

# The Golden Ratio in Time-based Media

Emily Verba  
4222 Dane Avenue  
Cincinnati, Ohio 45223

*Measure and proportion manifest themselves in all areas of beauty and virtue.*  
—Socrates

*Mathematics and visual communication share a long historical, symbiotic relationship. In their pursuit of achieving order and beauty, they find common ground through geometry. The golden ratio is a mathematic and aesthetic phenomenon inherent in nature that has consistently evoked sensory enjoyment since antiquity. It may be assumed that the manifestation of the golden ratio in nature accounts for human's innate enjoyment of it. Throughout the ages, the conscious application of the golden ratio to proportions found in art, architecture, poetry, literature and musical composition has consistently evoked subconscious sensory pleasure. However, the application of the golden ratio to visual temporal proportion, or time-based media, has seldom been investigated. This thesis investigates various applications of the golden ratio as a mathematical framework for choreographing visually harmonious temporal compositions through time-based media.*

*The proliferation of moving images we face on a daily basis is cause for great concern, as we have increasingly less free time in our days. Informative and pleasing images are buried in an avalanche of visual rubbish, constantly streaming into our physical and virtual worlds. Time-based media has the ability to expand and contract movement, thus directing the way viewers experience and spend their time. This investigation presupposes that editing moving images via increments of time determined by the golden ratio may streamline messages, isolating what is most symbolic and effectively communicative within a mathematical framework. A physiological and psychological benefit is created for viewers; there is no wasted time or space.*

*Image-makers and visual communicators have a responsibility to create only that which is useful and/or aesthetically pleasing. An investigation into the temporal structure of time-based media, using mathematical algorithms derived from the golden ratio, has led to the aim of creating through it a viable solution for the implementation of visual communication messages in today's society.*

**Keywords:** golden ratio, geometry, perception, image proliferation, motion, time, rhythm, iconic research, patience

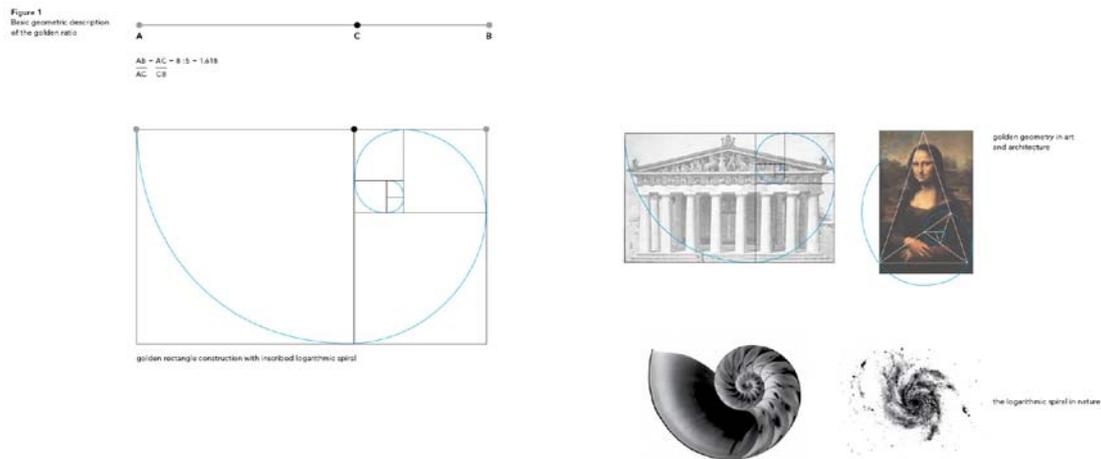
## 1. The Golden Ratio

### 1.1 Nature's Geometry

*Measure and proportion manifest themselves in all areas of beauty and virtue.*  
—Socrates

Mathematics and visual communication share a long historical, symbiotic relationship. In their pursuit of achieving order and beauty, they find common ground through geometry. The golden ratio<sup>1</sup> is a mathematic and aesthetic phenomenon inherent in nature, illuminated by Pythagoras and later elaborated upon by Euclid in 300 BC. It is most simply defined as a line divided into two uneven

segments where the ratio of the entire length to the longer length contained is equal to the ratio of the longer length to the shorter length, yielding a ratio of approximately 8:5 ( see Figure 1 ).



