the present evidence is correlational, we find it unlikely that causation runs in the opposite direction, at least for diagnostically colored objects. It seems unlikely that preferences for these objects are caused by people’s color preferences because there are such clear counterexamples. Chocolate and feces, for instance, are quite similar in color but dramatically opposite in valence. This should not happen if color preferences caused object preferences. Some third mediating variable could conceivably be at work, but it is unclear what that might be.

**Figure 8.4 Results of Experiment 2.** Weighted affective valence estimates (WAVEs) are plotted for the 32 chromatic Berkeley Color Project colors as a function of hue—red (R), orange (O), yellow (Y), chartreuse (H), green (G), cyan (C), blue (B), and purple (P)—for saturated, light, dark, and muted colors.
FURTHER TESTS OF THE ECOLOGICAL VALENCE THEORY

We are currently testing the implications of the EVT in a variety of ways. Below we sketch its predictions and, where available, describe pilot results that are relevant.

Cultural Commonalities and Differences

Critical tests of the EVT will come from cross-cultural studies of color preferences and their relation to corresponding WAVE data. The EVT clearly implies that the WAVE data generated by members of one culture will predict that culture's color preferences better than it will predict another culture's color preferences. We are currently working with collaborators in Japan, Mexico, India, and Serbia on collecting both color preference functions and WAVE functions within each culture. We now have color preference data from Japan and Mexico, but do not yet have their WAVE data.

Sub-cultural Differences

The EVT also predicts that if people have highly positive (or negative) emotional investments in a social institution that has strong color associations (e.g., an athletic team, gang, religious order, university, or even holiday) they should come to like the associated colors correspondingly more (or less) than the rest of the population, such that there will be a positive correlation between their liking/disliking of the institution and their liking/disliking of the associated colors. Preliminary results with university colors support this prediction: among students at the University of California, Berkeley, the amount of self-rated school spirit correlates positively with their preference for Berkeley's blue and gold relative to preference for the cardinal red and white colors of Stanford University, an arch-rival institution. The opposite pattern of results is found at Stanford. These findings support the prediction that sociocultural influences affect color preferences to a degree that depends on people's affective valence toward the institution. It also provides evidence of the direction of causation because it is wildly improbable that students' choice of and their attitude toward universities are caused by their color preferences: students who like Berkeley do not do so because they like blue and gold; they like blue and gold because they like Berkeley.

Individual Differences

The same logic described for using culture-specific WAVEs to test the EVT's ability to account for culture-specific color preferences also holds for any lower-level factors that might also influence color preferences. Thus, the EVT provides a theoretical framework for accounting for individual color preferences, provided that the WAVEs of colors can be accurately assessed for individuals. We are currently extending the basic WAVE procedure described above in two ways. One way is to have each observer make his or her own valence ratings of the “standard” set of objects for his or her culture (i.e., the 222 object descriptions compiled from other
U.S. participants). If Jack loves lemons and Jill detests them, for example, then (all else being equal) Jack’s personal WAVE for saturated yellow should be greater than Jill’s personal WAVE for that color, and Jack’s preference for saturated yellow should be higher than Jill’s. The crucial test of the EVT for individuals is whether individuals’ personal color preferences are correlated more highly with their own personal WAVEs than other people’s WAVEs. The second way is to include idiosyncratic colored objects in the analysis, which the EVT predicts should further improve the fit of their personal WAVEs to their personal color preferences. We can then test whether this truly idiosyncratic WAVE component produces a significant increment to the correlation with their personal color preferences.

Although the EVT focuses on the effects of object preferences on color preferences, we do not claim that color preferences have no influence on object preferences. Clearly they do, especially for functionally identical artifacts that come in many colors, such as cars, clothes, appliances, and personal electronics. Widespread (and presumably effective) market research on color preferences for specific products presupposes that such effects exist. Notice, however, that these effects too are compatible with the EVT: to the extent that people end up liking something that they bought, made, or chose initially because they liked its color, their preference for that color will be reinforced via positive feedback, provided that they continue to enjoy it. Color preferences will thus tend to be self-perpetuating until other factors, such as boredom, new physical or social circumstances, and/or fashion trends, change the dynamics of aesthetic response, as indeed they inevitably do.

