

A Classical Framework for Assessing Beauty in the Fields of Science and Engineering

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Beauty is that property of an object which clearly communicates itself to the object's perceiver, who is so pleased by what he perceives so as to inspire a movement of his will toward that object's beauty. Beauty is true and it is good, and it greatly enriches all aspects of human life. The sciences are no exception, as they too can be enriched by beauty. As science is concerned with the pursuit of truth for the good of all, it is only natural that beauty be a part of its patrimony. As such, beauty and science are assessed together in this article to find places of mutual enrichment and benefit. An internally consistent framework is presented herein which defines what beauty is and how to critically assess it. This framework is classical in origin and is re-presented here to a modern audience. Once properly understood, this framework can be used to objectively discuss and analyze beauty, particularly within the context of scientific and engineering disciplines. Examples are given to demonstrate how beauty can be better implemented into the sciences with respect to figures, presentations, and products. The ultimate goal of the work is to encourage the critical discussion of beauty and to empower scientists to more beautifully present their research.

There are certain attributes which are commonly valued across various scientific and engineering disciplines and even across different cultures. Beauty is something which has captured the imagination of people everywhere and in every age. Indeed, beauty inspires a movement of the human will towards a beautiful object. In the case of scientific research, more beautiful research should help attract the attention of the community. This has direct benefits in the field of science, as one of the final aims of science is to disseminate scientific findings as widely as possible to the broader community.

Several classical definitions of beauty will be presented and properly contextualized within a classical worldview. The benefit of this approach is that a systematic metric is defined by which beauty can critically, intellectually, and impartially be assessed. This offers distinct advantages over what is most often characterized as a subjectively emotional response to beauty. Beauty (along with other supplemental terms) will be defined and case studies presented to demonstrate how beauty can be best understood within the field of material science and engineering, for example. Assumptions made within this framework will be stated where appropriate. This is not a critical review of the classical understanding of beauty, but rather, an introduction into existing frameworks with which to discuss and even appreciate beauty. As such, select resources will be highlighted in this treatment which exemplify the following approach.

Defining Beauty

Four perspectives will be presented with which to conceptualize beauty. These perspectives are not mutually exclusive but synergistically define what beauty is and how to discuss it. The perspectives are internally consistent with one another and build upon one another as presented herein. When considered together, a clear understanding of beauty is constructed.

That Which is Transcendent

As already indicated in the introduction, mankind's fascination with beauty transcends time and culture, making it a truly transcendental phenomenon. Indeed, beauty, truth, and goodness have traditionally been classified as transcendentals – as integral aspects of what it means to exist (Schindler, 1991). Everything that exists has being (existence). Everything that exists also has a nature (or an essence). For example, the author is a human who has a nature which is universal to all humans, while retaining his own particular personhood which is unique to himself. This will be elaborated shortly. For now, it is enough to say that everything that exists has, at least, these three transcendental qualities. A transcendental is a property of being (Schindler, 1991). Everything that is, is true, is good, and is beautiful. It can even be said that the transcendentals themselves have a shared nature that in turn true, good, and beautiful. Each transcendental, since it exists as a real thing, has the properties of being which are truth, beauty, and goodness. Or to put it another way, that which is true is also good and beautiful. That which is good

is true and beautiful. Finally, that which is beautiful is true and good. This supplies us with our first definition of beauty – that which is true and good. Beauty can be qualified on the basis of truth and/or goodness. Religion is the human pursuit of goodness, which will not be treated here. Art is the human pursuit of beauty, which will be touched upon in part. Science is the human pursuit of truth which will be our focus.

In modern times, science has commonly been reduced to the study of those things which can be empirically demonstrated or studied; things which can be measured, tested, or experimented upon. This is a deviation from the traditional scope of science, which would include the pursuit of all forms of truth and not simply empirical or material truths. For this reason, Aristotle properly refers to things like ethics, politics, and physics as sciences, for example (Aristotle, 2013). It is a modern innovation to assume that the only form of truth is the empirical form of truth and that other forms of truth do not exist, such as those which can be determined by reason and logic. When considering that beauty is true and good, a severe injustice is incurred by reducing truth merely to empirical truths. It is difficult to experimentally or empirically measure how beautiful something is. Since it is very difficult to empirically determine if something is beautiful, people will tend to avoid discussing it in terms of objective and intellectual criteria. This moves discussion about beauty from the objective to the subjective, where beauty is relegated to the personal and emotional response of the individual. Once this underlying assumption about empirical truth is applied to beauty, all critical discussion is curbed, and each person is able to determine for themselves how beautiful something is. Who am I to say if something is beautiful to someone else, unless I have an alternative metric by which to assess beauty? The alternative to the modern subjectification of beauty, is a return to the more traditional worldview of being, beauty, truth, and goodness.