The geometry becomes more sophisticated as this proportion is used to construct golden rectangles, golden triangles, and other increasingly complex polyhedra. The same logarithmic spiral drawn within the framework of these golden shapes is found empirically in nature, from the molecular structure of DNA molecules to the curve of nautilus shells to the shape of galaxies.

The conscious application of the golden ratio to art, architecture, poetry, literature and musical composition has consistently evoked subconscious sensory enjoyment since antiquity. It may be assumed that the manifestation of the golden ratio in nature accounts for human's innate enjoyment of it. In 1854, the German psycho-logist Adolf Zeising described the golden ratio as:

... the universal law in which is contained the ground-principle of all formative striving for beauty and completeness in the realms of both nature and art, and which permeates, as a paramount spiritual ideal, all structures, forms and proportions, whether cosmic or individual, organic or inorganic, acoustic or optical; which finds its fullest realization, however, in the human form.<sup>2</sup>

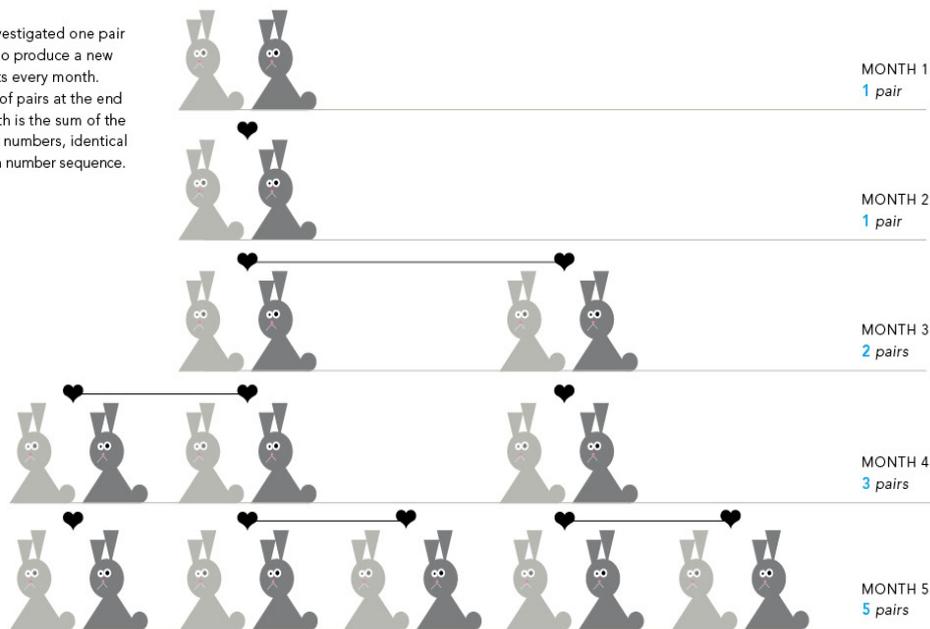
## 1.2 Through the Ages

The age of antiquity would employ the mathematical principles of the golden ratio to all endeavors in their quest to understand beauty and truth; it was their belief that the ideal human form possessed the proportions of the golden ratio. The numerical outcome of the golden ratio, 1.618, may be represented as the Greek letter phi ( $\Phi$ ), after the classical sculptor Phidias, who was said to have employed the proportion heavily in his work. Virgil utilized golden proportions as the underlying structure of his epic poem *The Aeneid*. Philosophically, this was explained by Aristotle as the Golden Mean—guiding principle of living between the unhealthy extremes of excess and deprivation. Although the Parthenon and many other structural gems of antiquity employed the golden ratio, knowledge of these geometric proportions had been recognized and implemented long before that time, such as in Stonehenge and the Great Pyramids of Egypt. From buildings as diverse as Notre

Dame Cathedral, Le Corbusier's Notre Dame du Haut and the UN Building, the golden ratio continues to improve the aesthetics and function of architecture.