Perhaps the most interesting implication of the EVT is that, if it is true and if there are indeed universal, cultural, sub-cultural, and idiosyncratic influences, then the human brain appears at some level to contain a statistical summary of the consequences of one’s interactions with colored ecological objects. We did not initially expect this to be the case, because we came into the study expecting that color appearance measures would provide the best predictors. Why else would people like a color than according to how it looks (appears) to them? Although the EVT’s fundamental claim (i.e., that implicit statistical knowledge of the outcomes of interactions with colored objects is the basis for color preferences) is retrospectively plausible, it was by no means obvious at the outset. We therefore view it as a genuine discovery that color preferences are largely determined by ecological statistics about the emotional valences of the colored objects one has encountered.

Spatial Composition

The second aesthetic domain we are studying is spatial composition. Painters, photographers, graphic designers, and other visual artists who work in two-dimensional media continually face the problem of how to position the subjects of their creations in aesthetically pleasing ways within a rectangular frame. We pose the problem like this: How should the to-be-depicted object(s) be situated within
a rectangular frame so that viewers, on average, have the most aesthetically pleasing experience? We avoid content issues (i.e., what particular objects or parts are depicted) by measuring people’s aesthetic responses to different compositions of the same object viewed from the same perspective.

There are several ways in which our research on this topic differs from the usual tradition in the analysis of art, which is for experts to introspect about their aesthetic reactions to real paintings (e.g., Arnheim and Gombrich). First, we collect data about the behavior of other people rather than relying on our own introspections. This decision is critical to a scientific approach, because behavioral measurements in a well-defined task can be confirmed by others. Second, we rely on the reactions of “average” viewers, rather than a designated elite, such as art critics, museum curators, patrons, and/or the artists themselves, because the elite often have very specific training about what is (or should be) aesthetically pleasing. Third, rather than studying the composition of complex art objects, such as actual paintings, graphic designs, and photographs, we study simple pictures that nobody would claim as art. Real paintings vary from each other in so many ways that it is nearly impossible to determine why aesthetic responses differ. Using simple, well-controlled visual displays allows us to understand aesthetic response from first principles to get a clear notion of which perceptual factors matter. Below we summarize an extensive series of experiments using a variety of tasks and measurements that reveal several simple, yet robust, compositional biases of average viewers.

HORIZONTAL PLACEMENT OF A SINGLE OBJECT

In the first experiment we will describe, participants performed a constrained adjustment task. They saw pictures of a single object against a minimal background (a black ground-plane and white wall-plane) and were asked to use a computer mouse to drag the object back and forth along the horizontal midline to find the most aesthetically pleasing position. They clicked the mouse when the object was at the best position. Each object was shown in three poses relative to the viewer: facing leftward, facing rightward, and facing forward. We measured the percentage of trials on which the object’s center fell into each of seven equal-sized horizontal bins.

The results of this experiment are plotted in Figure 8.5 for the left-, right-, and forward-facing images, averaged over the 10 objects we studied. Large, systematic interactions between facing direction and horizontal position are clearly evident. Forward-facing objects were strongly preferred at or very near the center of the frame, whereas left-facing objects were strongly preferred on the right side of the frame, and right-facing objects were strongly preferred on the left side of the frame. We believe that two strong aesthetic biases are at work: a center bias and an inward bias. The center bias alone acts on the forward-facing objects to produce the symmetrical distribution with a clear spike at the center. Both a center bias and an
inward bias seem to operate on the left- and right-facing objects to produce
strongly asymmetrical distributions with pronounced maxima on the right and
left sides of center, respectively. If the inward bias were operating alone, without
the additional influence of the center bias, we presume that the most extreme left
and right positions would be most preferred for the right-facing and left-facing
objects, respectively. By this logic, it seems likely that the center bias is at work for
all three facing directions, with the inward bias operating only for the left- and
right-facing objects.

We believe that the center bias is essentially due to the structure of the frame
itself. Arnheim argued that a square has the “structural skeleton” illustrated in
Figure 8.6A, with a clear singularity at the center. Indeed, his belief in the potency
of this position is reflected in the title of one of his excellent books on spatial com-
position: *The Power of the Center*. Experimental results by Palmer and Palmer
and Guidi using a “goodness of fit” rating task support the validity of this belief.
Their results are consistent with rectangles having the structural skeleton shown in
Figure 8.6B, in which the single most potent structural element of the frame is its
center, the point at which its vertical and horizontal axes of symmetry intersect. In
this sense, the center bias does not depend on any particular knowledge about the
object, except the location of the object’s own center, which can be computed just
from its visually evident contours.

