Interpreting the Beauty of Science through J. S. Bach's Music

YU Ziling
Global Economics and Finance, Morningside College

Introduction

Science and music are representatives of sense and sensibility to many people, and we often describe a law of nature with "scientific" and a piece of music with "beautiful" but rarely the reverse. However, quoting the ancient Chinese philosopher Zhuangzi: "heaven and earth proceed in the most admirable way, but they say nothing about them" ("Knowledge Rambling in the North"), the underlying laws of nature's proceedings have their own innate beauty. In this essay I will draw parallels between science and music of a special composer, Johann Sebastian Bach, to appreciate the beauty of science.

Shared Aesthetics: Harmony, Simplicity and Vastness

The beauty of science originates from intelligence and the harmonious order of simplicity and vastness (Poincaré 163–164). Music is an example of the beauty of science, as the inward, intimate, interior beauty of intellectual

discernment can be expressed in an external approach acoustically, vocally or instrumentally.

Harmony

Harmony is one of the most emphasized elements in music. Essentially, harmony is achieved by various music notes, which are the vibrations of air; because air vibrates at different frequencies, different pitches are formed. Pythagoras made the earliest discoveries about the tuning of harmonious music notes, which is known as the Pythagorean tuning, tells the intervals[1] of harmonious notes by ratios. For instance, notes of harmonious intervals have whole number ratios, in practice, playing half the length and the whole string of a lyre[2] would give the same notes of one octave span. If we examine this method from the point of view of modern physics, A440, or A_4 in pitch notation, corresponds to an audio frequency of 440 Hz and the audio frequency of A_5, the same note an octave above A_4, is 880 Hz. So the chord of A_4 and A_5, which are of eighth interval, being played together will be the most harmonious. By using this approach of calculating ratios between notes, Pythagorean deducted the one of oldest scale which became the basis of all Western music activities for a long time ("Pythagoras of Samos").

The origin of the music scale is deducted and calculated by a mathematician, and harmonious music does not simply emerge from a random outburst of imagination, instead, it is generated by applying the laws of physics in the right, pleasant way. Musicians of all times need to study music theory thoroughly to learn the features of notes, intervals,

1 In music theory, an interval is the difference in pitch between two sounds.
2 A string instrument in Ancient Greece.

tempos, structures and so on so that they can learn the acoustic law of harmony and achieve intended musical effects.

The same beauty of harmony lies in science as well, just not limited to an acoustic way of expression. For instance, Euclid applied "skillful organization in presenting and developing mathematical propositions" (Dunham 258), the elegant structural flow from definition to postulates and proposition in his deduction accords with the several music themes consist of music notes organized in an elaborate way and finally developed into a full piece of sonata. Euclid used simple syllogism to obtain propositions in the mathematical universe, which turned out to be a refined music composition of points, lines and shapes. This unifying character between music and Greek geometry originates from the logical thinking process and ends at intellectual harmony, it is not only an exercise of techniques and reasoning, but also a demonstration of artistry.

Simplicity and Vastness

Apart from harmony, simplicity and vastness also accompanies the beauty of music, and Bach's music is a typical example. For instance, in *Chaconne*[3], the basic theme consists of only four bars. However, Bach added various musical variations and compositional effects to the short theme, and the final work became one of his most appreciated violin solo. Fellow composer Johannes Brahms described: "On one stave, for a small instrument, the man writes a whole world of the deepest thoughts and most powerful feelings." ("Partita for Violin").

3 The fifth and final movement of the Partita No. 2 in D Minor, BWV 1004, by Johann Sebastian Bach.

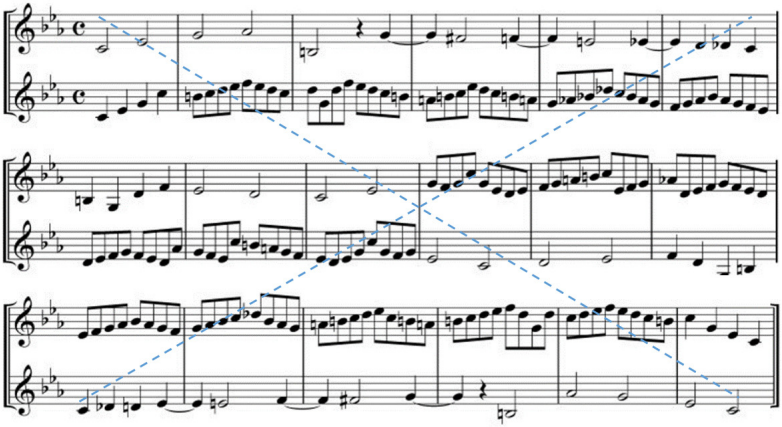
The philosophical transition between simple elements and the grand vista of the whole world applies to both arts and science. When Waston and Crick confirmed the two-chained double helix structure as the result of base-pairing, they instinctively felt "[a]nything that simple, that elegant just had to be right". (Watson 131). It is this simple mechanics of chemical substance that encompasses the secret of heredity, of the human body, and lives on earth. British poet William Blake once wrote, "To see a World in a Grain of Sand // And a Heaven in a Wild Flower, // Hold Infinity in the palm of your hand //And Eternity in an hour" ("Auguries of Innocence", qtd in Blake, "To See a World"), while the vastness of the galaxy brings about awe and admiration, what scientists are looking for is always as simple and elegant as the melody of four bars, and this is the key to decode the mysterious vastness.