In 1202, Leonardo Fibonacci of Pisa published his book *Liber Abaci*, which explored basic computational mathematics. This volume reintroduced a numerical sequence which was known to Indian mathematicians as early as the 6th century, and soon took Fibonacci's name. In the Fibonacci number sequence, each figure is the sum of the preceding two numbers, and the dividend of any number by its subsequent figure yields approximately 1.618—the golden ratio. Consequently, the numerical pattern formed becomes 1, 1, 2, 3, 5, 8, 13, 21, 34, and so on to infinity. Fibonacci linked this number sequence to the breeding patterns of rabbits, again establishing the uncanny existence of the golden ratio in nature (see Figure 2).

**Figure 2**  
Fibonacci investigated one pair of rabbits who produce a new pair of rabbits every month. The number of pairs at the end of each month is the sum of the two previous numbers, identical to the golden number sequence.



The Renaissance wholeheartedly accepted the golden ratio as mathematical doctrine, in its determined mission to demonstrate objectivity. Simple rules would make sense of the utmost complexities. Known in this time period as "The Divine Proportion," it was extensively used by masters of art, science and mathematics including Leonardo, Alberti, Michelangelo, Raphael, Dürer and others.

From the compositions of Bach to the construction of the Stradivarius violin, Kepler's Triangle to Rembrandt, the golden ratio has quietly embedded itself into the most functional and beautiful man-made artifacts of history. It is a timeless stream of quality which uniformly flows through the veins of the human experience.

### 1.3 Analysis in Cinema

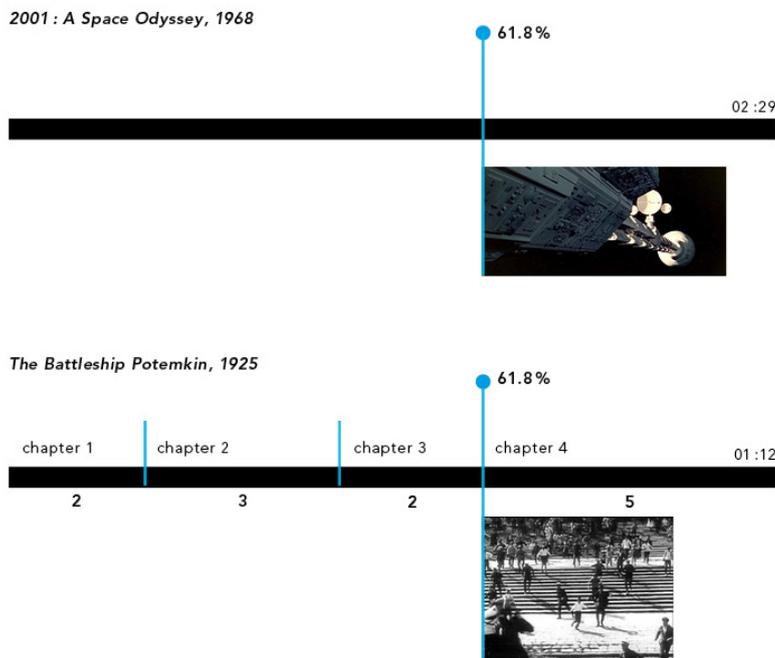
The application and aesthetic influence of the golden ratio in two-dimensional production, such as painting and photography, and three-dimensional production such as architecture, have been extensively researched. It may be assumed that the same aesthetic enjoyment and quality experienced in two and three-dimensional space may be translated into the fourth dimension of

Time. However, the application of the golden ratio to visual temporal proportion, or time-based media, has seldom been investigated.

The study of cinema has and will continue to inform new media, as the beginnings of cinema were based upon the sampling of time.<sup>3</sup>This thesis analyzes Stanley Kubrick's *2001: A Space Odyssey* and Sergei Eisenstein's *The Battleship Potemkin* case studies. Both films are considered by most film critics to be among the finest cinematic works of all time; they have proven to exemplify the utmost quality, craftsmanship and timelessness. Kubrick and Eisenstein both established aesthetic standards with their revolutionary techniques, not only in the realm of cinema but in all areas of visual communication. The analyses of *2001: A Space Odyssey* and *The Battleship Potemkin* reveal the intentional use of the golden ratio over the course of each feature-length film.

