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# The importance of applying Fractal Principles to Compositional Strategies for the Static and Moving Image

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## Philosophy of Visual Grammar

In 2004, Peter Stebbing argued that there are universal grammatical principles of visual composition (Stebbing 2004, p. 68). The basis for his argument is that the principles of artistic composition are also principles in the organisation and biology of organic form. Based on his analysis of 50 art and design texts, Stebbing identified contrast, rhythm, balance and proportion (CRBP), along with harmony, as the key principles that correlate to natural form; in particular, self-organisation. His hypothesis is that:

> our aesthetic behaviour in creating and appreciating visual compositions has evolved (exapted) from our innate ability to recognize the diversity of organic forms through the basic organizing principles of Contrast, Rhythm (pattern), Balance (symmetry) and Proportion which characterize organic organization. (Stebbing, 2004, p. 65–66)

Stebbing's hypothesis suggests that the principles of CRPB may be universal, as he finds evidence of them across different media and in different cultures. Given this universality, Stebbing's research also posits two potential opportunities to explore and explain these traits, each developed as a result of evolutionary processes. This first, 'that our ability for aesthetic organisation could have evolved from the ability to recognise form by pre-adaptation or exaptation' (Stebbing, 2004, p. 65), identifies exaption (an evolutionary technique where an adaptation that occurred for one particular purpose becomes useful in another function or purpose) as a potential mechanism from which the appreciation and creation of visual compositions can evolve from other, more basic, underlying human visual evolutionary systems.

The secondary hypothesis is that the trait could have evolved as an evolutionary spandrel, which is defined by evolutionary biologist Stephen Gould as 'a presently useful characteristic that did not arise from adaptation, but owes its origin to the side characteristic of other features' (Gould, 1991, p. 48). Like Stebbing, Gould makes similar psychological links between the idea of evolutionary exaptions in the area of visual constructions and their visual appeal. In their article, 'Adaptations, exaptions and spandrels', David Buss et al. (1998) highlight the differences between the terms 'adaptation' and 'exaptation', and emphasise that they are intended as explanatory concepts of evolutionary processes (Buss et al., 1998, p. 16).

The proposed theories of evolutionary psychology may be permitted to inform specific theories of aesthetics, but the leap that our research proposes is a logical and particular progression of at least one point made by Stebbing, coupled with the grand correlations of Gould. Our hypothesis is as follows: If we are to acknowledge the possibility of evolutionary exaptation or spandrels informing our sense of aesthetic organisation, we must concede that this happened a very long time ago. Furthermore, presuming our evolution and aesthetic sensibilities are entwined, then Euclid's geometries and Cartesian reasoning only have a small place in informing our visual grammar. That is, the structures, shapes and patterns that we find common in the lexicon of design are only a part of our aesthetic reasoning and, in some respects, are outside the design rules of self-organising systems. Our visual grammatical systems also need to include forms and structures that are complex, non-Euclidean, rough and fractal.

The reasons are for this are two-fold. First, fractal forms offer us the correlations of mathematical complexity and organisational systems in nature. We are given the ability to aesthetically describe systems and structure that have pertinence to us as biological beings. Second, and most importantly, there is a refined toolset within the realm of fractal mathematics that functions as a set of simple grammatical rules that permit extraordinary possibilities. Such a proposition is not new; fractal principles have been with us aesthetically for some time in the form of logarithmic proportion, Fibonacci's ratios, and much more. These systems are often described and utilised in terms of proportional systems. However, this paper proposes that proportion as a design principle should now include the tenets of fractal mathematics; namely, the active use of terms such as self-similarity, recursion, iteration and random dynamics. Each of these tenets should be applied as a tool for compositional structure to be informed and organised by the same fractal terminologies.

The above does not presume to replace Euclidean and Cartesian geometries, but an understanding of fractal complexity included in the broader grammar of visual composition is clearly warranted. Yannick Joye expresses particular urgency for exposure to fractals in art and design education because 'this field still often (implicitly) presupposes that such factors as culture and experience are the major determinants of aesthetic preference and behaviour' (Joye, 2005, p. 183). As the discourse on the 'universal' theories regarding aesthetic preference grows, it is imperative that the grammar of visual language is seen to incorporate current research and actively include the terms evolved from fractal mathematics.