Common Rationality: In Search of Natural Laws

So far I have reached the conclusion that science could be as beautiful as music in terms of outer aesthetics standards. However, science observes absolute facts and pursuits objective truth by reasoning, whereas music hardly resists subjectivity and sensibility. The two subjects seem to be contradictory, would they still share the same inner beauty in essence?

In fact, rationality and the pursuit of universal laws can be detected in Bach's music, these efforts manifest beauty, sense and rationality at the same time. For example, *The Musical Offering* is a collection of keyboard canons and fugues by Bach ("The Musical Offering"), and one of the most intriguing pieces is a "crab canon". As shown in the following music score, a crab canon is an arrangement of two musical lines that are complementary

and backward ("Crab Canon"), which is very rare and unique in music compositions. This rigid, subtle form with designated music theme is not designed for free, emotional, improvisational composing. Instead, given the fact that devising a piece in two voices that produce a pleasant sound whenever played forward or backward is extremely difficult, I see this composition as an exercise testing the boundary of musical composition. The composer went beyond the surface of the melody, and it is the fundamentals of harmony that are contemplated and it reveals the rational nature of the piece.



Graph 1: Music Sheet of Crab Canon

At the beginning of western science, Plato differentiated the sensible realm from the invisible realm, stating the importance of using rationality and evidence to discover truths (Lindberg 12), and scientists have been searching for laws underlying visible phenomena ever since. Bach's special intelligent investigation into the boundary of music is not at all less pleasant to listen to, in fact, its thoughtfulness increases its charm of tonic harmony, so there is no reason for a similarly rational scientific act to be branded

as not beautiful. The use of reason itself in search of a clearer visage of mankind and the universe is one of the most remarkable and gorgeous things we have done.

A fascinating fact pointed out by Douglas Hofstadter is that the structure of a crab canon is similar to palindromes, and DNAs are of the same organization (Hofstadter 209), which consist of double helix/ melody interweaving contrapuntally. The striking resemblance draws me to a perception: the painstakingly discovery of DNA structure just as adorable as a carefully composed crab canon.

The Unity of Truth and Beauty: Completeness and Consistency in the Process

When the analogy of Theory of Forms is applied on music, Bach composing a piece of music is like a carpenter giving the "initial idea or definition of a table" (Lindberg 12), the performance carried out by a string quartet is destined to be the "imperfect replica" (13) of Bach's intention, and music scholars are the truth seekers trying to solve the initial idea of the composer. Bach's music is so elegantly and ingeniously organized that the process of decomposing it is also beautiful. Music theorists found out that in *The Musical Offering* only a single music theme is used for all collections, and underlying similarities connect the apparent richness.

Scientists are similar music analysts in a way that they are trying to find out the "form" of a table designed by the carpenter. Science is beautiful by nature as it is not a business that only rewards beauty to winners of successful discoveries, instead, it entitles beauty to the process

of truth finding. For instance, in the exploration of inertia, Galileo carried out controlled experiments and found out that a ball rolled down would roll up another incline to the same height as started, then he initiated the concept of inertia. These are the first two steps of making a discovery: sensory experiments show a certain pattern and justify a phenomenon. His successor Newton took two steps further: Newton summarized the patterns and identified a quantitative relation, moreover, he upgraded the concept of inertia and applied it to the celestial motions. (Cohen 55, 59) Galileo missed hitting the "final target", but I doubt if anyone who is not a defendant of Roman theological authority has ever called his work a hideous failure. Every step taken in scientific discovery, though inevitably off the right track from time to time, has its own meanings and takes us closer to the truth.

The beauty of scientific discovery lies in the innate completeness and consistency of the research methodology—the formal deduction. Sivin holds a view that the Scientific Revolution unprecedentedly created knowledge with "no value except truth value" (235), I would argue there is beauty alongside truth value: the process of truth seeking is a logical flow of scientific experiments followed by a complete and cohesive deduction form, and the existence of such research approach reveals the potential for a new discovery as well as beauty. As in the case of inertia's discovery, it shows the operation of the formal system: first, carrying out experiments and concluding patterns; second, explaining certain phenomena; third, conducting theoretical construction of physical formulas; and finally, tracing the source to universal mathematical origins. Completeness and internal consistency are indicated in the logical approach to derive propositions from axioms or other existing findings. So is the unity of truth and beauty,

which is manifested through this unbreakable cohesion of the deduction system, suggesting rationality could be utilized and truth could be found.