The inward bias, however, is object-dependent and knowledge-based because it
requires the perceiver to know which side of the object constitutes its front, and
this depends on more than just the shape of the object. We do not yet know exactly
why it arises. It could be due to the high perceptual salience of the features on the fronts of objects and/or to expected forward motion of objects (although we did not find significant differences between objects that were capable of movement and objects that were not when we examined this factor explicitly). Alternatively, it may reflect asymmetries in the functional affordance space around an object. The notion of an affordance space is derived from J. J. Gibson’s notion of affordances and specifies the local area around an object where it typically interacts with humans and other environmental objects. Our untested conjecture is that there is generally a much greater area in front of an object that is of functional interest to
an observer than behind it, and no difference between the left and right sides, at
least for bilaterally symmetrical objects. If so, it is possible that the best location for
the different views of the same objects is that for which its affordance space, rather
than its actual physical extension, is centered in the frame.

We have studied aesthetic biases in the horizontal position of single objects
in several other ways, including two-alternative forced choice (2AFC) psy-
chophysical methods, free-choice photography of everyday objects (a steam iron,
a teapot, and a tape dispenser), and analyses of the positions of objects in single-
object stock photographs from a commercial database (corel.com). All methods
show essentially the same effects, although to different degrees: We always find a
clear center bias for forward-facing objects, and a combination of center and
inward biases for left- and right-facing objects. Interestingly, when we looked for
the effect with novel, letter-like, two-dimensional patterns containing a highly
articulated side that we presumed people would see as its front, we did not find
evidence of an inward bias.

VERTICAL PLACEMENT OF SINGLE OBJECTS

Another series of experiments examined aesthetic biases in the vertical position of
single-object pictures. This topic turned out to be somewhat more complex. One
set of expected issues related to the role of the horizon and gravitational support in
vertical placement. Unlike horizontal placement, there are severe gravitational
constraints on where an object can be located vertically relative to a supporting
horizontal surface. Unexpectedly, however, we also found effects of object-specific
world knowledge that we term ecological biases: effects due to the typical position
of the objects relative to human observers. In one experiment we studied vertical
preferences in the position of a bowl that was supported by a horizontal surface
below it and a light fixture that was attached to a horizontal surface above it. We
independently varied both the vertical position of the object itself and the vertical
position of the back edge of the horizontal supporting surface.

Examples of the displays in which the object and horizontal edge coincide are
shown in Figure 8.7 below the graph. The solid line and large data points at the top
indicate the results for the displays shown directly beneath them; the other lines
and points show the corresponding data for displays in which the horizontal edge
was above the bowl or below the light fixture. Two facts are particularly notewor-
ythy. One is that the most preferred position of the horizontal edge is always at the
same height as the object. Displacing the horizontal edge so that it was above the
bowl or below the light fixture caused preference to decrease monotonically as
distance increased. This result may occur because when the object is at the same
height as the horizon edge, the object occludes (covers) part of the edge and there-
fore most clearly indicates that the object is closer than the horizontal edge.

Evidence of ecological biases comes from a clear lower bias for the bowl and an
equally clear, and almost exactly opposite, upper bias for the light fixture. This pattern
of results for vertical position is so similar to the center and inward biases for horizontal position of left- and right facing objects that we currently believe them to be, in effect, corresponding phenomena in the vertical dimension. The bowl and light fixture do not have a “front” and “back” in the vertical dimension, of course, but it is easy to see by analogy that the top of the bowl and the bottom of the light fixture are their most salient functional parts. Indeed, if one were to draw their “affordance spaces,” it seems likely that the bowl’s would extend much further upward than downward and that the light fixture’s would extend much further downward than upward. This asymmetry is virtually guaranteed by the fact that these objects are attached to support planes below and above them, respectively. Thus, we believe that these compositional biases in the vertical dimension may be analogous to those in the horizontal dimension.