With these definitions of truth, goodness, and beauty at hand, it is possible to begin to assess beauty, particularly within material science and engineering. Since a beautiful thing is also a true thing, the sciences are instrumental in helping us to understand what beauty is. Being concerned with the properties of matter from which our world is constructed, material science is particularly pertinent to discussions concerning beauty, as beauty is conveyed to us by the material of this world. To put it another way, material science is concerned with substantial forms or the nature of substances like silver, iron, or bronze. Beauty is concerned with accidental forms of the nature of things as they exist as objects like a ring, a necklace, a statue, a painting. The substantial form of bronze is the same whether it is in the accidental form of a statute, a shield, a bowl, etc. The substantial and accidental forms can exist together in harmony as the nature of a thing being a bowl in no way excludes the nature of that

same thing being bronze. They work together as much as the material and the immaterial work together. In the natural world, matter never exists without form. Matter exists in possession of a form like copper, wood, table, etc. Ultimately, as composite beings of spirit and body, it is through the perception of the material world by which we come to know truths about the nature of things and by which beauty is communicated to us (by our intellect). We cannot directly perceive tree-ness or tree form with our senses from the natural world, but we can perceive tree trunks and branches and roots and leaves and so on. By the observation of many trees we come to abstract the tree-ness of what it means to be tree, or the nature of a tree. The role beauty plays in how these truths are communicated to us will be elaborated shortly.

An important assumption of the current framework is that truth does exist and can be known. Many in the modern culture argue a relativistic world view in which there is no absolute truth (it is something that each person makes for themselves), this reduces beauty (and other aspects of life) to a personal emotional response subjective to each person. This poses challenges to the sciences. In science, there is no room for relativism. Science is founded in the conviction that there are knowable, objective truths that are true for everyone in every time and place. We call these truths laws when they are so true that they have never been observed to be untrue (as with the laws of physics or the laws of thermodynamics). Indeed, the more powerful a law is the more universally it explains the world around us. Other scientific truths exist as well such as principles and theorems that, while not elevated to the status of law, are also held to be true. Without this common understanding of objective reality, science could not have flourished to the extent it has. It is helpful to introduce Aristotle's principle of non-contradiction here. It states that it is impossible for something to be and to not be at the same time and in the same manner (Aristotle, 2013). This is an underlying assumption in the philosophical sciences and the natural sciences as well. The first law of thermodynamics cannot be true for me and at the same time not true for you. It is always true for everyone. In this way, the scientific tradition firmly holds that there are objective truths that are knowable by us. Another popular objection is that truth might exist, but it is impossible for us to come to know what the truth is. This is again incompatible with the scientific tradition. Scientists throughout the centuries have pursued truth with the strong conviction that it is indeed knowable to us. Within Material Science and Engineering, for example, exists a significant discipline of characterization, devoted to the discovery of the structure and properties of materials of interest. Many and various techniques have been developed to assist us in coming to know the truth about our world. Even things which cannot be directly observed have become known to us through careful experimentation and logical deductions from experimental results. With all of this in mind,

it should be noted that a classical worldview and the scientific worldview both converge on the fact that truths exist and that these truths are knowable to the human mind. There is a confidence in the epistemological powers of the human person, or the ability of the human person to know truths and have confidence in those truths.

That Which is Most Easily Knowable by the Radiance of its Being

Thus far, beauty has been described as a transcendental, or a property of being, that is common to all things. All that is, is beautiful. However, with what kind of intellectual and objective framework do we compare the relative beauty between different things? How can we compare the beauty of one thing to another? Following on the transcendental framework we have developed, it would seem that a more beautiful thing is that which is more true and more good. We will focus more on the aspect of truth than on goodness in this treatment because the scientific institution is concerned with the pursuit of truth and also because this treatment is tailored to the perspective of the Material Sciences.¹ To know the truth about something is to know what it is, what the nature of that thing is. We come to know the truth about a tree by knowing what tree nature is. We come to know what tree nature is by studying lots of trees. Dendrology is the scientific study of trees. There is a scientific study of almost anything you can think of, with certain traditions being held in common across those studies. The scientific tradition is very fond of three things, for instance, which would be helpful to review: observations, definitions, and replications.

