The imperatives of the application of fractal principles applied to compositional strategies for the static and moving image.

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ABSTRACT

Whilst there are great examples in art and design of the application of fractal tenets, the use of those tenets is usually reserved for critique after the work has been produced. It is proposed that the tenets of fractal form, (self-similarity, recursion and iteration) be explored at the stages of compositional development as both a proportional principle, and as strategy for application of random dynamics for the explicit purpose of informing compositional structure based on the psychology of viewer interaction. This paper is informed by prior participant studies that evaluate the psychological response of the viewer to fractal images to build potential methodologies for fractal proportion and dynamics in composition. The argued imperatives from an educational perspective are for a set of design principles, in terms of the aesthetics of fractals, and their relationships to image and audience, to be informed and supported by current and ongoing studies in the fields of mathematics and neuropsychology. The convergence of fields, including growing interdisciplinary activity that seeks to understand and apply fractals in aesthetic terms leads to the important discussion of fractals in design education. This research proposes a consideration for the instatement of fractal principles as part of the grammar of design for education.

Key words: composition, fractal, education, design
PHILOSOPHY OF VISUAL GRAMMAR

In 2004 Peter Stebbing, Stebbing (2004) argued for universal grammatical principles for visual composition. The basis for the argument is that the principles of artistic composition are also seen as principles in the organisation and biology of organic form. For Stebbing, ‘Contrast, Rhythm, Balance and Proportion along with Harmony’, CRBP (the abbreviation used from this point on), are the key principles that have correlation with natural form and 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 63.).

Stebbing’s hypothesis suggests that the principles of CRPB may be universal, as he finds evidence in different media and in different cultures. Given this potentially universal nature, Stebbing’s research also posits two potential opportunities to explore and explain these traits, each developed as a result of evolutionary processes.

‘that our ability for aesthetic organisation could have evolved from the ability to recognise form by pre-adaptation or exaptation’2, Stebbing (2004 p.65)

This first example 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 appreciation and creation of visual compositions can evolve from other, more basic, underlying human visual evolutionary systems.

The secondary hypothesis, following a similar evolutionary theory, is that the trait could have evolved as an evolutionary spandrel, defined by 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.)

The work of evolutionary biologist, Stephen Gould (1991) also makes similar psychological links between the idea of evolutionary exaptions in the area of visual constructions, and their visual appeal. As a point of caution, David Buss et al. (1998), in Adaptations, Exaptations and Spandrels, writes of the lack of empirical evidence to support these ideas. This contention, in no way diminishes the debate. Specifically, reading, writing and the fine arts are all on Gould’s list of proposed exaptations and spandrels. Yet for each of these areas, they, as yet, have not met the standards of evidence.

In terms of compositional theory, our focus is rarely on factual evidence. The proposed theories of evolutionary psychology may be permitted to inform specific theories of aesthetics, but the leap that this research proposes, is a logical and particular progression of at least one point of Stebbing’s, coupled with the grand correlations of Gould, and that 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. And presuming, our evolution and aesthetic sensibilities are entwined, Euclid’s geometries and Cartesian reasoning only have...
a small place in informing our visual grammar. We now need to include in our visual grammatical systems, form and structure that is complex, non-Euclidean, rough and fractal.

The reasons are two-fold; fractal form offers us the correlations of mathematical complexity and organisational systems in nature. We are given the ability to describe aesthetically, systems and structure that have pertinence to us as biological beings. Most importantly though, we have a refined toolset within the realm of fractal mathematics, that function as simple grammatical rules permitting extraordinary possibilities. Essentially this is not new, Fractal principles have been with us aesthetically for quite some time in the form of logarithmic proportion, Fibonacci’s ratios, and much more. These systems often are described and utilised in terms of proportional systems. This research proposes that proportion as a design principle now include the tenets of fractal mathematics, namely the active use of fractal systems including self-similarity, recursion, iteration and random dynamics. Each applied as a tool for compositional structure to be informed and unpacked by the same fractal terminologies.

This is not presumed to replace formal and Euclidean geometries, particularly in terms of layout for composition, but that an understanding of fractal complexity is included in the grammar of visual composition. Yannick Joyce (2005), expresses particular urgency for exposure to fractals in art and design education, and the reason he gives is that 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 therefore an imperative that the grammar of visual language is seen to incorporate the current research and actively include fractal techniques.

DESIGN PRINCIPLES NOW

Stebbing’s analysis of fifty art and design texts offers insight into the commonalities of art and design education, and particularly the protocols that inform composition. His studies findings, of the recurrence of similar principles, are distilled into four common categories, Contrast, Rhythm, Balance and Proportion. Arguably the pedagogical implications for how design principles are taught for composition are always in flux, and no single principle is upheld at the expense of another. 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, whilst also agreeing with Dong Sung Cho (2001), stating ‘that there exist no one common view amongst scholars on these principles’. Despite the inconsistencies, the principles of Contrast, Balance, Rhythm and Proportion 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 frequent recurrence in the texts, ‘movement’ and ‘expression’ but had not included them in his principles as he referred to them as not describing conditions of arrangement, but rather perceptual effect. 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, Saint Martin (1990), paraphrasing Gaston Bachelard speaks of the semiotics of visual art and the 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. Directional for example, can speak of linear flow, rhythmic can emulate collinear flow, electromagnetic oscillations and frequency, arrhythmic unveils imperfection, a change in rhythm, a perturbation in flow.
That then leaves Random Dynamics to be discussed, and, using the language that physics and mathematics uses to describe observable phenomena, the idea of random cannot be left untouched because suddenly this term (that is usually lightly dealt with in the visual realm) now becomes a concept bigger than all other design principles.
The concept of random dynamics 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.
Art and Design practice has a long history of being informed by findings of mathematics and physics, and this research proposes that fractal mathematics is but one newly growing chapter that informs the practice and education of art and design.
The grammar of architectural design is perhaps slightly better informed by Fractal mathematics, and it is of interest to note that John Ruskin (2010), wrote of, and drew, what we now perceive to be fractal form in Eighteen Fifty Eight (see Figure 1) and surprisingly developed this form more than one hundred years in advance of Aristid Lindenmayer, a theoretical biologist and botanist, who is now acknowledged as developing the fractal subset of L-systems. Lindenmayer (1968).