There are further uncertainties about the interpretation of these vertical biases, however. They might also be due to a perspective bias, since the bowl is depicted from slightly above, so that its upper lip is visible, and the light fixture is shown from slightly below, so that its bottom is visible. Perhaps people like objects viewed from above to be lower in the frame and objects viewed from below to be higher in the frame. Such a perspective bias would provide redundant information about the viewpoint from which the object is being viewed, such that its preferred position correlates (negatively) with the perspective from which it is depicted (i.e., higher perspective views positioned lower in the frame and lower perspective views higher in the frame). Another potential factor is an ecological bias. Viewers might prefer the bowl to be low (and the light fixture high) in the frame because bowls are generally below (and light fixtures generally above) our vantage point. We conducted further experiments to test these possibilities.
Ecological Biases in Vertical Position

One problem with the bowl and the light fixture is that, when they are supported in the usual way (by a plane below and above them, respectively), they are not visible from certain viewpoints: the bowl is not visible from below its horizontal surface of support, nor the light fixture from above. We eliminated this problem in the next experiment by using pictures of objects that could, in principle, be seen from any viewpoint. For an object that is typically positioned above human viewers we chose a flying eagle, and for an object that is typically positioned below human viewers, we chose a swimming stingray. If the vertical position effects in the previous experiment are due to perspective effects, then we should see corresponding biases with both the eagle and stingray: when either object is viewed from above (as the bowl was), there should be a lower bias for both, and when it is viewed from below (as the light fixture was), there should be an upper bias for both. If the vertical position effects are due to ecological height, however, the flying eagle should produce an upper bias for all views because it is generally located above human viewers, and the stingray should produce a lower bias for all views because it is generally located below human viewers. It is important to note that these factors are not mutually exclusive: both perspective and ecological effects might operate at the same time, in which case some combination of the two patterns should occur together.

The other conditions we included in this study were designed to look for an analogue of the striking center bias we found in the first experiment we described about horizontal placement. When symmetrical objects were facing directly forward, people preferred them in the center of the frame. For the eagle and the stingray, we therefore included views from directly above and directly below to test for the existence of a corresponding vertical center bias.

We expected the results for the directly above and directly below conditions to produce a symmetrical center bias. The data, shown in Figures 8.8A and C for the eagle and 8.8B and D for the stingray, show a broad center bias, presumably due to the symmetry of the projections of these objects (and/or their affordance spaces) as viewed from directly above and below. However, it is an asymmetrical center bias, in which the eagle also exhibits a distinct upper bias and the stingray a somewhat less pronounced lower bias. These asymmetries are consistent with an ecological bias, because flying eagles are above earthbound observers, and swimming stingrays are below them. It is not consistent with a perspective bias, however, which implies that the eagle from directly below should exhibit an upper bias (which it does), whereas an eagle from directly above should exhibit a lower bias (which it does not), and vice versa for the stingray. It is worth mentioning that independent groups of observers saw the eagle pictures and the stingray pictures, because this fact eliminates the possibility that observers were responding to a “demand characteristic” of the experiment that might have arisen if the same observers had seen both the eagle and the stingray pictures.
The results for the side views reveal stronger ecological biases. Both side views of the eagle exhibit a strong upper bias, presumably because flying eagles are generally above us in the environment, whereas both views of the swimming stingray exhibit a lower bias that is almost as strong, presumably because stingrays are generally below us in the environment. Notice, however, that there is also a smaller, but consistent, perspective bias: the upper bias for the eagle is stronger for the side-below view than for the side-above view, and the lower bias for the stingray is...
stronger for the side-above view than for the side-below view. These patterns are just what would be expected from a perspective bias: objects seen from below are preferred to be higher in the frame and objects seen from above to be lower in the frame. These biases are analogous to the inward-facing bias we found in horizontal compositions, except that here they are combined with a strong ecological height bias.

OTHER ECOLOGICAL BIASES

Ecological biases imply that people prefer pictures of a focal object in which its known spatial characteristics within the environment are consistent with corresponding spatial characteristics of their depicted two-dimensional framed images. Such effects are not restricted to height within the frame, however, as we will now consider for the domains of ecological perspective, size, and orientation.

Previous research by Palmer, Rosch, and Chase on perspective effects in object perception identified a phenomenon that they called canonical perspective: certain views of objects are systematically rated as “better” pictures of the object in the sense that some perspective views “look more like the depicted object” than others. Palmer and colleagues showed that the better (more canonical) perspective views allowed the depicted object to be more quickly recognized and that people more often reported imagining the object from more canonical perspectives. Figure 8.9A, for example, shows the “best” perspective views of 4 of the 12 objects Palmer and colleagues studied in terms of having the highest ratings among the nine perspective views they studied. Figure 8.9B shows several perspective views of the horse that vary from best (left) to worst (right).