One way to determine the nature of something is to observe it. There is a philosophical principle that action follows upon nature. The way something acts is a result of the way it is. Dogs bark and chase their tails and run with the pack. Metals conduct electricity, donate electrons, and have a sheen. By observing the actions (or properties) of things, it is possible to come to an idea about the nature of a thing. This is precisely what happens in science when a scientist asks, "what is the nature of gravity?", after having observed that such a thing as gravity exists. Once the question has been postulated, more observations are made. When the actions of a thing have been thoroughly observed in their natural course, different observations can be made as to how a thing acts in response to a perturbation made by the scientist; experiments are conducted. With enough observational evidence conclusions can then be drawn about the nature of a thing. Indeed, it is clear to see how this principle of action following nature fits within the scientific method. Perhaps within every scientist is the hidden thought "why does this thing do what it does. What is the governing principle (or nature) that makes it behave the way it does?". It should also be noted what other sorts of underlying assumptions are implicit within this framework. Namely, that the world is

intelligible and that the world around us is subject to experimentation (Ratzinger, 2004). It is easy to see then, how the scientific revolution manifested itself in the Western World, which believed at the time that the world was created logically and that the impersonal world is itself not divine and can be tested, prodded, and experimented upon.

Another pastime of the scientific endeavor is an astute attention to detail, especially with definitions (to the chagrin of many students). Meticulous detail is paid to defining things and terms in science. Indeed, once the nature of a thing has been identified through observation, it is named and defined. Whether by words or equations, there's a scientific definition for metal, electron, gravity, zwitterion, etc. Each definition names something universal about the things which the definition defines. Gravity has the same nature here as on Mars, while being particularly distinct in each instance. My computer has a real computer nature that is particularly manifested by my computer, while still having the same computer nature as my lab mate's computer. In this way, there is an objective truth that exists within the object and definitions and nomenclature name something real about the object. This harkens back to Plato, who proposed that particular objects which might be beautiful are only so because they really share in the nature of The Beautiful (universal)(D. Plato Gallop, 1999). There are other ways to explain how universal terms are applied to particular entities, but the realist way shown here is the most coherent within the framework presented for defining beauty.²

One more staple of the scientific process is the virtue of replication, or duplication. It is evident that when relying on observation to determine the nature of a thing, it is good to rely on many observations rather than few. In science, results are favored which include many trials of replicates to ensure that what is concluded about the nature of a thing actually correlates to the truth of that thing's nature. Suppose that if a young child from an arid climate were to watch Mary Poppins, they may conclude that umbrellas are sometimes useful for flying from place to place if they did not have enough observational experience to know that in reality, umbrellas are best implemented to keep oneself dry from precipitation and not for flying (unfortunately). From many observations of particular things, scientists come to abstract the nature of

¹We will not focus on goodness for the sake of length, not because there aren't also objective standards by which goodness can be assessed (again see the ancient philosophers, who had much to say about goodness and good living).

²Realism is the notion that a universal term names something real in an object, that there is a real nature contained within an object that makes it the way that it is. The reader should be aware that an alternative philosophy is that of nominalism, which holds that there is nothing real within the object that makes it the way that it is, but that it when a term is applied to an object, it is merely applied to that object in name only, and not to identify something real about the object.

