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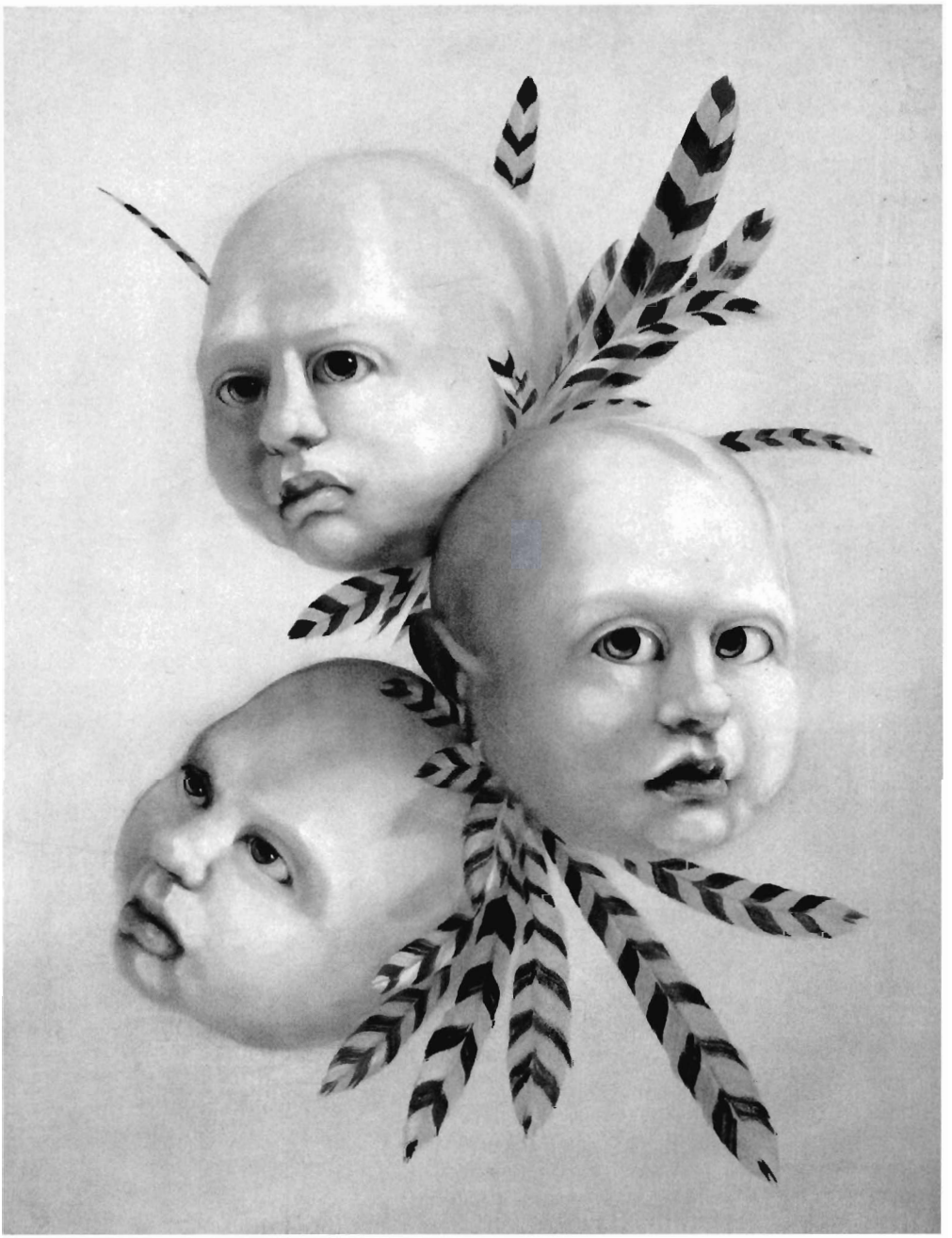

On the "Golden Section"

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Abstract

The "golden section" ($\phi' \cong 0.618...$) is a proportion that in various geometric, arithmetic, biological, and artistic contexts has fascinated, for 2,600 years, some of the finest minds in European philosophy, sciences, and the arts. It has been called "divine" and the epitome of beauty. An overview of the author's large-scale experimental and archival investigations (1995-2001) of the significance of ϕ' in the structure and composition of Western paintings is presented in this article. The main conclusions are: (a) the use of the golden section in Western art is elusive and subtle, but detectable, and its purpose often seems to be the introduction of an optimal degree of tension; (b) there appears to be a marked nonlinearity and contextuality of its application; and (c) one of the implications of such highly contextual treatment of the golden section in Western art is that the differences between Western and some non-Western aesthetic ideals—notably Far-Eastern—may have been needlessly exaggerated in numerous accounts.