The outcome of the golden ratio, 1.618, may be applied to duration through the establishment of golden time points. The golden time point in any duration is exactly 61.8% through its entire length, and is considered the aesthetic sweet spot in any length of time.<sup>4</sup>Kubrick began the second half of *2001* precisely at the golden time point of the film's duration, preceded by a dramatic, pitch black, three minute intermission complete with eerie music(see Figure 3). Similarly, Eisenstein began the climactic Odessa Staircase scene<sup>5</sup> at the golden time point of Potemkin's duration. Additionally, he divided the entire length of the film into golden proportioned segments and began each of four important chapters of the film at each point (see Figure 3).

Figure 3  
golden ratio time points in  
*2001: A Space Odyssey* and  
*The Battleship Potemkin*



A crucial question arises from the analysis of these two classic films: can the application of the golden ratio to short time-based media outputs, such as animated logos, film trailers and advertisements, create the same geometric foundation for aesthetic quality as has been achieved by the aforementioned feature-length films? The visual investigations contained within this thesis are structural studies for such outputs. An investigation into the temporal structure of time-based media,

using mathematical algorithms derived from the golden ratio, has led to the aim of creating through it a viable solution for the implementation of visual communication messages in today's society. Golden number sequences are used as a spine for sampling and creating logical structures for duration. Various applications of the golden ratio are used as mathematical frameworks for choreographing visually harmonious temporal compositions through time-based media.

#### **1.4 Aesthetic Preference and Irregularity**

*That which is not slightly distorted lacks sensible appeal; from which it follows that Irregularity—that is to say, the unexpected, surprise and astonishment, are an essential part and characteristic of beauty.*

— Baudelaire

Art historians and psychologists have identified that the human eye recognizes and prefers the golden ratio, yet are not able to pinpoint exactly why. In 1876, the German psychologist Gustav Fechner measured the aesthetic preferences of various rectangle proportions. He found an overwhelming proclivity for those forms embodying the golden ratio. Thus, Fechner proved that the golden ratio is generally pleasing to one's sense of sight and touch. In discussing these experiments, Rudolph Arnheim suggested that the golden ratio "may successfully combine unbreakable unity with lively tension."<sup>6</sup>

Humans relate to and gravitate toward comprehensible order and patterns. However, our inherent preference for and enjoyment of the golden ratio suggests the existence of a subconscious natural order—innately understandable and determined by mathematics. The utilization of the golden ratio in visual communication may fulfill our need for order and balance, while offering us the variety and surprise we also seek. The golden ratio's outcome is approximately 1.618. It is an irrational number; never quite exact. Beauty rests in this organic irregularity, much like the beauty we find in the imperfections and quirks of the people and objects we hold dear. Again, the root of this phenomenon lies in nature and mathematics. The limitations of the golden ratio's irrationality enables the limitless, as is illustrated in the endless logarithmic spiral.

Just as the golden ratio itself is an irrational number, time-based media is irrational. It does not necessarily follow a particular chronological order; the inclusion of time within the moving image renders past, present and future indistinguishable. The visual investigations of this thesis use the irrational properties of the golden ratio as a rational method for creating time-based images. Tension is born through irregularity of form, expectantly giving way to elevated emotion and meaning.

## 2. Mathematical Editing

### 2.1 Tension and Rhythm

*To edit; to wrest, through the camera, whatever is most typical, most useful, from life; to organize the film pieces wrested from life into a meaningful rhythmic visual order, a meaningful visual phrase, an essence of "I see."*

— DzigaVertov

Life is a constant rhythm of internal and external tension and release. Time-based media<sup>7</sup> is successful when the pacing of its editing mimics this modulation. In cinema, audiences consistently expect things to occur; as events draw near, tension builds. The event eventually takes place, and tension is released. Time-based media has the power to control emotional and physiological reactions as such.