A Glossary of Terms Appropriated Here	
Abstract	The process of consolidating a universal concept from the observation of many particular entities. In abstraction, the extraneous details pertinent to the individual entities are left behind and the universal common nature shared by all the entities is retained. Analogously, the abstract of a scientific paper should retain only the fundamental concepts of the study while omitting unnecessary details.
Accidental Form	The unique aspect of an object that makes it what it is. A table has a table form that, when applied to wood, gives rise to a table. The same material substance (say, bronze) can exist with different types of forms (shield, bowl, doorknob) while retaining the same substantial form (bronze).
Beauty	Four perspectives of beauty were discussed herein. Beauty was shown to be: <ul style="list-style-type: none"> · A transcendental; true and good · The radiance of being · That which is balanced in integrity clarity, and proportion · That which, when perceived, pleases
Form	All material things have a form. A form applied to matter gives rise to a thing's essence. The form of copper applied to matter gives rise to copper. The form of table applied to wood gives rise to a wooden table.
Nature, Being, Essence	As applied here, these are terms that describe what a thing is and what a thing does. Action follows upon nature. Being is distinguished as existence, or real-ness.
Realism	In this context, realism is the philosophical conclusion that universal terms can be applied to individual entities because of something real in those entities that is held in common for them all. There is something real about tree nature that the universal term tree is associating with.
Substantial Form	The unique aspect of a material that makes it what it is. Copper has a substantial form that manifests itself in a uniquely different way in matter than the substantial form of silver. While the accidental form of an object may change, the substantial form of the material from which it is made need not.
Transcendental	A property of being, or a property that all existing things possess. Beauty is a transcendental, because everything that exists is beautiful.
Will	The rational faculty of choice possessed by rational creatures. The will is informed by knowledge (from the intellect and the senses). The will is directed towards perceived goods.

the things they are observing. From observing many trees, we abstract the nature of tree as a universal concept and apply that concept to particular trees we may see in the future. Even if we have never seen a particular tree before, once we do see it we can tell it is a tree because it conforms to the form of tree we developed from our “database” of previous observations of other trees.

Now, since beauty is related to the truth of a thing, and truth is ultimately related to the nature of things (the conformity of a thing to its nature), we now arrive to our next def-

inition of beauty. Beauty has also traditionally been called the radiance of being.³ Something is more beautiful when it more perfectly signifies its nature to the exterior world. When an object's being is so radiant that it is obvious what it is, then it is beautiful. Simply put, for a thing to be beautiful we must ask if the outward appearance of the thing corresponds to that thing's nature. We've already discussed how we come to know the nature of things and how we abstract

³In an analogous way, truth is the conformity of being and goodness is the excellence of being.

the nature of a thing from many observations of what we perceive about particular occurrences of that thing. In this way we abstract dog nature from the many individual instances in which we have perceived or observed individual dogs. In this way, when we see a dog in the future, we will know it is a dog because it has the form of a dog which corresponds to dog nature. If the outward appearance of that dog corresponds to its dog nature, then it is a beautiful dog. If beauty is the radiance of being, then a more beautiful dog is a dog whose appearance more perfectly corresponds to its dog nature. When we look at a beautiful dog we know instantly and easily that it is a dog. Indeed, beauty alleviates the mind from the arduous task of abstraction. We don't have to even think about what the dog is, we just know. In contrast, a less beautiful thing is a thing that puzzles us as we try to figure out what it is.

It is necessary however, for the observer to have enough sense experience (or observational data) to have a clear idea of what dog nature is. If someone had not seen many dogs before, they may not be certain that a chihuahua was a dog, nor would they think that it was beautiful, let alone a beautiful dog. Furthermore, certain conventions may exist which also influence our perception about a dog's nature. Along with dog nature there is also a common expectation of specific dog breeds, like dalmatian nature or German shepherd nature. A dalmatian and a shepherd both have dog nature, but they each retain their specific breed nature as well. For this reason, it is likely that someone might say that a pure-bred dalmatian is more beautiful than an ambiguous mutt, because while it is radiantly clear that both are dogs, it is unmistakably clear that the dalmatian is a dalmatian while the breed of the mutt is unclear. Since there is a convention that dogs have breeds, it influences how beautiful each dog is perceived to be. In another analogy, the same convention does not apply to cats. If someone were to see a typical Manx, they would immediately realize that it was missing something that cats are supposed to have - a tail! Since most cats we see have tails, the form of a Manx wouldn't correlate perfectly to the form of cat that most people identify. The first question is usually "What happened to their tail?" on the natural assumption that it must have had one at some point. Some are shocked to discover that Manx is a breed of cat from the Isle of Man which usually does not have a tail. The conventions about dog and cat nature informed beauty differently for these two examples. That is why it is important to realize how both conventions and observational sense experiences impact beauty. There are often conventions within various disciplines (like art and science) that are expected by their adherents and of their adherents. While it is possible to produce beauty outside of an existing convention, you usually have to be very good to achieve that end.