More recently Khalil and McBeath reported the results of a study in which they explicitly asked their participants to rate their aesthetic judgments of different perspective views. These aesthetic preferences generally corresponded well with

![Figure 8.9](image-url)

**Figure 8.9** Canonical perspective images (Palmer, Rosch, & Chase, 1981). (A) shows the “best” perspective views chosen by participants for four objects, and (B) shows four examples of different perspective views of the horse.
the results reported by Palmer, Rosch, and Chase. Ecological perspective biases associated with canonical perspective thus reflect another way in which people’s aesthetic preferences reveal implicit knowledge about objects in the world: people like pictures of objects that make them most recognizable by showing their most informative parts and interrelations.

Recent research by Konkle and Oliva has made a corresponding case for a phenomenon in the size domain that they call *canonical size*. Certain sizes of two-dimensional framed images of objects are rated as better depictions, are better recognized, and are more frequently drawn than other image sizes within the same rectangular frame. Moreover, these sizes are systematically related to the relative sizes of the objects: the “best” picture of an elephant, for example, is bigger than the “best” picture of a mouse, and the optimal size of the object relative to the frame is a function of the logarithm of the object’s actual size. Linsen, Leyssen, Gardner, and Palmer found similar results in people’s choices of the most aesthetically pleasing picture of objects at different sizes.

Another ecological bias that is perhaps so obvious that it scarcely seems worth mentioning is canonical orientation. Many, if not most, real-world objects have canonical orientations within the environment—their “upright” orientations—that are dictated largely by gravitational stability and functional constraints. Dogs, chairs, cars, trees, and people are among the multitude of commonplace objects that have clear canonical orientations. Such objects are most easily recognized in their canonical upright orientations, and, roughly speaking, larger deviations from upright lead to more difficulty in recognizing them. Although we know of no aesthetic research that has specifically addressed this question, it is intuitively obvious that most people will find pictures of such objects most aesthetically pleasing when they are depicted in their canonical, upright orientations.

The center bias excepted, all of these biases in spatial composition—the inward bias, the perspective height bias, and ecological biases in position, perspective, size, and orientation—depend strongly, but implicitly, on statistical knowledge about the properties of the depicted object. The inward bias, for example, depends on the observer knowing that the object has a distinguished front and a back, and prefers the front to be closer to the center. Ecological biases in position are based on knowing where objects are typically located relative to human observers; ecological perspective biases depend on observers knowing which surfaces of objects are most informative; and ecological size biases depend on the observer knowing how big objects are. In each case, people tend to prefer pictures in which their knowledge of these object properties is reflected in corresponding properties of its image within the picture frame.

**MERE EXPOSURE, FLUENCY, AND FIT**

Now that we have some clear idea about what spatial compositions people find aesthetically appealing, we can ask why people might prefer those compositions.
Perhaps the most obvious explanation is that the biases we find result from “mere exposure” effects: people might prefer images with such compositions simply because they have seen more pictures composed in these ways than in other ways. The problem with this account is that, by itself, it suffers from infinite regress and thus fails to answer the why question. You might prefer the compositions that you have seen most frequently in the past, but why did the people who created those images use those compositions? The mere-exposure explanation requires that the bias was caused by those people preferring the compositions that they saw most frequently in their viewing histories. But why did they prefer those compositions they did? The obvious problem is that the mere-exposure explanation thus must be applied endlessly, always appealing to what the previous generation of image creators experienced most frequently and never “cashing out” the explanation in terms other than frequency-of-viewing histories. This is not to say that mere exposure has no effect on aesthetic preferences—see Cutting for an interesting analysis of its impact on the canon of Impressionist paintings—but only that its explanatory value in answering the why question is limited to preserving a status quo that arose for some reason other than frequency-of-viewing histories.

The fluency theory of aesthetic preference, as outlined by Reber (Chapter 9 of this volume) and colleagues (e.g., Winkielman), provides a far more satisfactory account. Its basic claim is that any factor that allows a picture to be perceived more easily (or “fluently”) enhances a viewer’s aesthetic experience. Standard examples of fluency concern context-free image properties, such as having high degrees of clarity, figure–ground contrast, symmetry, and exposure frequency, all of which should make them easier to perceive, independent of their specific content. (Notice that although a fluency account includes exposure frequency as a factor, it actually explains exposure effects by appealing to their influence on how easily people can perceive the current exposure rather than simply appealing to the person’s exposure history itself.)