**Design Principles Now**

Design 'principles' or the 'grammar of visual language' are taught in a variety of ways in a multitude of institutions; Stebbing merely points at commonalities, acknowledging Dong Sung Cho, who highlights that 'there exists no one common view amongst scholars on these principles' (quoted in Stebbing, 2004, p. 65). Despite the inconsistencies among design education systems, the CBRP principles proved to be the four most common terms in Stebbing's analysis of 50 texts concerning visual composition. Stebbing also noted two terms that had frequently recurred in the texts, 'movement' and 'expression', but did not include them in his principles because he thought they described perceptual effect rather than conditions of arrangement. This idea has merit in terms of the psychology of viewer interaction, but there are many who will argue that movement or dynamics are tangible systems applicable to the development of compositional structure. To add weight to this argument, Fernande Saint-Martin, paraphrasing Gaston Bachelard, speaks of the semiotics of visual art and its inherent relationship to physics. He writes 'Visual Semiotics has every reason to abandon previous paths and to adopt an epistemology which is more in agreement with the dynamisms of observable phenomena' (Saint-Martin, 1990, p. 4).

The terminology of dynamics or dynamic systems is therefore relative to visual language through the use of words that have connection to observable phenomena. Dynamics, in terms of its subsets, can be utilised in a compositional sense relative to its correlations to observed systems. Directional, rhythmic, arrhythmic and random dynamics can be conceived of and utilised in a visual sense according to relative dynamic systems. For example, 'directional' can speak of linear flow; 'rhythmic' can emulate collinear flow, electromagnetic oscillations and frequency; and 'arrhythmic' unveils imperfection, a change in rhythm or a perturbation in flow.

This leaves 'random dynamics' to be discussed, and, using the language of physics and mathematics to describe observable phenomena, the idea of 'random' cannot be left untouched because suddenly this term (which is usually lightly dealt with in the visual realm) becomes a concept bigger than all other design principles because it introduces an element of disorder into design. Not too long ago, principles of order were stringently upheld in design terms, and disorder was simply the opposite: disorder was chaos. If we permit chaos theory into visual art theory and methodology, which is inevitable, the study of randomness becomes something quite different for visual art and design practitioners and theorists.

Rudolf Arnheim defined disorder as a 'clash of uncoordinated orders' in his collection of essays *Toward a psychology of art* (1972, p. 125), while he spoke of the 'noise of nature' in *The dynamics of architectural form* (1984, p. 170). In his *Fractal geometry of nature*, Benoit Mandelbrot described nature as 'a cascade of self-similar order' (Mandelbrot, 1982, p. 173). Carl Bovill offers design solutions to the clash of orders not in respect to unification but in the semiotic interpretation of his terms, regarding flow and cascade. Bovill proposes self-similar relationships as a method of informing objects in the built environment inspired by the structures in the surrounding landscape, which can easily be accommodated by any discipline.

It is interesting to note that John Ruskin wrote of and drew what we now perceive to be fractal forms in the third volume of *Modern painters* (c. 1858, see Figure 1). Surprisingly, he developed this form more than a century before Aristid Lindenmayer, the theoretical biologist and botanist who is now acknowledged as developing the fractal subset of L-systems (Lindenmayer, 1968).