Returning to cats, most people, if given the choice between petting a tail-bearing cat and a tail-less cat would prob-

ably choose the tail-bearing cat (or the "normal" cat). This is because their will is directed towards the more beautiful cat. For our purposes, the will is the rational power of choice that humans possess which is informed by knowledge and directed towards an apprehended good. Most people have the expectation that a cat should have a tail and based on their knowledge of what a cat should be, would choose the cat with the tail. However, someone from the Isle of Man may indeed choose the tail-less cat (Manx or not) because of their additional knowledge about the Manx breed. Beauty is what naturally pulls on our will and draws us to an object in accord to what the will knows about that object from the intellect. In this way, a beautiful object communicates knowledge of itself to the perceiver and this knowledge informs the will in its choice to gravitate towards the beautiful object.

That Which is Perfectly Balanced in Integrity, Clarity, and Proportion

The way people normally react upon seeing a tail-less cat is an indication of how natural it is for us to expect something to have the integrity proper to its nature. There is just something off about a cat without a tail like there would be about a dog without legs (or a hot dog with legs). This points us to one more traditional formulation of beauty. A beautiful thing is that thing which is complete in integrity, clarity, and proportion (Aquinas, 2012). The more perfectly balanced a thing is with respect to these three attributes, the more beautiful it is. In one way or another, these attributes are oriented towards the form of the object (both substantial and accidental).

Much has been discussed already on the integrity of a thing with respect to its nature. A dog without legs is lacking in the full integrity (or the full unity, or wholeness) of what it means to be a dog. A dolphin without legs, however, does not lack integrity according to its nature. In this way, the integrity of a thing must correspond to the truth about that thing.

We have also touched upon clarity in discussing how clearly or radiantly the nature of a thing is conveyed by its outward appearance. Beauty is dazzling in its clarity. Although we may not always be able to pinpoint exactly what it is that captures our attention, we do know that it has been captured. This is a subtle clarity that speaks to us very loudly, but in a language we may not be able to understand until we have learned how to speak about beauty.

Proportion is the attribute of beauty that orders all things such that size, shape, material, color, etc., so that they are perfectly and harmoniously balanced together. A tie-dye colored cat would be more distracting than beautiful. The same would apply to a dog that has one leg that was twice as long as the other three. Here, symmetry is often a helpful component of proportion. There is often an underline symmetry or

geometric/arithmetic principle which guides the creation of art, music, and architecture.

Let's examine a practical example of integrity, clarity, and proportion from material science and engineering. Drug-resistant superbugs are a growing concern as bacteria are more commonly becoming "immune" to antibiotics. Copper ions are naturally anti-microbial, and bacteria can't develop resistances to them. Copper-based metallic alloys can be incorporated as components in a high-touch surface and designed to release a bacteria-lethal amount of copper ions through corrosion (Hutchison, Zhou, Ogle, & Scully, n.d.). For example, this copper alloy could be used to make doorknobs in a hospital to reduce the risk of infectious outbreaks. This alloy would need to consistently release enough copper ions to kill bacteria within a few minutes of contact with the doorknob. The alloy would also need to not corrode to the point where the doorknob looks unpleasantly corroded – a dirty looking doorknob is not a welcomed sight in a hospital (even though it is likely much cleaner than a shiny, stainless steel doorknob in terms of germs). These two requirements (release copper ions while not looking corroded) are seemingly at odds with one another. Additionally, the copper alloy would need to do this under the influence of human sweat/oil because this would be the most likely electrolyte in which corrosion would occur. Knowing how the alloy would need to act, we can begin to understand the nature of the alloy itself (since action follows upon nature). This will inform what is proper to the nature of an anti-microbial doorknob. If the final doorknob failed in any of these regards, it would lack the full integrity of an aesthetically pleasing, anti-microbial doorknob.

Here, the context of the situation matters. It matters that the doorknob looks aesthetically pleasing because it needs to appear to be worthy of a hospital setting, where dirty looking things can be unsettling to patients, care providers, and guests alike. A dirty-looking corroded copper doorknob while retaining the true nature of an anti-microbial surface would (by convention) have the appearance of a dirty doorknob to the normal observer. There would be a clarity problem, because the outward appearance would not correspond to the inward reality (the luster of being would in fact be tarnished; literally and figuratively in this case!). Instead, if the doorknob successfully looks clean aesthetically, and is actually clean medically, then there is a fullness of integrity, a luster of being.