The aesthetic biases discussed above are different from such basic fluency factors because the former are context-specific and depend importantly on specific knowledge about the kinds of object depicted in the image. Nevertheless, most of the biases we have discussed above are consistent with a fluency account because they all plausibly increase the ease with which the depicted object can be perceived and/or identified within the picture. The center bias locates the object at or near the center, where it is least susceptible to lateral masking and crowding effects arising from the borders. The inward bias puts the object in a location where its most important side (front, top, or bottom) is closest to the center and thus is most easily perceptible. The various forms of ecological biases place the object in a relation to the frame that is most consistent with our knowledge about the object’s likely location, perspective, size, and orientation in the environment, so that its most informative parts, its typical size, and its typical position relative to a human observer are optimally represented when viewing the picture. Indeed, canonical perspective and, more recently, vertical position relative to the observer have already been shown to facilitate identification performance.
Even so, we are not convinced that fluency theory provides a full and satisfying explanation of aesthetic response. The problem we see is that it is pitched at too low a level to explain many important aesthetic effects. It seems well equipped to explain the compositional effects we have just presented, which are relevant to understanding the aesthetic appeal of, say, high-quality stock photography or National Geographic images, in which the presumed intent is to create an image that depicts a particular object optimally. However, it seems problematic in dealing with the aesthetic appeal of less standard images in which there is some more complex perceptual, cognitive, and/or emotional message behind the image. Our view is that the compositional biases we have discussed thus far are essentially default preferences that apply when the conveyed meaning is essentially just the default message: “This is a picture of X,” where X is the appropriate category of the portrayed object or situation. Under these conditions, optimality presumably means that the depiction is the most easily (or fluently) perceived image of that object or situation, and it is reasonable to suppose that it would be composed so that the focal object would tend to be centered, to be facing inward, and to reflect whatever ecological information is most relevant.

Nevertheless, there is often some deeper, less obvious, yet more important message that an image is intended to convey—or that it simply does convey to a particular viewer at a particular time, regardless of the creator’s intentions. Such messages are often poorly served by adhering to default aesthetic biases such as the ones we have just described. A good example is shown in Figure 8.10. Nature’s Writing is a striking photographic image by Jean-Paul Bourdier from his book Bodyscapes, in which he composes the female body within the frame so that it violates several default biases—including the center and inward biases both horizontally and vertically as well as ecological biases toward canonical perspective, orientation, and color—in ways that serve to convey the message that people’s bodies are an integral part of the natural world and that even the boundaries between us and our environment are unclear and permeable. Clearly, a stock photograph of a woman standing on a sandy landscape would fail to convey such complex and subtle meaning.

Rather than trying to stretch the admittedly elastic concept of fluency to cover cases in which expectations have been violated in ways that create such obvious disfluency, we prefer to conceptualize aesthetic considerations in spatial composition in terms of what we have called “representational fit.”54 (“Fit” alone might be the more general and appropriate term, since “representational fit” is presumably relevant only to visual objects that qualify as representations, such as pictures or representational paintings.) The idea behind the “fit” hypothesis is that the aesthetic value of an image will vary with the extent to which the spatial composition of the image successfully conveys a meaningful message to a viewer. The content of this message might be sensory, cognitive, emotional, or any combination of these; ideally, it would encompass all of them together. It might be what the artist had in mind while creating the image or it might not, as viewers often generate meanings of their own when viewing such images.
Within the “representational fit” framework, there is an effective default message, which is simply that the intent of the picture is to portray the object, scene, or situation it depicts in a perceptually optimal way. We take this to be the effective message of a stock photograph, for example, and it may be true, as fluency theorists propose, that under such an interpretation, the image is more aesthetically appealing to the degree that it is more easily perceived as that object, scene, or situation. But there are many more complex, meaningful, and emotional messages that an image can convey, and they are often carried at least in part by defying default aesthetic expectations, such as the center, inward, perspective, and the various ecological biases in spatial composition.

To investigate this issue, we have begun to study how compositional preferences can be influenced by conceptual content. We do so by giving the same set of compositionally manipulated images different titles (meanings) and asking people to
judge their relative aesthetic response to the different compositions. Figure 8.11 shows five compositions of the same racehorse against a uniformly motion-smeared background in which only the position of the racehorse varies. To manipulate the message, we gave the images three different titles. The default title was simply “Racehorse.” Here we expected that the center and inward biases we found in our earlier studies would hold. We also used two titles that biased the composition in different and opposite ways. “Front Runner” was expected to bias the composition toward positions in which horse was, in effect, running out of the picture because the empty space behind it implies that it is far ahead of its (unseen) competition. “Dead Last” was expected to bias the composition toward positions in which horse was, in effect, running into the picture because the empty space ahead of it implies that it is far behind its (unseen) competition. Similar kinds of title manipulations were used with other images that implied the presence of other unseen objects either behind or in front of the depicted object (e.g., chasing versus being chased). Another set of images were based on a temporal metaphor in which empty space in the image could be seen as consistent with interpretations emphasizing different parts of a journey: for example, a man walking with the titles “Man Walking” (default), “Journey’s End” (biasing images of him walking out of the frame), and “Starting Out” (biasing images of him walking into the frame).