Pioneer Soviet director and film theorist Sergei Eisenstein had an extreme fascination with Pavlovian psychology, and integrated these principles into his work. His groundbreaking efforts in film-editing, or montage, paved the way for modern filmmaking and other time-based media. He implemented techniques such as gradually decreasing the length of successive shots to tense his audience and build up to grand culminations.

Eisenstein discovered through his innovative formal experiments that rhythms edited metrically to mirror the human heartbeat have a strong impact on an audience, as this pattern mimics our biorhythms. In Eisenstein's view, film editing absorbed the audience much more than the passive presentation of information through long, static shots. In Hegelian tradition, he always offered viewers the visual equivalent to thesis and antithesis, so that they might arrive at synthesis carefully crafted by Eisenstein himself. These dynamic film sequence rhythms drove audiences into hysteria. It was Eisenstein's wish to create this mania for revolutionary purposes, as in the tradition of Marx, he believed the goal is not to understand history but to change it.

### 2.2 Formalism versus Naturalism

Since the beginning of film, war has existed between the theories of formalism and naturalism. Those from the camp of naturalism argue against any manipulation to film form—film should be used to depict reality as it stands. While formalism uses film editing, or montage, to stress difference and juxtaposition ( $A + B = C$ ), naturalism stresses similarity ( $A + B = AB$ ). Quintessential opponents in this conflict were French film theorist Andre Bazin and Sergei Eisenstein. A classic proponent of naturalism, Bazin believed that montage was too manipulative, and that viewers need more room to make personal interpretations through uninterrupted *mise en scène*. Emphasis was to be put into reality, not into the image. Eisenstein believed that art should always be conflict, as its social mission is to illuminate and mirror the contradictions of our very existence.

Lev Kuleshov, Soviet creator of the world's first film school and teacher of Eisenstein, stated that the essence of film was montage—the juxtaposition of one shot with another. To illustrate his principle, he created what has come to be known as the Kuleshov Effect. The Kuleshov Effect juxtaposes the same shot of a straight-faced man against separate shots of a plate of soup, a beautiful woman, and a dead child. Viewers interpreted hunger, desire, and grief, respectively. This experiment indicates the power of film editing. Viewers bring their own personal response to sequences of images, and project those emotions onto actors with their own internal feelings. Therefore, meaning is contextual. The combination of the images within a film is arguably more important than the content of the images themselves.

The long-standing argument between montage and naturalism is worth reflecting upon with regards to how time-based media is experienced today, not only with regards to our internal biorhythms, but rhythms of the world around us. One such rhythm is that of collective patience. Rudolph Arnheim suggested that film language “evolved to interface with the rhythms of human attention, and by extension, the temporal structure of the world.”<sup>8</sup> In our hyperlinked and database driven lives, the world is viewed in fragments as we skim headlines and watch videos while working, driving, and multi-tasking in general. We are increasingly comfortable with our fragmenting patience as such; our current reality is therefore best depicted in fragments. This information suggests that the naturalistic, linear narrative should be subverted. New media theorist Lev Manovich suggests:

...If we are now used to switching our attention rapidly from one program to another, from one set of windows and commands to another, we may find multiple streams of audiovisual information presented simultaneously more satisfying than the single stream of traditional cinema.<sup>9</sup>

### **2.3 Towards Mathematical Montage**

Eisenstein defined several primary categories of montage. Metric montage emphasizes tension created with lengths of shots. Rhythmic montage derives the length of segments from the content within the frame. Tonal montage uses the characteristic emotional tone to drive the editing. The conflict and collision of images involved in these methods of editing give way to narrative. Such is the case in Chris Marker’s revolutionary film *La Jetée*. Marker had no preconceived plot in mind before shooting—he merely collected footage and the narrative emerged during the process of editing film.

Lev Manovich suggests that film exists at the intersection between database and narrative. Database, at its most basic definition, is a set of elements not ordered in any manner, yet accessible in a variety of ways. Raw film footage, or time-based imagery which has not yet been edited, may be considered a database of sorts. It is a readymade platform which invites deconstruction and manipulation.