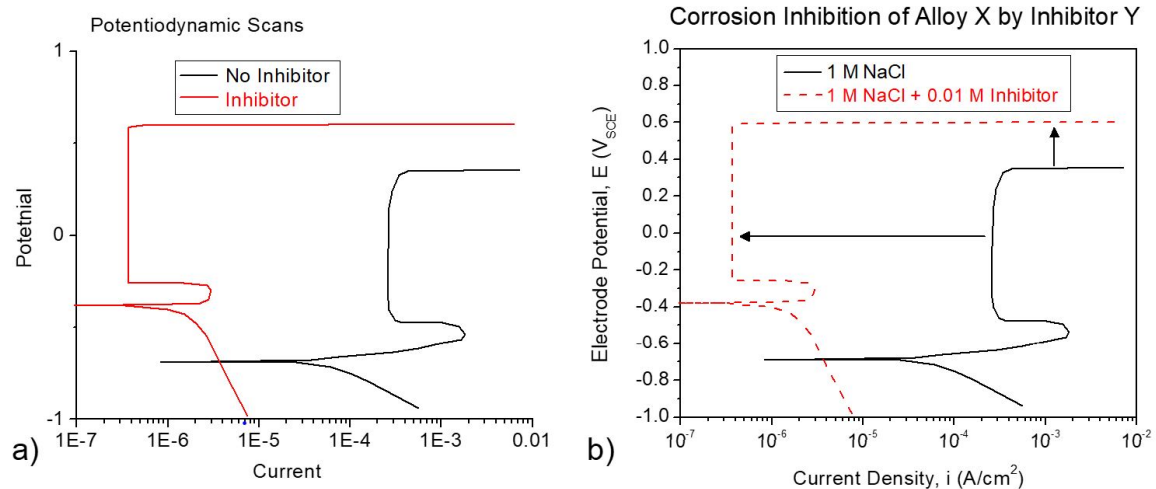
The appearance of the doorknob is an important factor in its final beauty. The common convention of what constitutes a dirty doorknob versus a clean doorknob is important in this situation, even though the doorknob could successfully be anti-microbial while breaking this convention. In this same way, it is fortunate in this case that copper-based alloys (brass, bronze, etc.) have already been used as a conventional material with which to construct doorknobs. In-

deed, even if a purple-colored alloy could be made that was anti-microbial, it may not be able to be deployed as a doorknob because it would lack the appropriate color normally expected for doorknobs. The purple color of the object would be disproportionate to the object itself. Likewise, the choice of copper over other metals is decided with respect to proportion. Silver ions are also anti-microbial and could in theory also be implemented in an anti-microbial, tarnish-resistant doorknob. However, using silver (an expensive and noble metal) to make (many) commonplace doorknobs would be an unproportionate (and inappropriate) material selection given the function of the final component.

Another example of how to apply these principles is offered in Figure 1, which presents two variants of a figure depicting the same data. Figure 1a is constructed as a less beautiful portrait of the data, while Figure 1b is constructed as a more beautiful portrait of the data. The caption highlights some of the features which are different between the two figures and how each feature relates to either integrity, clarity, or proportion. Integrity is absolutely essential for any figure which is meant to convey some meaning to the reader. If that meaning is lost upon the reader, then the figure may as well not be used. Cues which aid in maintaining the proper integrity of the figure (and the data) include informative labels, color- and symbol- coding, and correct spelling. The meaning of the data must be presented clearly to a general audience for them to understand. Ways for figures to be presented with clarity include proper use of text, color- and symbol- coding, and observance of conventions and customs. Lastly, proportion correctly balances colors, sizes, position, etc. to make the meaning of the figure more aesthetically presentable to the observer. Proportion plays an important role in text sizing, coloring, positioning, and symmetry in placement of figure elements. Ultimately, the goal of a beautiful scientific figure is to evoke in the observer the question "what is that?" with a sense of scientific studiousness. Conversely, a less beautiful figure evokes the question "what is that?" with a sense of confusion and distracts the observer from the true meaning of the data.