The golden section (GS; $\phi' \cong 0.618...$; ϕ is for Phidias) is a proportion that in various geometric, arithmetic, biomorphological, and artistic contexts has fascinated, for some 2,600 years, some of the finest minds in European philosophy, science, and the arts. It has been called "divine" (by the astronomer Johannes Kepler) and considered the epitome of beauty by many influential others, including the father of (philosophical) aesthetics A. G. Baumgarten (1750-1758/1961) and A. Zeising, who studied it in greater detail a century later (1854, 1855, 1884-*posthum.*). In the 20th century, Borissavlievitch (1952), among others, has discussed the pervasive role of the GS in aesthetic theory, Huntley (1970) has used it as a major example of aesthetics in mathematics, Bouleau (1962) has analyzed it as one of the keys to Western painters' "secret geometry", and Le Corbusier (1951) has made the GS the building block of his *Modulor*—the proposal for a fusion of the functional and the aesthetic in architecture.

However, it was the Leipzig scientist Gustav Fechner who performed the first experiments regarding the GS in his seminal work on ordinary people's preferences for rectangles of various dimensions (1871; 1876). Important as these experiments were in representing the beginning of modern *empirical* aesthetics (the so-called "aesthetics from below", based on research data, and in opposition to Kant's aesthetics), they paradoxically proved to be, in several important respects, *too* influential.

Countless researchers, mostly psychologists, have since attempted to examine the significance of the golden section more or less rigorously (for recent extensive reviews, see Green, 1995 and Höge, 1995; the former article also contains a good introduction to the basic mathematics of the GS). The main problem is that much of this research has been far too restricted: (a) to non-artistic stimuli (especially rectangles and a few ellipses); (b) to objects presented without an aesthetic context; and (c) to non-artists as research participants—mostly students who had not had even a modicum of training or conoisseurship in the arts (a possible confusion of "aesthetics from below" with "subjects from below").

Such research limitations can perhaps be traced to modern scientific psychology's frequent and rather naïve adherence to the model of 18th-century physics and the equally quaint belief that the GS is a concept so broad and powerful that it can be

captured with almost any stimuli, setting, and type of subject. For these and various other methodological and substantive reasons, the results appeared inconclusive: When an entire issue of a major journal of empirical aesthetics was devoted not long ago to the golden section (*Empirical Studies of the Arts, 1997, 15,* No. 2), that seemed to be the consensus. This state of affairs motivated the initiation of the author's broad research program.

A Multipronged Program of Research

This author's six-year research program on the golden section can be divided into four related parts. The first of these attempted to aestheticize and contextualize the GS. However, in this work—perhaps unfortunately, with hindsight—the tradition of using undergraduate psychology students as research participants was continued.

The Vase on the Mantelpiece: The Golden Section in Context

In three classroom and laboratory experiments (Konečni, 1997), using a total of some 260 undergraduate research participants (mostly psychology students), the GS was investigated, for comparative reasons, by means of both traditional research tasks (line bi-section, production of rectangles), and novel stimuli (contours and cutouts of vases constructed by the GS and non-GS rules) and tasks (the placement of "vases" on both an imaginary and a laboratory, purpose-built, mantelpiece).

Several conclusions could be reached. First, using traditional tasks and stimuli, the GS did not emerge as a notable proportion. Second, there were many complex, but interpretable statistical interactions involving the type of stimuli, type of task, and type of research setting—the lesson here being that the demonstrable neglect of methodological and conceptual details makes the lack of replicability of much prior research on the GS hardly surprising. Third, the use of the GS in quasi-aesthetic objects (contours and cutouts of vases) produced no advantage of their placement on the GS points of either the entirely imaginary or the almost-real (laboratory-built) mantelpieces: Yet the subjects' consistent, overwhelming use of *balance* principles for vase contours and cutouts—the bigger the vase, the closer to the center of the mantelpiece it was placed, on both the imaginary and "real" mantelpieces—shows that they took the task very seriously indeed. Fourth, when subjects were asked to choose one from among 11 simultaneously presented "vases", five from the GS, and six from the non-GS series (but with other interesting proportions, such as 0.50, 0.67, and 0.75 also present), almost 50% of the respondents chose the same vase. Although this particular vase was from the GS series, there was no overall preference for the GS-series vases.