This thesis proposes systems for mathematical montage—frameworks determined by golden ratio time increments. The methods employed in this thesis meet Lev Manovich’s criteria for qualification as true modern day montage. He states:

... a new media object should fulfill two conditions: the juxtapositions of elements should follow a particular system; and these juxtapositions should play key roles in how the work establishes its meaning, emotional and aesthetic effect. These conditions would also apply to the particular case of new spatial dimensions of a digital moving image. By establishing a logic which controls the changes and the correlation of values on these dimensions, digital filmmakers can create what I will call spatial montage.<sup>10</sup>

### **2.4 Breaking the Time Grid**

This thesis employs the golden ratio as a series of mathematical grids. It should be noted that the proposed mathematical framework is merely a grid, or recipe. Grids are employed by all those involved in creative pursuits. A painter creates a framework for his composition, a typographer of his layout, an architect of his plans. Any grid is meant to be broken when deemed necessary by the

intuitive judgement and improvisation of the image maker. Jan Tschicold employed the golden ratio to his typographic grids, yet broke it when he felt it improved them. Similarly, the intuition of a cook who adds a secret ingredient or strays from a recipe when they see fit is breaking the established standards. Success in any creative act, be it writing, cooking, composing, or designing, involves breaking grids. However, the decision to break a grid should be as rigid and intentional as the grid itself.

### 3. Structure and Form

#### 3.1 Practical Approach

As with any endeavor in visual communication, the question remains: What is the most harmonic way to arrange a set of visual elements — on a printed page, in architectural space, in time? This thesis takes a radically structural approach to providing an analytical explanation of methods for applying the golden ratio to visual imagery.

Structural film, or “cinémapur” was an experimental movement prominent in the United States in the 1960s and 70s. This genre prioritized form over content, in an effort to decode the basics of cinema from a technical point of view. The shape of the film itself was crucial. This thesis is a study in film form; thus content is secondary in order to isolate the illustration of the golden ratio in an analytical fashion. Form becomes content, and meaning is created through the careful ordering of movement, space and time.

The films contained in this research meet theorist P. Adams Sitney’s formal criteria for qualification as structural. These include fixed camera position, flicker effect (strobing due to the intermittent nature of film), and looping. The loop establishes repetition and allows the viewer to recognize order and patterns within the film sequence. Other structural devices used include the formal thread of the circle as well as the method of analytical comparison.

With its inherent properties of change and motion, time-based media may be likened to Aristotle’s description of a circle as being constructed of contraries. The circle is formed by motion and rest, things which are inherently opposed to each other. The analytical time-based media in this thesis research gradually evolves from abstract circular forms to realistic imagery. It is intended that the progression and unity of the imagery enhance the storytelling and explanation of possible uses for the golden ratio in time.

Simple comparative methods are used to analyze and isolate differences between unedited film sequences and those employing different mathematical solutions in golden ratio-based time proportions. Comparison may illuminate change, as visual breakdowns incite the innate human tendency to self-organize and analyze. Rudolph Arnheim suggests that the order of structures is not perceived modularly, but as an integrated organization of whole patterns. He stated that “the calculating mind can only approximate Gestalt by establishing a network of relations, the perceiving mind can fully realize it by relying on the field of interacting forces itself. Instead of figuring out the single elements and their connections piecemeal, the mind can rely on the tensions resulting from the integrated action of all the forces concerned.”<sup>11</sup> The principles of editing film involve breaking inertia and mentally reconstructing a whole from a set of elements. The process is inherently Gestalt, emphasizing the whole as greater than the sum of its parts. Editing techniques such as cutting, pausing, dissolving and repetition may be likened to a kit of parts in any process, such as cooking. It is the similar disassembly and reassembly of pieces into new wholes.

### **3.2 Gestalt**

According to structuralist filmmaker Peter Kubelka the preparation of food is the oldest form of communication.<sup>12</sup> A cook may be likened to any artist or creator. The rhythmic repetition of choreographed movement in chopping, stirring, spinning and so on exists all around us, taking form anywhere from the movement in dance to the movement of the cosmos. Kubelka notes that a steak is a sculpture cut from a cow, yet a fake steak is also a sculpture, perhaps made of plastic. Editing time-based media is a sculpture in time, as shots are carved from raw footage and pieced together to create something new.