Conclusion

When the American biologist Lewis Thomas was asked what message humanity should take to other civilizations in space, he said: "I would send the complete works of Johann Sebastian Bach." Bach's music remarkably illustrates the encounter of scientific beauty and musical glamour. It is qualified as the representative of humanity as a demonstration of art, of science, of the artistic beauty of science.

Science shares homogeneous attributes with music. Aesthetically, science is harmonious, simple and vast; in essence, rationality is a superior exercise of human intelligence; more importantly, the beauty is not derived from successful discoveries only, its roots are embedded in the logically complete and consistent process of research, which entitles science its innate beauty. Hence, science illustrates the encounter of sense, sensibility and beauty, all of which are the backbones of our civilization.

Works Cited

Blake, William. "To See a World." *Poetry Lovers' Page*, www.poetryloverspage.com/poets/blake/to_see_world.html. Accessed 15 May 2020.

"Crab Canon." *Wikipedia: The Free Encyclopedia*. Wikipedia Foundation, Inc., 17 Apr. 2020, en.wikipedia.org/wiki/Crab_canon. Accessed 12 May 2020.

Cohen, I. Bernard. *The Birth of a New Physics*, 1960. Rpt. in *In Dialogue with Nature: Textbook for General Education Foundation Programme.* Edited by Chi-wang Chan, Wai-man Szeto, and Wing-hung Wong. Rev. 2nd ed., Office of University General Education, The Chinese U of Hong Kong, 2016, pp. 49–62.

Dunham, William. *The Mathematical Universe*, 1994. Rpt. in *In Dialogue with Nature: Textbook for General Education Foundation Programme.* Edited by Chi-wang Chan, Wai-man Szeto, and Wing-hung Wong. Rev. 2nd ed., Office of University General Education, The Chinese U of Hong Kong, 2016, pp. 257–272.

Hofstadter, Douglas R. *Godel, Escher, Bach*. Penguin, 2000.

"Knowledge Rambling in the North." *Chinese Text Project*, https://ctext.org/zhuangzi/knowledge-rambling-in-the-north. Accessed 12 May 2020.

Lindberg, David C. *The Beginnings of Western Science*, 2007. Rpt. in *In Dialogue with Nature: Textbook for General Education Foundation Programme*. Edited by Chi-wang Chan, Wai-man Szeto, and Wing-hung Wong. Rev. 2nd ed., Office of University General Education, The Chinese U of Hong Kong, 2016, pp. 11–48.

"The Musical Offering." *Wikipedia: The Free Encyclopedia*. Wikipedia Foundation, Inc., 17 Apr. 2020, en.wikipedia.org/wiki/The_Musical_Offering. Accessed 12 May 2020.

"Partita for Violin No. 2 (Bach)." *Wikiquote*. Wikipedia Foundation, Inc., 2 Apr. 2020, en.wikiquote.org/wiki/Partita_for_Violin_No._2_(Bach). Accessed 12 May 2020.

Poincaré, Henri. *Science and Method*, 2001. Translated by Francis Maitland. Rpt. in *In Dialogue with Nature: Textbook for General Education Foundation Programme*. Edited by Chi-wang Chan, Wai-man Szeto,

and Wing-hung Wong. Rev. 2nd ed., Office of University General Education, The Chinese U of Hong Kong, 2016, pp. 159–176.

"Pythagoras of Samos." *The Story of Mathematics*, www.storyofmathematics.com/greek_pythagoras.html. Accessed 12 May 2020.

Sivin Nathan. "Why the Scientific Revolution Did Not Take Place in China—or Didn't It?", 1982. Rpt. in *In Dialogue with Nature: Textbook for General Education Foundation Programme*. Edited by Chi-wang Chan, Wai-man Szeto, and Wing-hung Wong. Rev. 2nd ed., Office of University General Education, The Chinese U of Hong Kong, 2016, pp. 217–242.

Watson, James Dewey. *DNA: The Secret of Life*, 2003. Rpt. in *In Dialogue with Nature: Textbook for General Education Foundation Programme*. Edited by Chi-wang Chan, Wai-man Szeto, and Wing-hung Wong. Rev. 2nd ed., Office of University General Education, The Chinese U of Hong Kong, 2016, pp. 97–140.

* * * * * * * * * *

Teacher's comment:

Ziling made a brilliant choice of Bach to demonstrate the similarities between the beauty of science and that of music, highly convincing and sentimentally beautiful. She grabs the essence of scientific beauty, namely, the harmony, simplicity, vastness and the rationality lying behind, further elaborates the fact that it is not so different from artistic beauty as it first appears. For me as a teacher, it also provides an opportunity of learning, to know more about classic music which I am not familiar with. (WU Jun Vivian)