What do these experiments disclose about the GS? The two judgment situations in which the respective subjects whose responses were summarized above found themselves ought first to be examined in some detail. In one of these, the subjects arrive to the laboratory one by one. At one end of a large room, there is a realistic-looking mantelpiece with the non-existent fireplace covered by a piece of canvass. From a table at the other end of the room, 11 vases—all bottom-heavy, but of either GS or non-GS proportions—are handed to the subject one by one, in a random order. The task is to consider the vase as precious—Etrurian, Greek, Ming—and the "fireplace" as the focal place of one's home. The exact placement of the vase on the mantelpiece, it is patiently explained, will become a salient visual element of daily living in one's home, as well as an issue of pride with regard to respected visitors.

What the subjects do in this situation is extremely orderly: The bigger the vase (regardless of its GS or non-GS proportions), the closer to the center of the mantelpiece it is placed on the average. The smaller the vase is, the greater the variability. Thus, whereas the placement distributions of each of the 11 vases have their respective

means at mantelpiece midpoints, the dispersion of the vase placement is inversely related to vase size. The GS does not matter, balance does. The perception of a big vase close to the end of the mantelpiece is uncomfortable—*the basis will tip!* —even if the vase is a cutout and the mantelpiece made of solid wood.

In the second situation, the subjects—in a group, but making the ratings individually—looked at all 11 "vases" simultaneously, with no mention of placement or mantelpiece, but with the instruction that they should imagine that all the vases were of extreme beauty and value and that they could take the chosen one with them. Almost 50% of the research participants chose the same vase—which had GS proportions—although the GS vases were not generally preferred; the most chosen vase was not the biggest, so that the idea that the bigger the vase the better can be discarded.

Evidently, for the significance of the GS to be demonstrated, it is not sufficient that the stimuli are somewhat aestheticized and somewhat contextualized. These half-steps cannot offset the disadvantage of the GS when it is pitted against a truly powerful aesthetic need, such as that for balance, at least not when people untrained in the arts are used as subjects. Yet one of the vases from the GS series was the overwhelming favorite of these very subjects. The GS may be important, but only in conjunction with several other factors, as a part of higher-order interactions. These ideas were explored in the next step of the research program, with practicing painters as subjects.

Painters' Differential Accuracy in Capturing the GS and Other Proportions

In another experiment (Konečni, 2003), the relative significance of the golden section was investigated using a new—unobtrusive—methodology, a modified Fechnerian "method of production."

Fourteen professional painters sketched under controlled laboratory conditions—with instructions to do so "veridically, accurately, and realistically"—27 complex stimuli presented as slides. The stimuli were: Four of the vases used in the experiments that were described in the preceding section (two of which were from the GS series, including the most favorite vase, and two from the non-GS series), each of which had been photographed in color at four points of the mantelpiece (0.50, 0.62, 0.70 = "control," 0.75), for a total of 16 vase stimuli; seven stimuli were color slides of original abstract and semi-abstract paintings by Robert Kodama, a young and relatively unknown San Diego painter (who had incorporated the GS and other proportions into his paintings both prior to having a formal knowledge of the concept and intentionally, after learning about it); finally, four stimuli were color slides of well-known paintings by Piet Mondria(a)n and James Whistler (two each; no writings by and about Whistler emphasize proportions or the golden section; the opposite is the case for Mondrian).

The golden section and other significant and control proportions (120 occurrences: 48, collectively, in the vases; 30 in the seven Kodamas; 42 in the four Mondrians and Whistlers) were identified beforehand in the stimuli. The 378 sketches produced by the 14 painters were measured to determine the accuracy with which the various proportions (a grand total of 1680 instances) had been reproduced by them. Hypotheses were derived from psychological notions concerning attention, cognitive processing, and the "prestige effect" (e.g., Francès, 1976), and, especially, from extensive interviews with professional painters (other than those used as subjects), who were treated as *research informants* —in the sense that this term is used in anthropology. It was predicted that the sketching accuracy would depend on the amount of attention devoted to the stimuli and that the painters would experience more of a respect-induced and welcome challenge when confronted with authentic paintings—especially by well-known painters—in comparison to the vase stimuli. It

was also expected that the GS would be *differentially* more accurately sketched than would other proportions when the stimuli were famous paintings, rather than vases and works by Kodama. Finally, the greatest accuracy of sketching and the greatest advantage of the GS was predicted to occur for the two works by Mondrian, because of the respect he commands and the welcome challenge he would pose as a supreme modern master of the proportions (including the GS) and the relational details of geometric forms.