The metaphor of cooking and editing time-based media reminds us that we are all part of one connected Gestalt whole. Walter Benjamin alludes to this through a comparison of the cameraman to the surgeon. The cameraman delves deep into reality with his equipment, yet the result is free of equipment.

The messages of cooking speak about time. Kubelka offers the example of cheese.

We can feel what age means when we taste a two-day-old mozzarella as opposed to a two-year-old Parmesan. Yet, both come from mother's milk. In cooking, we separate meat from fat, good from bad, important from unimportant. The same must be done in editing time-based media, as well as in our daily experience. We ingest the food and media which we find beautiful, and it nourishes us.

## **4. Time-based Media**

### **4.1 Reality and Distance**

Moving images allow us to temporarily escape our lives. They are a window into an abstracted reality, simultaneously real and unreal. Slavoj Žižek suggests that cinematic fiction is in fact more real than reality itself; that cinema possesses a "crucial dimension we are not able to confront in reality."<sup>13</sup> This displacement of observed reality affords the viewer a necessary and comfortable distance which helps in understanding his or her own life.

Walter Benjamin defines aura "as the unique manifestation of a distance."<sup>14</sup> We can then say that distances with which we experience moving time-based images have drastically changed. Time-based media is no longer relegated to the dark cinema, where viewers are immobile and fully focused on a singular projection. We now experience moving time-based images in a variety of platforms and environments. What Roland Barthes describes as the pictorial tableau is long gone: the "pure, cut-out segment with clearly defined edges, irreversible and incorruptible; everything that surrounds it is banished into nothingness, remains unnamed, while everything that it admits within its field is promoted into essence, into light, into view."<sup>15</sup> Our phones, computers and tablets have become our tableaux, and we are quite the opposite of immobile. Technology interferes with and changes the way we experience distance. How do the ways we experience time-based media today affect our own auras, the atmospheres which surround and define us as individuals?

### **4.2 Memory and Death**

Image as both adversary and epitome of memory is an ancient opposition — Plato recounts the legend of the King of Egypt, who believed that writing would bring forgetfulness. The methods through which we record, collect and distribute personal time-based images are tools for the externalization of memory — unique permissions to forget. However, when these past images are

accessed, a different type of excavation takes place within the memory as opposed to the viewing of a still photograph or solely relying on the fragmentation of one's inner memory.

The unalterable silence and stillness of a static photograph resembles death, not only in the literal possibility of that which is pictured as deceased, but in that the moment itself is most definitely dead. Time-based media possesses a unique quality of preservation. When viewing time-based images, initiated senses activate nostalgia as the past magically unfurls. The dead moment now possesses a semblance of life, rendering it undead. The viewer is afforded the opportunity to see new imagery with each viewing, as the camera captures more than the eye can perceive in one instant.

Here lies the fascination with time-based media. Film can recreate that which was alive more acutely and move us emotionally. The past is made uncanny as past traces are once again animated. The time-based image innately holds multitudes of information, including sound information. It is simply more imagery—a succession of multiple stills, and therefore more memory and emotional data is contained within. The time-based image tells a comprehensive story.

The images we keep and surround ourselves with indicate how much of the past, present and future we would like to be aware of. Images will last beyond our lifetimes and live on as our many varieties of intended proof. Proof of travel, of landmark events, of a life well-spent. Conversely, we are accustomed to frequently delete those images we do not deem “good enough.” It is all part of the curatorial process of our modern-day self-expression, in life and in preparation for death. It may be said that a subconscious fear is associated with these acts of curation. Are we afraid of being forgotten, or that our lives will not seem a certain way to those who outlive us?

Image proliferation and privacy issues might ironically leave one less inclined to create and circulate images. If moving images are not captured, one must most likely rely on a random catalyst sometime in the future to spark and deliver the memory. Therefore, passing up opportunities to record memories makes sense insofar as the moment is already dead. The ultimate death of experience is even more evident when we view live images of our past. It is a futile attempt to escape the inevitability of death.