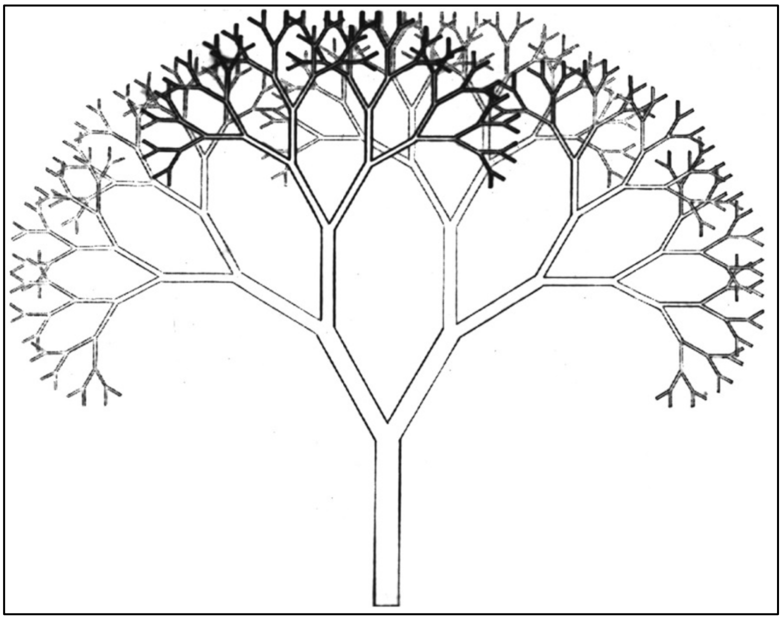

Figure 1. John Ruskin *Sketch by a Clerk of the Works* (drawn in 1858), published in *Modern Painters* volume 3, 1904.

**Biological and Fractal**

Stebbing's position on the urgency of implementing strategies for visual grammar in art and design education stems from the biological; indeed, his proposition is that 'the evolution of a perceptual-grammatical system gave early humans the ability to recognize organic forms including those never seen before' (Stebbing, 2004, p. 67). He goes on to reference E. H. Gombrich's statement regarding a biological basis for the emotive standpoint of aesthetic sense: 'The greater the biological relevance an object has to us the more we will be attuned to its recognition' (quoted in Stebbing, 2004, p. 68).

In terms of connection to the environment, studies such as Taylor et al. (2005) have proposed that the level of fractal complexity in the environment is directly linked to the ability of people in that environment to relate to and connect with the space. Terry Mikiten, Nikos Salingeros and Hing-Sing Yu (2000) stress the presumed neurological connections to natural form and its inherent complexity. Mikiten et al. assert that 'we cannot connect to objects that are either too random, or too simple; we subconsciously use as a template the ordered complexity of our own mind so as to extend our consciousness outside our own body' (Mikiten et al., 2000, p. 68).

This imperative is made clear in designs for the built environment, as we engage in space with all of our senses. The same is true, however, for the static and moving image, since we take our perceptual cues from the world around us and cognitively apply the same reasoning. If we are to permit Stebbing's proposition—that our ability for aesthetic organisation could have evolved from the ability to recognise form by pre-adaptation, exaptation or spandrels, and that these processes have developed as a result of our evolution within the natural environment—it follows that we read images in the same way as we read our environment, where the organising rules of biology and physics apply. These rules of organisation transpose from the natural world to principles of organisation for composition. Applying fractal forms to the created image offers the variance in complexity evident in the physical world. The tenets or conditions of the fractal form, including iteration, recursion and particularly self-similarity, permit an enhanced depth of opportunity in compositional construction and arrangement for art and design, and dramatically expand upon a relatively short list of visual grammatical terms.

Andrew Crompton states, 'composition may be successful because it produces fractals', suggesting that 'fractals are attractive and satisfy many of the rules of thumb for good composition that are observed in painting and architecture' (2002, p. 456). As he continues, 'following rules of composition will tend to produce objects that are scaling; furthermore studying fractals might help explain traditional rules of composition which otherwise seem today to be arbitrary and formalistic' (Crompton, 2002, p. 456).

Self-similarity is a key feature of fractal shapes. In mathematical terms, a fractal must meet a certain set of conditions, but in aesthetic terms, 'An object is said to be self-similar if it looks "roughly" the same at any scale' (Harris & Stocker, 1998, p. 113). Thus, an image is called fractal if it displays self-similarity; that is, it can be broken into parts, each of which is (approximately) a reduced size copy of the whole.

The concept of a fractal pattern being self-similar does not inherently require it to be either complex or simple; a range of possible levels of fractal complexity exist within this mathematical space. From an art and design perspective, this permits fractal complexity as a changeable variable to alter the visual and aesthetic nature of the content being created.