The overall accuracy in rendering the vase-stimuli proportions was relatively low, 20%. In part because the vase-placement proportions at 0.50 and 0.75 were rendered somewhat more accurately than the structural proportions of the vases themselves, the vase overwhelmingly preferred in the earlier research, and thus the golden sections in general, had no advantage in the accuracy of being rendered for these stimuli.

The overall accuracy for the seven Kodama paintings was almost as low, 22%. However, the Kodama golden sections were rendered significantly more accurately than was the case for the vases (26% vs. 18%), although 1.00, in its rare two occurrences (as three sides of a square and a circle), was rendered even more accurately than the GS within the Kodama stimuli.

Significantly higher overall accuracy than for the vases and the Kodamas was observed for the four Mondrians and Whistlers collectively, 42%. Furthermore, with regard to these works, whereas the accuracy for other proportions was in the 28% to 43% range, that for the GS (61%) and 1.00 (57%) was considerably higher; and for each of the four paintings, the GS was the most veridically rendered proportion, followed closely by 1.00. However, the Mondrians did not significantly differ from the Whistlers in the accuracy with which either the GS or 1.00 was rendered.

The relatively high accuracy of rendering proportions in general essentially validated the new research method that was developed for this study. The overall accuracy increased considerably from the vases and Kodamas to the Mondrians and Whistlers. The GS and 1.00 were rendered more accurately than other proportions for all the paintings (as opposed to vases), but this differential effect was especially pronounced in the Mondrians and Whistlers. Very high—71%—accuracy, was observed for the golden sections in one Whistler and one Mondrian; the highest accuracy of rendering 1.00 was 66% in that same Mondrian. Extensive exit interviews with the 14 participating painters revealed that they had not found the request to sketch accurately odd and that they had been unaware throughout that the GS was the special object of investigation, hence the methodology deserves being called "unobtrusive" or "nonreactive" (Webb, Campbell, Schwartz, and Sechrest, 1966).

Most of the predictions thus proved to be correct. That the 0.62 and 1.00 depicted by a painter famous for masterful geometricity were not rendered more accurately than those presented by Whistler is somewhat surprising, but not essential. In addition, since the square and the circle are considered in aesthetics and the Gestalt perception theory as perfect and strong forms (e.g., Arnheim, 1974; Koffka, 1935), the very accurate rendering of 1.00 in the paintings certainly does not decrease the significance of the GS.

The present results show that the GS is considerably more important than one would have concluded on the basis of the research with vases and psychology undergraduates: It is subtle, but its elusiveness can be considerably decreased by using authentic, first-rate paintings as research stimuli, professional painters as both methodological informants and research participants, and an appropriate new methodology with which to tease out unobtrusively such subjects' selective viewing of, and responding to, the different critical proportions.

The GS in the Structure of 20th-Century Paintings

The 20th century is of particular interest with regard to the GS because it is con-

spicuous, on one hand, for the rejection of traditional learning and ideas, and, on the other, for geometricity and abstraction. The next step in the author's research program (Konečni, 1999; 2001) was to ask whether or not the GS was used in the structure of 20th-century paintings and, if so, in which way; also, it was of interest to find out which other proportions were typically represented in the works which contained the golden section(s).

The intention of this research obviously was not to obtain the accurate incidence and prevalence values (in epidemiological terms) of the GS in the total population of 20th-century paintings (an impossible task of induction) or even in a genuine random sample (because various insurmountable logistical problems precluded such sampling). Rather, the goal was, first, to derive from a larger pool of paintings a sizable sample (of about 100 paintings), in which each one would contain at least one GS. Second, these paintings were to be closely scrutinized with regard to the GS and other significant proportions (such as 0.50, 0.67, 0.75, 1.00).

An initial pool of 250 paintings was sufficient for the detection of 95 paintings, each of which contained at least one GS (by the four criteria listed below)—which by itself is roughly informative about the incidence of the golden section in 20th-century paintings. The 95 works in the final sample were by 52 painters and all the decades of the 20th-century were represented to some extent.

In most paintings, including abstract ones, one can usually identify in their content many relationships that can be expressed as proportions. In this research, only the major and prominent structural and compositional elements, on which there was general agreement among the author, art authorities, and colleagues, were selected for measurement. The following elements were measured in each of the 95 paintings, with the measurements described under (b), (c), and (d) representing the new substantive contribution of the present study to the GS literature:

(a) Overall dimensions of the painting ("picture size");

(b) Vertical bi-section of the painting, which addressed the issue of left-right balance or the horizontal distribution of perceptual weights;

(c) Horizontal bi-section of the painting, which addressed top-bottom balance or the vertical distribution of weights;

(d) In addition to the proportions obtained by line bi-section, as in (b) and (c) above, various proportions, including the golden section, were identified and measured in various geometric shapes that may occur in paintings either as pure forms (e.g., the "golden rectangle," where a/b = 0.62) or incorporated in the forms of the depicted objects; therefore, the facial and bodily proportions of the key human figures were identified and measured, as well as the dimensions of the various structurally prominent objects, such as houses, bridges, windows, crosses, vases, etc.; in addition, the major compositional relationships, including the spatial arrangement of color (for example, in "color-field" paintings), were identified and measured.