In this experiment, the intended message of the images was provided by the title in the context of a brief cover story, in which participants were told to imagine
that they were artists, who had decided on the title and the object for an image, and were now trying to decide on the composition of the image within a rectangular frame. They then ranked all the horizontal compositions for that title from most to least aesthetically pleasing. The results, plotted in Figure 8.11, show a very clear pattern that is consistent with our predictions. The default titles yielded aesthetic preferences like those we found in our previous experiments for facing objects: a clear center bias with an inward-facing asymmetry, peaking at the position in which the depicted object was close to the center, yet also clearly facing into the frame. The titles that biased non-standard interpretations, however, produced strikingly different preference functions. When the title promoted the idea that the depicted object was ahead of other implied objects or was at the end of a journey, the preference curve peaked at the two positions where it faced most clearly out of the frame. When the title promoted the idea that the depicted object was behind other implied objects or was at the start of a journey, however, the preference curve peaked at the two positions where it faced most clearly into the frame.

We interpret these results as supporting our notion that default compositional biases can be overridden by violations that fit (i.e., are consistent with) the message implied by the title. The aesthetic response to an image will thus be greatest when its spatial composition effectively conveys (fits) the message defined by the title it was given. It is possible that the results can also be interpreted as supporting a revised and expanded fluency account (see Chapter 9). The trick is to reinterpret the original notion that fluency reflects ease in perception of the focal object to encompass ease in some particular conceptual interpretation. The racehorse running out of the frame may not be the most easily perceived image of a racehorse, for example, but it might well be the easiest image to perceive as a front-running racehorse, where the additional conceptual content implies that the horse is ahead of the competition. The reason the two theoretical frameworks are consistent with each other is that a good fit between the title's meaning and the image should facilitate (make fluent) the apprehension of that meaning.

One problem that arises for fluency theories of aesthetics is that, despite its apparent flexibility, some kinds of expectancy violations necessarily make the image less, rather than more, fluently perceived or conceived by any reasonable understanding of fluency. Most problematic are cases in which the artist intentionally creates an image that is difficult to perceive and/or understand. Much of modern art, at least from Cubism on, poses challenges of this sort. It is even evident in the Nature's Writing image reproduced in Figure 8.10. Certainly part of the point of this image is to make the viewer scrutinize it carefully to try to find out what, if anything, is present in the picture other than a series of mounds of reddish earth. It is quite implausible, we think, to claim that its aesthetic value hinges on fluency of any reasonable sort. The most plausible argument would be that it is aesthetically pleasing because it is fluently perceived as disfluent. We find this move to be a perversion, if not an outright contradiction, of fluency theory.
Conjectures and Conclusions

When we began our studies of aesthetic response to visual displays, we naïvely expected that the underlying principles would be essentially knowledge-free. We thought, for example, that people’s average color preferences would be largely explicable in terms of color appearances (i.e., the coordinates of colors in some appropriately structured color space) and that people’s compositional preferences would be largely, if not completely, explicable in terms of the relation between objects and the structural skeleton of its rectangular frame (e.g., Arnheim). In both cases, however, the results we obtained led us to a surprising conclusion: implicit knowledge of environmental objects and their relations to us appears to be absolutely central to people’s aesthetic response in both domains. We initially avoided studying the aesthetic effects of specific content (i.e., the nature of the focal objects in a picture or scene) because we expected such considerations to involve strong, self-evident knowledge-based effects that would be difficult to study: people would like pictures of objects/scenes/situations that they liked for reasons quite independent of the picture’s composition. Even when the displays consist of single colors or spatial compositions of the very same object in the very same pose, however, we are finding strong, and not particularly self-evident, effects of specific world knowledge. In the color domain, average preferences appear to reflect the statistics of how much people, in general, like the objects that are characteristically those colors. In the spatial domain, they appear to depend on people’s knowledge of the salient characteristics of the objects depicted and how they relate to the observer.