Several research studies have measured the aesthetic preferences of participants with regard to images with varying levels of fractal complexity. By using images from both nature and digitally generated imagery, the studies point to an average aesthetic preference for a fractal complexity level in the range of 1.3 to 1.5 (Spehar et al., 2003; Hagerhall et al., 2008). In terms of the quantification of fractal complexity, the numbers used here refer to fractal dimension. Mathematically, it is the geometric space between the integers 1 and 2 for the two-dimensional plane, and between 2 and 3 for the three-dimensional object. This space between integers or the fractional space is referred to as the parameter of fractal dimension or D value. The rule of self-similarity is that a pattern that fills the plane in very simplistic terms (a low order of roughness and irregularity) has a D value close to 1, and a pattern that fills the plane with detailed and intricate structure will have a D value close to 2.

**Physics and Fractals for Composition**

In 1913 (coincidentally, around the same time that Ruskin published *Modern painters*), Marcel Duchamp produced a tool for the ‘chance’ use of composition. *Three Standard Stoppages* (1913–14, Figure 2) was made by dropping three threads, each a metre long, onto three strips of canvas painted Prussian blue. The threads were dropped at a height of one metre and, by chance, formed three different curves. Duchamp then made wooden rulers that were shaped to match the profile of the curved threads. These rulers were then utilised to draft guide lines into works, including *Network of Stoppages* (1914, Figure 3) and *The Large Glass* (1915–1923). Without investing too much energy in elucidating Duchamp’s forays into physics—or to use a term that he borrowed from Alfred Jarray, ‘Pataphysics’—or the ‘science of imaginary solutions’ (Hugill, 2012; Williams, 2000), it suffices to state that Duchamp’s threads complied with the known laws of physics and dynamic systems. For whatever reasons—Dadaism aside—the curved profile of the final result of the thread landing on canvas was informed by mass, gravity, the properties of the thread, and wind shear.

Figure 2. Marcel Duchamp, *Three Standard Stoppages*, 1913–1914. Image credit: MOMA.

Figure 3. Marcel Duchamp, *Network of Stoppages*, 1914. Image credit: MOMA.

Therefore, the ‘chance’ use of tools influenced by physical systems for the purposes of informing proportion and dynamics in compositional structure owes its origins to Duchamp. An initial set of experiments in ‘random’ compositional structure illustrates the ease with which an infinite variety of layouts can be generated. The composition illustrated in Figure 4 utilised a flatbed scanner and polystyrene spheres. The spheres were dropped into a box on the scanner surface and scans were taken of the spheres as they came to rest in their positions. This system was used to demonstrate that physical systems can easily give rise to compositional layouts, and the objects used in those layouts evidence the properties of the materials and systems. The composition illustrated in Figure 5 demonstrates some simple scaling of shape.