Picture size. The results of the various types of measurement were interesting and instructive. With regard to *picture size* (expressed as the ratio of the shorter to the longer dimension), which was used only for auxiliary purposes in this research, the findings were in close agreement with some much larger samples (e.g., Fechner, 1876; Shortess, Clarke, & Shannon, 1997) in terms of both the relative scarcity of the GS and the relatively high incidence of 0.75 —which should increase the confidence in the quasi-random sampling procedure by which the initial pool of 250 works was obtained.

Symmetry and balance. Before turning to the results of the measurement of the vertical bi-section (the point on the horizontal side of the painting where the vertical axis intersected it was expressed as the ratio of the longer section to the entire width of the painting), a comment about symmetry and balance is in order. Mirror-image symmetry with regard to a vertical

line that intersects the width of the painting at midpoint (0.50 in the present research, but 1.00 if the ratio of one of the two sections to the other is the unit of analysis) gradually began to disappear from Western painting some 650 years ago. It was replaced by balance, or the harmonious left-right distribution of perceptual weights—but with reference to an identically (centrally) placed vertical axis.

What art judgment tests and psychoaestheticians alike mean by imbalance is the situation where the weights within a picture deviate from a harmonious distribution around the central vertical axis. However, note that almost every painting thus unbalanced can in fact be considered balanced, but with reference to an imaginary vertical axis that is shifted from the center. The present research was concerned with the existence and the degree of such shifts. Specifically, when an artist, consciously or not, chooses to break the norm—presumably consisting of the central placement of the vertically bi-secting line—where does that artist shift laterally and why?

Vertical bi-section. For 63 of the 95 paintings in the sample, the vertical bi-section was found to be exactly at midpoint or in the 0.501-0.545 region. Thus, even in the 20th century, at least as it is represented in this sample, 66% of the paintings are balanced with regard to a centrally placed vertical axis and thus intuitively follow a traditional prescription.

Of the remaining 32 paintings, in 10 works the vertical axis was shifted from the center to the 0.546-0.595 region; however, in 22 works—an impressive 23% of the sample and 69% of the non-center subsample—the shift was to the GS (the 0.596-0.645 region). The shift of the vertical axis from the midpoint does not taper off, but rather a jump is made from the center to the golden section via a relatively little-used fuzzy region in-between. And it is noteworthy that none of the 95 paintings had the vertically bi-secting line shifted to beyond the GS region.

Consciously or not, artists who avoided the (boring?) centrally placed vertical bi-section, also avoided the (fuzzy and thus annoying?) adjoining region of the perceptible, but too small a shift from the central axis. The golden section may be the just-right region between the midpoint and two-thirds, in part because its legendary mathematical appeal gives it an intriguing advantage over, say, the nondescript 0.59, whereas a left-right imbalance greater than a vertical axis in the GS region is unacceptable to artists, at least in this sample.

Horizontal bi-section. Balance with regard to a horizontal axis has been far less discussed, mostly because the top-bottom mirror symmetry has been so very rare even early in Western art (cf. Bouleau, 1963). But this type of balance, specifically in terms of a centrally positioned horizontal axis, certainly was quite common in the 15th- and 16th-Century Italian, Flemish, and Spanish religious art. Painters tended to fill up the canvas, typically with the bottom part being taken by earth-bound doings of interest to the Roman Church, with the top reserved for the godly, angelic, and saintly presences. A good example is El Greco's stupendous *The Burial of Count Orgaz* (1586), a painting of irregular shape, but the horizontal axis of which can reasonably be estimated to intersect the height at 0.55 (the longer, top, section divided by the entire height, which was the procedure for computing the horizontal bi-section in the present research).

Even without statistical evidence, one could vouch that in the later centuries the top part became even longer—mostly by virtue of the painters relieving the sky or the ceiling of heavenly weight. Already in Velasquez's *Las Meninas* (1656), within—by the present sample's standard—a very rare ratio of overall dimensions of 0.87 (317.50 × 275.60), the ratio analogous to that computed for *Count Orgaz* can be estimated at 0.63 (close to the lower golden section).

