

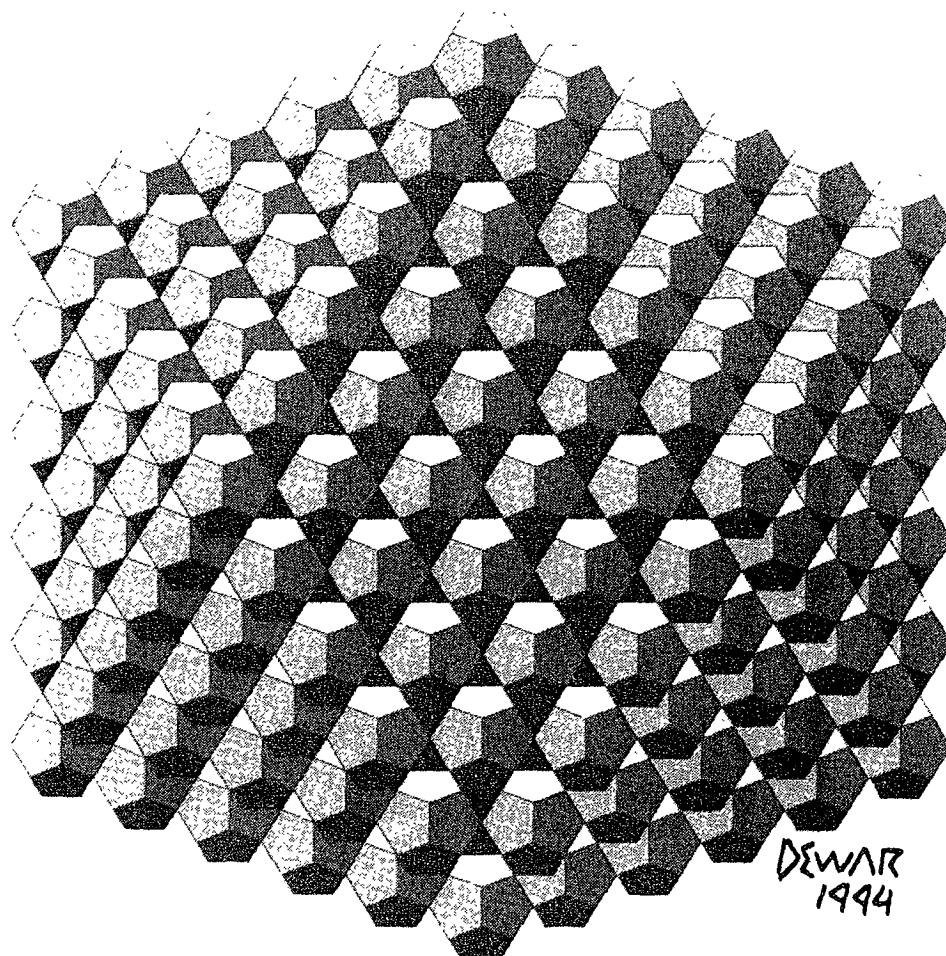
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THE GOLDEN SECTION:
A NATURAL BALANCE BETWEEN SYMMETRY AND ASYMMETRY?

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The *golden section* is that division of a line segment into two unequal parts such that the shorter portion a is to the longer portion b as the longer portion b is to the whole $a + b$.



That is, $a/b = b/(a + b)$. The value of the common ratio is $(\sqrt{5} - 1)/2 \approx 0.618$. At an age in excess of 24 centuries, the golden section has become the subject of modern debate. Some hold that it represents a natural and ideal balance between perfect symmetry and extreme asymmetry, akin to, if not identical with, the Golden Mean of Greek philosophy. In this paper, we will discuss this idea as it relates to music, human perception (in particular, the preferences people have for proportion in what they see and hear), and the way people judge each other. I will offer an analysis of some musical works and also some new data on human perception of proportion.

The golden section relationship appears in nature in various forms. It can be found in the star fish and in five-petaled flowers. Via the related Fibonacci sequence, the golden section appears in the spiral patterns of the florets in sunflowers, pine cones and pineapples, and in phyllotaxis—the arrangement of leaves along the stems of plants (Ghyka, 1949, pp. 98, 113–114; Hambidge, 1959, pp. 3–14; Sinnott, 1960, pp. 150–169). Some would say that it is also present in the graceful spiral of the chambered nautilus and in the proportions of the human form, though an entertaining study at Middlebury College (Calise *et al.*, 1992) would suggest otherwise.

Perhaps it is because the golden section is in some sense natural, that artists, architects, and composers have often been influenced by it (Hedian, 1976). And perhaps this is to be expected, even when not deliberate, insofar as art imitates nature. Le Corbusier (1961) constructed his rubric, *Le Modulor*, around the golden section. Some have thought that

Leonardo da Vinci incorporated the golden section into his work and that the facade of the Greek Parthenon has golden section proportions, though George Markowsky (1992) offers a well-argued counterpoint. Musical works by Bartók (Lendvai, 1971) and Debussy (Howat, 1983) exhibit golden section proportions. Mozart's sonatas for piano seem to be divided remarkably near to the golden section as well and, given Mozart's love of numbers, there may be good reason for this. I will show some fairly compelling data which I have collected on these sonatas and analyze it in two different ways—one more convincing (but less valid, I will argue) than the other. I will have some comments about the correct way to go about this kind of research.