That Which, When Perceived, Pleases

That which, when perceived, pleases. This definition provided by St. Thomas is the final one we will discuss (Aquinas, 2012). A beautiful thing pleases upon being seen. This is not the same a beauty is in the eye of the beholder. Here Saint Thomas has in mind that a more beautiful thing pleases the more virtuous pleasures. He is assuming that the perceiver is a well-formed human person. A rather dull thing may appear beautiful to one person and a beautiful thing may appear rather dull to a different person. Everything we have discussed so far in this traditional framework has made the case for the objectivity of beauty – that beauty is in the object. This differs from subjective beauty, when beauty is in



- Text:** The text size contributes to proportionality with larger text utilized for more important elements. Spelling mistakes compromise the integrity of the research. Text should be used to add details that make the message of the figure clearer. The title adds detail for the observer to understand what is happening, it should not just be used to compensate for what should be clear from the beauty of the figure.
- Scale:** The number formatting of the scale units should be consistent to maintain proportionality. The unit increment should also be proportionate between the x and y scales. Adding the second set of scale bars adds a symmetric proportion and also clarity to distinguish between various elements of the graph.
- Data:** The two curves are different colors to make the different behaviors clear to the observer and to maintain the integrity of the trends as well. One curve is also dashed to maintain integrity even if a black and white figure is reproduced. The arrows help make the message clear to those who may not know what trends to look for.

Figure 1. Comparative assessment of how data can be presented in a lesser (a) and more (b) beautiful way.

the subject (the beholder). This is rather like the example of objective and subjective truth discussed earlier. It may very well be the case that something is subjectively beautiful to a given person for a reason only known (or unknown) to that person. However, not all beauty is reduced simply to subjective beauty. If this assumption is made, then no intellectual conversation about beauty can be had. However, with the current framework in mind, we are indeed able to engage in objective dialogue about the nature of beauty. To be clear, subjectivity does matter. A trip through the Louvre for a blind man, his young son, and his seeing eye dog will have a very different impact on each of them. For obvious reasons ranging from sensory experience, to attention span, to rational capacity, each subject will have very different subjective experience of the art on display. It is in this way that we see how the disposition of the perceiver influences the subjective beauty of the art. However, nothing about the art changes, the objective properties of the art are the same for all three subjects. Our previous discussion herein was made with respect to the objective reality of beauty. Since subjective beauty depends on the perceiver, we may maintain a metric for discussing the objective beauty of a thing by appealing to the subjective response of the person who is most disposed to perceive and be pleased.

Here it is helpful to discuss the classical understanding of pleasure. Plato wonderfully explains in his Republic the three levels of pleasure which correspond to the three powers of the soul: sensation, courage, and contemplation (Plato & Bloom, 1968). By analogy he compares the soul to the city which contains three classes of citizens: the common man, the warrior class, and the ruling class. In this way, Plato (through Socrates) enumerates the three levels of pleasure. The pleasure of sensation corresponds to the common crowd, which is easily swayed by feelings of happiness, hunger, excitement, thirst, fear, etc. This is the most common form of pleasure as it is available to all and often (as with eating). The power of courage which corresponds to the warrior class gives rise to the pleasure of conquest. This is a less common pleasure that requires time, effort, and the coordination of the lower bodily sensations such as achieving a promotion or mastering a new skill. The final, and highest pleasure is that of contemplation and it corresponds to the ruling class. The ruling class (in a happy city) orders all things justly in their proper place to the flourishing of all, just as the intellect should order all things in the human person. This is a rarer pleasure and requires the coordination of the whole person but is the highest of pleasures. With this in mind, we can see what St. Thomas means when he says beauty is that which,

when perceived, pleases. He has in mind the pleasures of all three levels of the soul, the highest of which is contemplation. The more beautiful a thing is, the more it pleases all three levels of pleasure. Within the context of the presented framework, a beautiful thing pleases the senses when it maintains integrity, clarity, and proportion, it pleases the sense of conquest when the mind can easily determine what the thing is, and it pleases the power of contemplation when the observer can rest in the beauty of a thing and take it into his own mind to contemplate.

The concept of appealing to all three pleasures of the soul can be exemplified in the construction and delivery of a scientific presentation. Briefly, we can examine how a beautiful scientific presentation might appeal to the pleasures of the senses, the pleasures of conquest, and the pleasures of contemplation. For sensory pleasures, it is important that a presentation have an aesthetically pleasing color scheme and that elements of the presentation are easy to read given the lighting of the room, the distance from the presentation to an audience member, and the quality of the medium of presentation. The presentation should not be overly hindered by text and should be constructed with a consistent scheme or format. When possible, it may be useful to engage the audience's senses by bringing in a sample that the presentation is about for them to see and touch in their own experience.