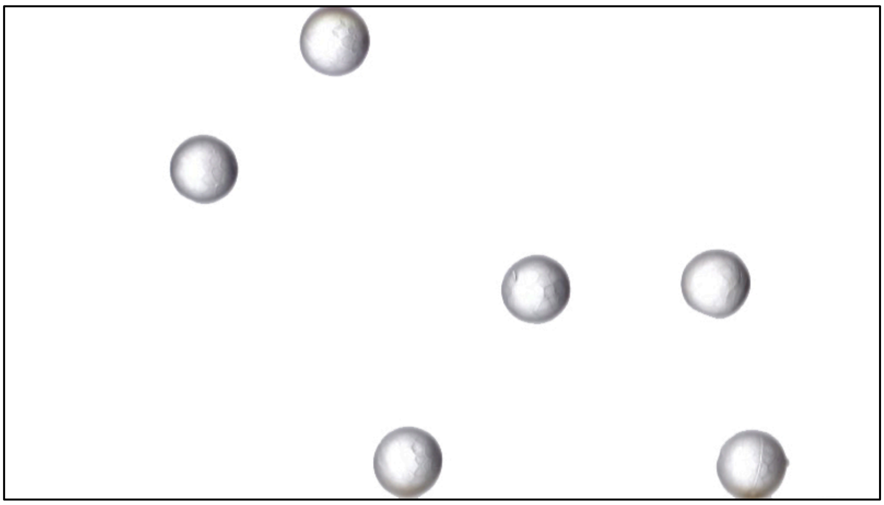

Figure 4. Scanner Composition Example 1

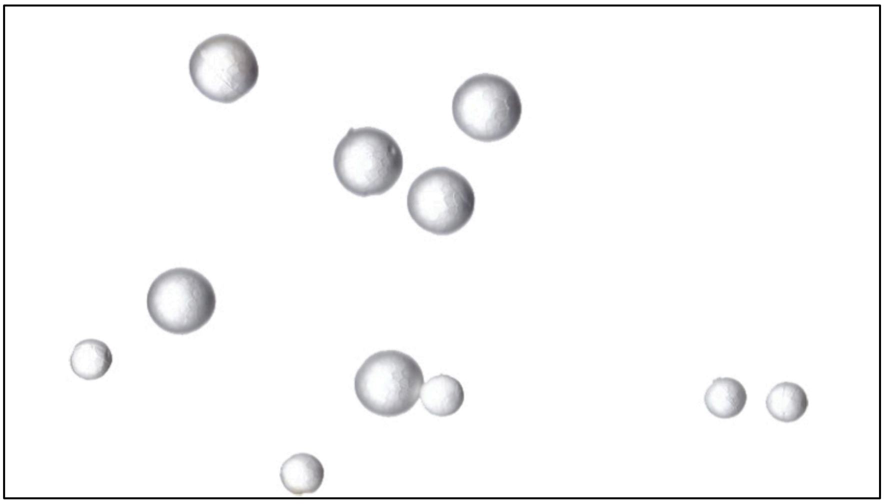

Figure 5. Scanner Composition Example 2

The research logically progressed to using software-based particle systems to emulate real world systems. Particle systems are common inclusions to photo and video editing software, animation and modelling software and games development software. The use of such a variety of software packages, as well as third-party plug ins, offers  great flexibility to other practitioners, as the opportunities for compositional structure using particle systems can be manipulated in two- and three-dimensional spaces.

For the compositions illustrated in Figures 6 and 7*,* Adobe After Effects proved to be a simple tool to generate compositional opportunities using particle systems; namely, the CC Particle world plug in by Cycore Systems. The compositions used a standard spherical particle, and a camera was applied to permit depth of field, to assist with scaling parameters for layout, and to induce scaling factors to the particles in a three-dimensional environment. The two illustrations provide an insight into the immense variety of opportunities available, inclusive of virtual gravity and decay of the system over an animated timeline. It should be noted that CC Particle world includes inbuilt fractal parameters for the animation of particles.