One could have reasonably expected the 20th-century "sky" to fill up, starting with the Cubists, and continuing with the various forms of abstraction, thus bringing the ratio close to 0.50. Indeed, in the present

research, 62 of the 95 paintings were found to have the horizontal axis at 0.50 and another eight in the 0.501-0.545 region. At least in the present sample, there is a very considerable degree (74%) of safe top-bottom balance with regard to a centrally placed horizontal axis. For the majority of the painters represented in the sample, the top-bottom direction seems to have been a somewhat less attractive one for the purpose of experimentation with balance than was the left-right direction; the former may be perceptually or aesthetically a less hospitable medium.

The remaining 25 paintings were almost equally divided between the regions of 0.546-0.595 (13 paintings) and 0.596-0.645 (the golden-section region with 12 paintings, all within the range of 0.60-0.63, five at 0.62). Thus, for none of the 95 paintings did the ratio of the longer part to the entire height, resulting from the horizontal bi-section, exceed 0.63: The GS region was again the limit of the off-center balancing experimentation.

Vertical and horizontal bi-sections considered jointly. When the vertical and horizontal bi-sections are considered jointly, over half of the paintings in the sample (49) are found in the cell defined by both bi-sections being at, or very close, to 0.50. However, the pattern of shifts away from the double central balance is highly instructive. The most interesting cell is undoubtedly the one with the paintings (seven) displaying the greatest displacement from both central axes, that is, those shifted into the GS region with regard to both types of bi-section (see Table 2, p. 35, in Konečni, 2001).

Without judging other attributes of these paintings, perhaps only one strikes this author as having a dubious composition. In all the other cases, the double displacement to the GS region is effectively used to maximize both interest and focus on the desired feature(s). The key structural and thematic attributes would have been boring or awkward had they been more centrally placed with regard to either axis. These painters sought the viewer's interest more than pleasure.

Proportions within paintings. Finally, one can examine the results of the measurement of the various proportions within paintings (note that the summary results below exclude picture size and both bi-sections). Although the method of selection must have contributed to the fact that the GS was used 254 times within these 88 paintings (no occurrences within seven works), or 2.89 per painting, this high number testifies to the popularity of the use of the GS in the structural, compositional, and thematic elements of numerous 20th-century works. Furthermore, the variety of styles and decades in which such heavy use occurred is impressive. The most frequent appearance of the GS (over five per painting) was in six works in which geometric patterns were used repetitively. Given that these canvases are entirely filled up by patterns, it is not surprising that 11 of 12 vertical and horizontal bi-sections of these six works were in the 0.50 region.

Other proportions were used in the key structural elements to some extent (1.57 per painting) in those, seven, works in which the GS did not appear—and considerably less than that in the paintings in which the GS made a moderate appearance (one, two, and three occurrences). It was only in paintings with four and more occurrences of the GS that the average use of other proportions equals and then substantially exceeds that in the seven paintings without a structural GS.

So, two tendencies seem to be at work. One is to avoid the GS altogether and use other proportions (these seven paintings were included in the sample because of the ratio of the overall dimensions or because of one of the bi-sections). The other is a preference for geometricity that is reflected in the clear trend that as the use of the GS increases in frequency so does that of the other proportions.

The total number of occurrences of non-golden-section proportions in the 95 paintings was 122 (1.28 per painting), of which over one half (63, or 52%) were 1.00 and 0.67. The ratio of 1.00 was especially frequently used— in squares, partial squares,

implied perpendicular diameters of circles, the shapes of regions around key figures, and within various depicted objects. This finding confirms 0.62 and 1.00 as serious rivals (Konečni, 2003).

The "Golden Woman": Western Art and Evolution

In ancient Greece, the GS emerged in art and aesthetics in part through the depiction of the human facial and bodily proportions. Measurement of the GS in the human body was also a research focus of Zeising (1854) and a great interest of Le Corbusier (1954; cf. Arnheim, 1966). For such reasons, a separate study (Konečni & Cline, 2001) was conducted on all the paintings—24—in the previously described sample of 95 that contained female figures (a total of 28 figures).

The woman (including the nude) is, of course, one of the major themes of Western painting. From a socio-biological perspective, the pictorial representations of women are of interest in that they may intuitively summarize, in the work of some very talented artists, the accumulated beliefs regarding the relationship of the female bodily proportions and "reproductive fitness"—perhaps mediated by attributes such as age, health, and attractiveness (e.g., Buss, 1994; Cunningham, 1986; Gangestad & Thornhill, 1997; Johnston, 2000; Jones, 1995; Katz, 1999; Singh, 1993).