With regard to the pleasure of conquest, the presentation should be planned in such a way so as to bring the audience along in triumph after triumph. First by introducing the subject matter to them in such a way that they really do understand the unresolved problem at hand and where the current research stands with solving this problem. Having recognized together a problem in our understanding of some topic, the audience can then be invited to solve that problem with the presenter by developing an experimental procedure to answer unknown questions. When data is presented, the audience should be guided to the point where they understand what the results mean and how it relates back to the problem at hand. Finally, at the close of the presentation, when conclusions are made and the problem (or at least some aspect of it) has been solved or understood, the audience should also feel as though they have come to solve the problem too; they should feel a sense of conquest. If at any point in the presentation an audience member feels as though they have lost you (either in understanding the material, or in their attention span) then they have indeed lost something, there can be no sense of conquest in that moment. Worst of all, is if they feel like they have lost twenty minutes of their life by attending the presentation; certainly, a feeling of defeat and not of conquest.

The final level of pleasure is the level of contemplation. In this level, the audience should be invited to reflect on what they have just learned for further contemplation even beyond the presentation. Having just successfully "conquered" the

presented material, they are now empowered to make what they have learned their own through contemplation of the material. In some sense, this is what a question and answer session after a presentation should be about. Audience members earnestly proposing questions to the presenter which are a fruit of contemplating the presentation. This is facilitated by the presentation directly inviting the audience to contemplation by proposing future areas of work or highlighting what new questions have been raised in the course of the study. Alternatively, the conclusions reached in the presentation may have such an impact on the audience so as to inspire a change within them. Having now learned what was just presented, they can never be the same. Even better than the question and answer session, is for an audience member to approach the presenter later in the conference (or beyond) and say "I've been thinking about your presentation ever since I heard it" or "I can't stop thinking about _" or "have you ever thought of _". That indeed would be the sign of a beautiful presentation – that the perceiver has been forever changed for the better. Beauty, it is said, inspires us, moves us, and changes us. Scientists, most of all, should be amenable to this change and to contemplation at large. Good scientists are naturally formed in the ways of contemplation, as they are trained to sit, stare, think, ponder, question, and engage the world around them. It is one of the few professions in which you are expected, from time to time, to sit and do nothing other than to contemplate. It is for this reason that this author believes there is a fertile ground for the growth of beauty within the fields of science.

Conclusion

An intellectual framework with which to objectively assess and analyze beauty has been reviewed. Emphasis was given to relate the principles discussed to applications in the sciences. Many commonalities and points of similarity between the scientific framework and the classical understanding of beauty were highlighted. Several practical examples by which to better understand the classical framework were given. To summarize, beauty can be understood in the following way:

- Beauty inspires a movement of the perceiver's will towards the beautiful object of its perception. For this reason, it is beneficial to understand how to make science more beautiful so as to attract the wills of peers, funders, the public, and students to it. If for no other reason, scientific works should be made beautiful simply for the sake of its own good.
- Beauty was firstly described as a transcendental property of being. Along with truth and goodness it is an essential property of what it means for a thing to be. As such, beauty itself, inasmuch as it exists, can also have the property of being true and good. The chief aim

of science is the pursuit of truth, usually for the good of humankind. For this reason, beauty (that which is true and good) is naturally affiliated with science (that which is concerned with truth and goodness).

- Since the beauty of a thing is dependent upon the truth about what a thing is, it is necessary to know what the nature of that thing is. Scientific principles were deployed to understand how we come to know the nature of a thing, and by knowing its nature make a judgment about its beauty.
- Once the truth about what a thing is (or should be) is known, an assessment can be made to determine if the exterior observances of that thing truly signify what it is to the perceiver. A beautiful thing is radiant with the truth of what it is. Beauty relieves the mind from the arduous task of determining what something is and simply reveals that truth to us straightaway.
- There are three attributes which communicate beauty to us and which must be present together in harmony for a thing to be beautiful: integrity, clarity, and proportion. All three attributes work in harmony to make a thing more beautiful.
- A beautiful thing is beautiful in and of itself regardless of how it is perceived. A beautiful thing is pleasant to behold and pleases the beholder. A more beautiful thing pleases the higher functions of the soul, with contemplation being the highest.

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