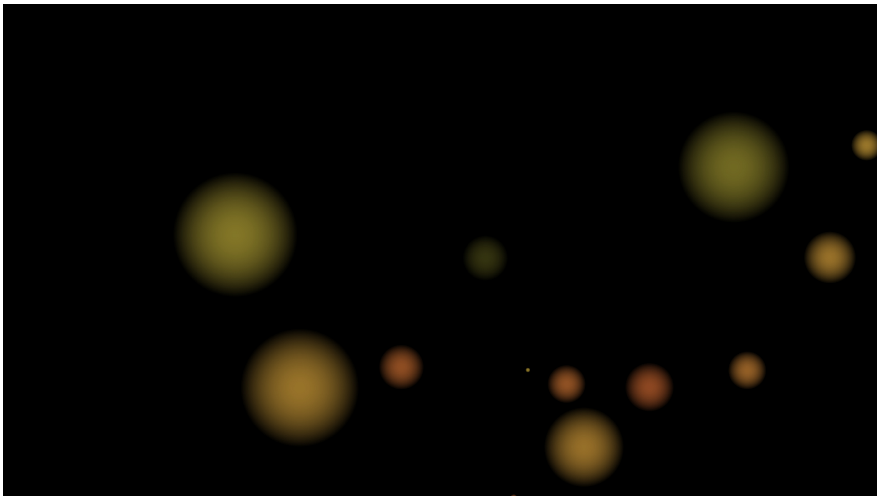

Figure 6. Adobe After Effects particle composition 1

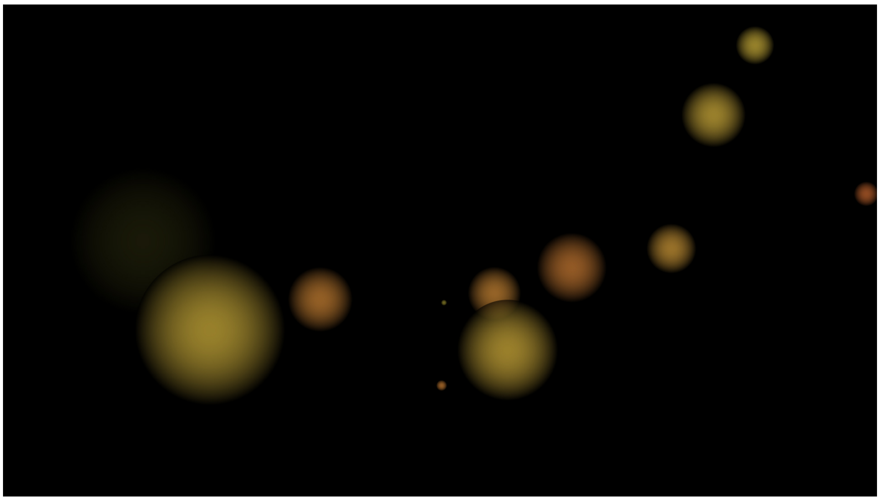

Figure 7. Adobe After Effects particle composition 2

The final illustration, Figure 8, demonstrates the potential for using a variance in particle type for the purpose of better informing dynamics within the composition; the triangular polygons have potential to additionally inform directional dynamics and hierarchy. The key benefit in using particle effects within software or other systems is that parameters affecting degrees of complexity can be quickly generated as a guide to inform the composition.

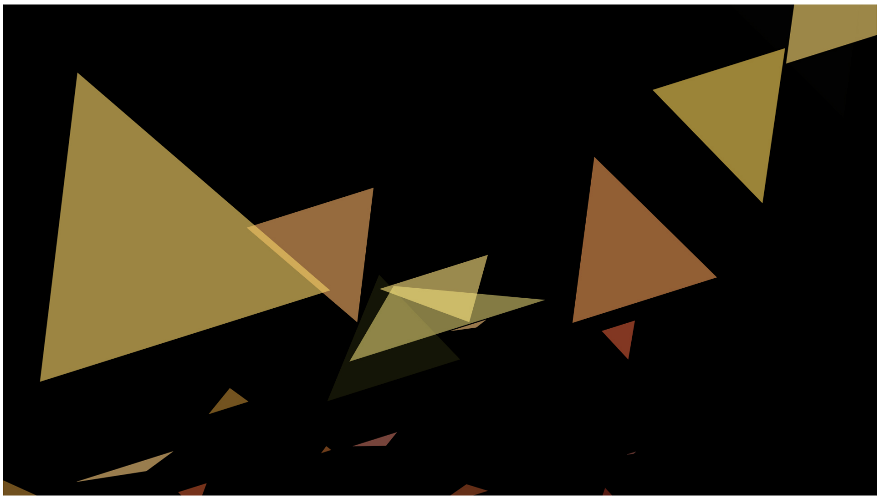

Figure 8. Adobe After Effects particle composition 3

**Conclusions**

The goals of this research are for practitioners and educators to use, as easily as possible, an array of enabling software and fractal systems to help generate layout possibilities for the design principle of proportion, and to guide strategies for implementing ‘random’ dynamics. It should be noted that the range of fractal types well exceed the base grammar of design elements and principles. As art and design practitioners and educators already presume, design elements such as shape and line have the possibility of infinite permutation, especially when informed by fractal mathematics. This research simply asks that the compositional strategies of ‘proportion and random dynamics’ are supported by the study of fractal mathematics and of corresponding dynamic systems.

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