Some studies indicate that people may tend to choose the golden section as a balance between perfect symmetry and extreme asymmetry. The *golden section hypothesis* holds that the golden section offers the most aesthetically pleasing proportion (Plug, 1980, p. 468) and more generally that, whenever people divide a whole into two unequal portions, they tend to make the division near the golden section (Benjafield & Adams-Webber, 1976, p. 12). The first empirical investigation of this hypothesis was the work of Gustav Fechner (1876) who asked subjects to choose their favorite among ten rectangles of equal area but various proportions, including the rectangle with golden section proportions, the *golden rectangle*. Fechner's subjects preferred the golden rectangle most often, and the rectangles nearest to that shape were ranked second and third. Thompson (1946) tested preschoolers, third-graders, sixth-graders, and college students and observed that college-aged subjects preferred rectangles with ratio 0.55, and that children's preferences became increasingly similar to this with increasing age. Nienstedt and Ross (1951) tested college students and aged subjects using four series of rectangles: two with constant length, and two with constant area. Their results indicated that college students preferred the ratio 0.65, and that aged subjects were remarkably similar to Thompson's sixth-graders, preferring rectangles near the square, the rectangle representing perfect symmetry. Borissavliévitch (1958, pp. 38–39) suggested that preference for the golden section was due to the shape of the binocular field of vision rather than to an aesthetic balance of symmetry and asymmetry, but subsequent studies have not supported this hypothesis (Hintz and Nelson, 1970).

In a cross-cultural study, Berlyne (1970) showed that aesthetic preference for rectangles differed between Eastern and Western cultures. Using constant-length rectangles with Fechner's ten ratios, he found that Japanese subjects preferred rectangles near the square (symmetry), whereas Canadian subjects preferred more elongated ones (asymmetry).

The foregoing studies were subject to a fundamental limitation. Subjects were presented with a fixed range of choices which may or may not include a given subject's preferred rectangle. Other experimenters have attempted to avoid this by asking their subjects to draw the rectangle which they find the most pleasing. While better, this method is still subject to bias in that the subjects drew on paper which was itself a rectangle. I will share the unpublished results of a recent experiment which attempts to avoid these problems. The present study involves the use of computer graphics software. Subjects sat in a dark room and manipulated a computer mouse to generate a rectangle of any size and shape. The goal was to enable subjects to create a white rectangle, whose dimensions they could vary at will, against a borderless field of black. The data do not support the golden section hypothesis. I will also share some new data collected in a related experiment on the proportions people prefer in what they hear.

There is also evidence that people tend to categorize others asymmetrically into one of two groups. Some studies have indicated that when people evaluate themselves and others on a bipolar criterion, they tend to separate people into two groups in golden section proportion. For example, Benjafield and Adams-Webber (1976) analyzed data collected when subjects were asked to categorize their acquaintances according to positive/negative characteristics such as bold/timid and energetic/lethargic. They found that the proportion of those positively categorized was near the golden section. I will comment on the validity of using this particular ratio in such research.

References

- Benjafield, J., & Adams-Webber, J. (1976). The golden section hypothesis. *British Journal of Psychology*, 67, 11–15.

- Berlyne, D. E. (1970). The golden section and hedonic judgments of rectangles: A cross-cultural study. *Sciences de l'Art/Scientific Aesthetics*, 7, 1–6.
- Calise, L. K., Caruso, T. M., Cunningham, J. B., & Sommers, P. M. (1992). The golden middle. *Journal of Recreational Mathematics*, 24, 26–29.
- Fechner, G. T. (1876). *Vorschule der aesthetik*. Leipzig: Breitkopf & Härtel.
- Ghyka, M. (1949). The Pythagorean and Platonic scientific criterion of the beautiful in classical western art, in *Ideological Differences and World Order: Studies in the Philosophy and Science of the World's Cultures*, edited by F. S. C. Northrop. New Haven: Yale University Press.
- Hambidge, J. (1959). *The Elements of Dynamic Symmetry*. New Haven: Yale University Press.
- Hedian, H. (1976). The golden section and the artist. *Fibonacci Quarterly*, 14, 406–418.
- Hintz, J. M., & Nelson, T. M. (1970). Golden section: Reassessment of the perimetric hypothesis. *American Journal of Psychology*, 83, 126–129.
- Howat, R. (1983). *Debussy in Proportion: A Musical Analysis*. Cambridge: Cambridge University Press.
- Le Corbusier. (1961). Le modulator, in *Le Corbusier, Œuvre Complète 1946–1952*, 3rd ed. Zurich: Editions Girsberger.
- Lendvai, E. (1971). *Béla Bartók: An Analysis of His Music*. London: Kahn & Averill.
- Markowsky, G. (1992). Misconceptions about the golden ratio. *College Mathematics Journal*, 23, 2–19.
- Nienstedt, C. W., Jr. & Ross, S. (1951). Preferences for rectangular proportions in college students and the aged. *Journal of Genetic Psychology*, 78, 153–158.
- Plug, C. (1980). The golden section hypothesis. *American Journal of Psychology*, 93, 467–487.
- Sinnott, E. W. (1960). *Plant Morphogenesis*. New York: McGraw-Hill.
- Thompson, G. G. (1946). The effect of chronological age on aesthetic preferences for rectangles of different proportions. *Journal of Experimental Psychology*, 36, 50–58.