Now that we have established that statistical world knowledge is relevant to aesthetic response, there is the deeper question of why this might be so. For the case of color, the EVT provides a plausible answer: preferences perform an adaptive “steering” function, biasing sighted observers to approach objects that are likely to be beneficial and to avoid objects that are not. This explanation is satisfying from an adaptive, evolutionary perspective because acting in accord with such aesthetic preferences would be beneficial for the organism to the extent that the preferences are correlated with (i.e., carry predictive information about) what is “good” versus “bad” for the observer.

It is not so obvious what adaptive function might be served by the spatial compositional effects we have found: the center bias, the inward bias, and the various ecological biases. A central problem for any adaptive theory of these biases is that they all apply to framed representational visual displays that did not exist when humankind was presumably being shaped by evolution. Even in modern times, the composition of static, rectangular, framed images seem to be largely irrelevant to people’s lives, at least outside the world of art, websites, and wall decorations. To be more generally relevant, the domain to which these principles apply would have to be broadened to include other, more adaptive decisions and behaviors.
One intriguing possibility is that the compositional biases we have found may be related to optimal eye fixations. People make thousands of eye movements every day, the purpose of which is to bring various ecological objects into view so that we can see them clearly and identify them efficiently. Perhaps the aesthetic effects we find in spatial composition are rooted in principles that people would use to optimize eye fixations.

The general idea is that if the composition of an image within a rectangular frame is conceived as roughly analogous to the position of objects within the visual field, it would be adaptive for people to make fixations that make the most important information about the relevant objects most available in the image. The center bias would be related to the strong foveation of retinal receptors and the cortical magnification of information at or near the central area of the visual field. The inward and perspective biases would similarly be related to putting the most important and informative parts of the focal objects at or near the foveal region. Ecological biases would be related to providing proximal image features that are consistent with distal object features, depicting small things as small in the frame, large things as large in the frame, high things as high in the frame, and low things as low in the frame.

There are differences between rectangular frames and the field of vision, to be sure. One is that the frame of a picture is explicitly visible whereas the boundary of the visual field is not, being defined merely by the absence of sensory input. Another is that the shape of the visual field is oval rather than rectangular. But, such relatively minor differences aside, the eye-fixation hypothesis provides a plausible, ecologically relevant rationale for why people might have these kinds of default biases.

The notion that these default expectations can be violated when some meaning other than the nature of the object or situation is foregrounded becomes analogous to an observer who is making eye fixations with some meaningful expectation about what the scene will contain. If the observer expects to see a front-running racehorse, then the best fixation might be behind the horse to look for the competition, whereas if the observer expects to see a racehorse that is dead last, the best fixation might be in front of the horse for an analogous reason. These ideas are mere hypotheses at this point, of course, but that is always precisely the starting point for the next round of experimental testing. They at least have the virtue of making a bridge between our aesthetic effects and adaptive properties of real-world perception.

We began by briefly outlining our conception of aesthetic science. We then went on to show that aesthetic response to both colors and spatial compositions is influenced by hidden knowledge about the observed colors and objects. We offer the research we have described essentially as an existence proof that scientific approaches to aesthetic questions are useful and productive. We freely acknowledge that our results to date have raised more questions than they have answered, but this is not at all uncommon in science, especially in the initial stages of investigating
new phenomena. Even so, we are encouraged by the new questions our studies have raised, in large part because the answers we get when we examine them seem to fit together in an internally coherent and theoretically interesting way.

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Endnotes

14. This gender difference was reported in Hurlbert and Ling’s (2007) initial study of color preferences, but a subsequent experiment failed to replicate it, as both males and females weighted negatively on the L–M axis, preferring colors that were more blue-green than red (Ling & Hurlbert, 2009). They did still find that females weighted less negatively than males on this axis, however.
27. Unique hues are those hues that contain one and only one of the four chromatic primary hues: red, green, blue, or yellow.
34. More precisely, the inward bias means that people prefer the object to be positioned so that the vector from its center to its front points in the same direction as the vector from its center to the center of the frame.
45. This ecological perspective bias should not be confused with the positional perspective bias described above. Ecological perspective biases are based on the aesthetic effects arising from different perspective views of the same object, in all of which the object is located at the same position within the frame (i.e., the center). Positional perspective biases are based on the aesthetic effects due to different positions for the same object within the frame, all of which are taken from the same perspective.