Two additional facial and two bodily measurements were made on each of these female figures (where this was feasible); furthermore, a sample of 81 research participants (of whom 50 were women) assessed the age and physical attractiveness of the painted figures.

When the painters depicted young female figures, they tended also to impart a considerable physical attractiveness to them. The most attractive figures differed from the rest of the sample in three of the four proportions that were measured in this study. Although one might perhaps be able to identify other proportions that would distinguish the most attractive members of the sample from the older and less attractive young members, it is notable that two of the three distinguishing proportions—the "facial cross" (the ratio of the distance between the cheekbones to face length) and the body bi-section at the navel—are golden sections that have been an important part of the classical ideas of youth, health, fertility, and beauty, and used as such in Greek statues (see Konečni, 1991, regarding this issue in portraiture).

Two thousand years later, painters in the sample (16, mostly European, men), despite working in a variety of styles, collectively continued to give life to these ideas through their use of female proportions. The fact that their meaning was correctly communicated many decades later to young Californian viewers of both sexes, mostly unschooled in the arts, testifies to their being an aspect of accumulated human beliefs—or, may one say, wisdom?

Conclusions and Implications

In this final part of the paper, there are three sections: (a) a summary of the findings; (b) contextuality of the GS; and (c) implications of the findings for comparisons of Western and Far-Eastern art.

A Summary of the Findings

In line bi-section, the GS is a source of tension, a perceptual pull away from the center. This tension is not tolerated in vase placement on a mantelpiece, at least not for large vases and by non-artists. In modern paintings, however, the bi-secting point of the horizontal dimension is placed at the GS fairly often, perhaps to avoid the predictability of central placement and introduce the novelty of a noticeable, but not too big, lateral shift. Interest, rather than tedious comfort, is presumably sought. In the bi-section of the vertical dimension of paintings, the GS placement is more rare, but in terms of the bi-section of the female figure at the navel, the GS is the ideal that

is captured in paintings and highly evaluated by ordinary viewers.

With regard to the use of the GS in cross shapes, the precise context is again paramount. The golden facial cross appears to be a key aspect of female attractiveness and is implicitly recognized as such by both painters and ordinary viewers. A vase containing an inverted golden cross was the most preferred, but that was not true for other, both bigger and smaller, vases built on the basis of analogous golden crosses.

Context also seems to govern the use of golden rectangles, as well as the compositional, structural, and color features *within* paintings. In works characterized by geometricity, the copious use of the GS is often accompanied by an increased use of other significant proportions, especially 1.00. Again, it can be rather safely assumed that the juxtapositions of golden rectangles and ellipses with squares and circles (e.g., in a Mondrian, Kandinsky, or Klee) are meant to introduce interest, complexity, and the desirable amount of tension.

These results, taken together, suggest that the traditional elusiveness of the golden section can be attributed to its subtle, contextual use by both artists and nature (for example, in the human body); perhaps in order to have impact, it is used sparingly—but it is detectable by means of an analytically and methodologically careful inquiry.

Contextuality of the Golden Section

The term "contextuality" is used here to refer to the findings that the GS is not operative as a potent single factor (a "significant main effect, with no significant interactions," in the language of the analysis of variance), but rather as a factor modulated by the context in which it is placed, that is, by the presence of multiple other factors in the artwork and the situation (a main effect that is qualified by its "higher-order interactions" with other factors). It is possible that the legendary status and mathematical appeal of this "epitome of beauty" misdirected many empirical psychoaestheticians into a somewhat simplistic, and therefore disappointing, search for the GS as a ubiquitous and powerful single factor.

Either because the idea of parsimony (taught in the philosophy of science to be a good feature of theories) is misunderstood, or because of experimental and conceptual myopia, the tendency to seek single-factor explanations of a phenomenon is frequently encountered in psychoaesthetics and psychology in general. A recent illustrative example can be found in the kin area of creativity research. Following the appearance in the *American Psychologist* of a special section on creativity (Sternberg & Dess, 2001), a number of commentaries from creativity experts were subsequently published and most of these sought to explain creativity by a single attribute (such as curiosity, self-confidence, etc.). Only Raven (2002) offered a complex multi-factor account. What is noteworthy is that Sternberg (2002), in responding to these comments, and having described Raven's contextualist position with apparent care, then proceeded to offer a single, "key attribute" of his own—"the decision to be creative." Yet it is immediately obvious that such a decision must be both preceded and followed by Raven's complex factorial constellations and is simply another component in a long process—a component which itself requires a multi-factor explanation.