**BIOLOGICAL AND FRACTAL**

Stebbing’s position on the urgency of art and design education to implement strategies for visual grammar 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). And he goes on to reference Rudolf Amheim (1984) and E. H. Gombrich (1968) by drawing attention to 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’.
In terms of connection to the environment, several studies have identified that the level of fractal complexity in the environment is directly linked to the ability for people in that environment to relate and connect to the space. Mikiten, Salingeros and Yu (2000) stress the presumed neurological connections to natural form and its inherent complexity. The supposition Mikiten et al (2000) make, is ‘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’.

The imperative is made clear in design 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, we take our perceptual cues from the world around us and cognitively apply the same reasoning.

If we are to believe in Stebbing’s (2004) 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. We then therefore read images in exactly the same way as we read our environment, where the organising rules of biology and physics apply. And it is these rules of organisation that transpose from the natural world to principles of organisation for composition. The application of fractal form to the created image offers the variance in complexity evident in the physical world. The tenets or conditions of fractal form, including iteration, recursion and particularly self-similarity, permit 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 (2002) states, ‘Composition may be successful because it produces fractals’, he suggests that ‘fractals are attractive and satisfy many of the rules of good composition that are observed in painting and architecture. 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’.

Self-Similarity is a key feature to understanding and implementing 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’, 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. There exists a range of possible levels of fractal complexity within this mathematical space. From an artist and design perspective this allows the ability to consider the fractal complexity as a changeable variable to alter the visual and aesthetic nature of the fractal content being created.

There have been several research studies that have measured the aesthetic preferences of participants with regard to images with varying levels of fractal complexity. By taking 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 3 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.

Participant and EEG (brain activity through scalp electromagnetic measurement) studies conducted by Caroline Hagerhall et al (2008), sought to expand upon earlier studies of Richard Taylor and Branca Spehar (2003), and to some extent begin to quantify the viewer's preferences for particular fractal ranges. The findings of the study concluded that images shown to participants with a fractal dimension of 1.3 elicited the largest changes in EEG response, and the results pointed to a complicated interplay between different brain areas when experiencing this fractal range. The fractal stimuli in the 1.3 D range generated maximal alpha response in the participant's frontal region of the brain, consistent with the hypothesis that they are most restorative and relaxing.

PHYSICS AND FRACTALS FOR COMPOSITION

In 1914, the same year that Ruskin had coincidentally published ‘Modern Painters’, Marcel Duchamp produced a tool for the ‘chance’ use of composition. ‘Three Standard Stoppages,’ 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 which 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’, Figure 3 and ‘the Large Glass’. Without investing too much energy in elucidating Duchamp’s forays into physics, or to use a term that he borrowed from Alfred Jarry, ‘Pataphysics’ or the ‘science of imaginary solutions,’ Hugill (2012), Williams (2000). It suffices to state that Duchamp’s thread complied with the known laws of physics and dynamic systems, and for whatever reasons dada-ism 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.

For the purposes of informing proportion and dynamics in compositional structure, the ‘chance’ use of tools influenced by physical systems can take its cues from Duchamp, and the initial set of compositional experiments in ‘random’ compositional structure to illustrate the ease with which an infinite variety of layouts can be generated did just that. The composition illustrated in Figure 4, utilised a flatbed scanner and polystyrene spheres. The spheres were dropped or thrown into a box on the scanner surface and as the spheres came to rest scans were taken of their position. 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.

It proved relevant that the research progressed to using software based particle systems to then emulate real world systems. This gives great flexibility to other practitioners as the software of choice can provide opportunities in two and three dimensional space.
For the compositions illustrated in Figures 6 & 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 to assist with scaling parameters for layout, a camera was applied to permit depth of field, and to induce scaling factors to the particles in a three dimensional environment. The two illustrations provide an insight into an 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.

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.

CONCLUSIONS

The imperatives in terms 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 particularly in guiding strategies for the implementation of ‘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 ‘proportion and random dynamics’ as compositional strategies are supported by the study of fractal mathematics and of corresponding dynamic systems.
REFERENCES


List of Illustrations

Figure 1. John Ruskin ‘Sketch by a Clerk of the Works’ (drawn in 1858), published in ‘Modern Painters’ volume 3, 1904.
Figure 2. Marcel Duchamp, ‘Three Standard Stoppages’ 1913-14, Image credit; MOMA.

Figure 3. Marcel Duchamp, ‘Network of Stoppages’ 1914 Image credit; MOMA.

Figure 4. Scanner Composition Example 1.
Figure 5. Scanner Composition Example 2.

Figure 6. Adobe After Effects particle composition 1.
Figure 7. Adobe After Effects particle composition 2.

Figure 8. Adobe After Effects particle composition 3.