## **5. The Time Ahead**

### **5.1 Continued Research**

This iconic research opens only a tiny window into the broad potential of this subject matter. An interesting and logical next step might be to measure the aesthetic preference between the golden ratio films and original footage films contained within this thesis. Simple questions may be posed to viewers regarding which films they prefer, which films appear more visually harmonious or aesthetically pleasing overall. Patience could be measured through inquiring if one film seems to be completing faster than another. Although we may simply ask these questions verbally eye-tracking and neuroimaging could be implemented for scientific results regarding which film is truly viewed more. Further, it would be interesting to see if the film which is proclaimed more pleasing is in fact the most frequently viewed. Lastly, viewers might be asked which films were most memorable upon completion of the measurement, to measure potential correlation with the golden ratio film sequences. Such a measurement has potential to interest artists, designers, scientists, mathematicians and psychologists alike.

## **5.2 The Image Maker's Responsibility**

This thesis is a stance against arbitrary, careless methods of image production. Image makers and visual communicators have a responsibility to create only that which is useful and/or aesthetically enjoyable, in order to enhance experiences for viewers. The proliferation of images we face on a daily basis is cause for great concern. Informative and pleasing images are buried in an avalanche of visual rubbish, constantly streaming into our physical and virtual worlds.

Time-based media has the ability to expand and contract movement, thus directing the way viewers experience and spend their time. Editing time-based images through increments of time determined by the golden ratio may streamline messages, isolating what is most symbolic and effectively communicative within a mathematical framework. Through thoughtful reduction, a physiological and psychological benefit is created for viewers; there is no wasted time or space.

Notes:

1. Peripheral terms and synonyms for the golden ratio include golden section, golden proportion, golden mean, golden cut and Divine Proportion.
2. Zeising, Adolf, *Aesthetic Research* ( Frankfurt a. M.: Verlag vonHeidinger John & Company,1855 ).
3. Manovich, Lev, *The Language of New Media* (Cambridge, Massachusetts: The MIT Press, 2001), 50.
4. It is worth mentioning that both directors began their careers as photographers, and carefully considered the golden ratio with regards to two-dimensional shot composition. This topic has been heavily explored and researched in many other media, and is therefore not pursued in this thesis. However, an early analysis of the golden ratio in the two-dimensional composition of both 2001: A Space Odyssey and *The Battleship Potemkin* is offered in the process documentation.
5. This groundbreaking massacre scene would inspire many a homage in later films, such as Francis Ford Coppolla's *The Godfather*, Brian De Palma's *The Untouchables*, and Woody Allen's *Bananas*, to name a select few.
6. Arnheim, Rudolph, "A Review of Proportion" in *Toward a Psychology of Art* (Berkeley and Los Angeles: University of California Press, 1966), 103–109.
7. The slightest addition of movement to any static image leads one to perceive time within that image.  
Thus, time-based media may take the form of anything from cinema to commercial advertisements, web banners, animation, digital video, television, and so on.
8. Arnheim, Rudolph, *Film as Art* ( Berkeley, Los Angeles, London: University of California Press, 1957).
9. Manovich, Lev, *The Language of New Media*(Cambridge, Massachusetts: The MIT Press, 2001 ), 274.
10. Manovich, Lev, *The Language of New Media* (Cambridge, Massachusetts: The MIT Press, 2001 ), 147.
11. Arnheim, Rudolph, "A Review of Proportion" in *Toward a Psychology of Art* ( Berkeley, Los Angeles, London: University of California Press, 1966 ).
12. "The Edible Metaphor" ( PeterKubelka, lecture, February 12, 2006).

13. Fiennes, Sohie( Dir. ), *The Pervert's Guide to Cinema*. P Guide Ltd. 2006.
14. Benjamin, Walter, "The Work of Art in the Age of Mechanical Reproduction" in *Illuminations* (Schocken, New York: Schocken, 1968).
15. Barthes, Roland, "Diderot, Brecht, Eisenstein" in *Image, Music, Text* (London: Fontana Press, 1977).

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