Invoking single-factor explanations for complex phenomena may well be a general human tendency, the quasi-causal discourse of choice in both everyday life and literary narrative. In the autobiographical story "Fate" by the Chinese writer Jin Shui (*nom de plume* of Shi Tie-sheng, born in Beijing in 1951), the main protagonist becomes a writer only after an accident has left him paraplegic and dashed his dreams of worldly travels. When someone later asks the protagonist how he "happened to take the road to creativity," he responds: "Having reached an utter dead end, I sank to this level."

Western 0.618... as Eastern "Profound Subtlety?"

The golden section is one of the concepts with a remarkable pedigree in Western culture and art. Precisely for this reason, one can venture the supposition that had the GS been more appropriately investigated by empirical aestheticians, the results might have discouraged or muted some of the recent misguided descriptions of Western art (to go with the allegedly prevalent Western "epistemological types" and "mindscape types") as "linear," "hierarchical," "one-truth," and "homogeneous" —attributes which are then contrasted with those of the Far-Eastern art and aesthetics, such as, to give just one example, Zeami Motokiyo's 14th/15th-century *yûgen* (e.g., Deutsch, 1975; Maruyama, 1991, 1992; Maruyama, Farkas, & Capron, 1994; Servomaa, 1997).

The contextuality and configurality of the applications of the GS, which have been revealed in the present research, contradict such "post-modern" views of Western art to a considerable extent. The criticisms turn out essentially to be misdirected: They seem more pertinent to the naively optimistic, positivist methods by which the GS had traditionally been investigated than to the details of the aesthetic contexts in which it has actually been placed and found. Thus it may be Western scientists of the antiquated positivist persuasion who deserve the attributes "linear" and "one-truth," rather than Western art and artists.

In any case, it is a reasonable assumption that the misguided characterizations of Western art as linear, rather than contextual, have contributed to the exaggeration of the differences between Western and Far-Eastern art and aesthetics. As noted above, both Far-Eastern and Western otherwise serious scholars have provided exaggerated accounts of the differences. There are rather obvious sociology-of-scholarship and even cultural-anthropology-of-scholarship reasons for this tendency that could be invoked. And perhaps in addition to seeking single-factor explanations, humans—scholars included—have a cognitive need to form contrasts and classify phenomena into Type A and Type B. [Of course, there are unsystematic, light-hearted exaggerations of the differences between Western and, for example, Japanese art, such as Tanizaki's (1977) *In praise of shadows;* here, the comparisons are often facile to the point of becoming perverse.]

Less doctrinaire comparisons than those found in the post-modern deconstruction sources are numerous and have resisted the political, linguistic, and cultural temptations to exaggerate the differences (e.g., Bowie, 1911; Buhot, 1961/1967; Lee, 1994; Neuer, Libertson, & Yoshida, 1979; Terada, 1976). The hints and echoes of kinship are, in fact, many. Correspondences to the classical Western concepts of "unity-in-variety," dialectics, polarity, and symbiosis can be readily found in the *yin-yang* principles of the Tao (cf. Rowley, 1959). Echoes of Plato abound in Confucius and Liu Hsieh, of Epicurus in the Taoist Yang Chu (Munro, 1965). As he steps into the character, a Western Stanislavskian actor is guided by principles that appear very similar to the "living movement," *sei do,* or *kokoro mochi*—a key notion of Japanese painting, which, as described by Bowie (1911), urges the painter to experience the essence of the subject he is about to paint.

Perhaps most intriguingly, all seven attributes of Zen aesthetics that are described by Hisamatsu (1958/1971) in his distinguished *Zen and the Fine Arts,* including the fifth, the aforementioned *yûgen* ("profound subtlety"), are shared, in the author's opinion, by the GS. In its many mathematical, biomorphological, and artistic manifestations, the golden section is a marvel that implies *yûgen* just as the *karesansui* rock garden of the Ryôanji in Kyoto does so.

Endnote

A shorter version of this article (entitled "The 'Golden Section' as Aesthetic Idea and Empirical Fact") was presented at the

15th International Congress of Aesthetics, Tokyo, Japan, in August 2001, and is available on the Congress Proceedings CD-ROM *(The Great Book of Aesthetics)*. A Serbian translation of that version was published in the journal *Likovni život* (No. 97-98, 2002; Belgrade, Serbia); an Estonian translation appeared in the journal *Akadeemia* (No. 6, 2003; Tartu, Estonia). Please address correspondence to Vladimir J. Konečni, Department of Psychology, University of California, San Diego, La Jolla, California 92093-0109. E-mail: vkonecni@ucsd.edu

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