

# University of Otago



## Making the Abstract Tangible: Computer Generated Images and the Science Documentary

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## ABSTRACT

Documentary is an ever-developing genre and has undergone significant changes in the last two decades due to the influence of digital technologies. Advancements in these technologies now allow for the rapid creation of relatively low-cost Computer Generated Imagery (CGI). This is a totally new tool for documentary filmmakers, a tool which has enhanced their ability to make highly abstract concepts tangible for their audiences. This new ability has enabled filmmakers to tackle topics which may have been previously deemed too difficult for documentary, and have given audiences new insight into various scientific subjects. However, this new ability has also had certain negative consequences. In some cases CGI may not be the best communicative tool for a filmmaker to use. Furthermore, the stylistic decisions that filmmakers make to determine the look and feel of a CGI piece can mislead their audience and distort the truth. Through the analysis of several documentaries which make extensive use of CGI, as well as my Science Communication Masters Thesis film *Coming Clean*, a better understanding of these consequences will be developed. Additionally, some guidelines for documentary filmmakers will be proposed. These guidelines will assist producers and directors to make informed decisions about how and why CGI should be used in a science documentary.

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## FOCUSING QUESTION

How has CGI affected the ways in which science documentary filmmakers attempt to make abstract concepts tangible for their audiences and what are the perceived consequences of this development?

## INTRODUCTION

The documentary *Coming Clean* (2011) was completed as the primary part of my Science Communication Masters Thesis. It is a 25 minute documentary which makes extensive use of Computer Generated Imagery (CGI) in its attempt to explain New Zealand's Emissions Trading Scheme. The scheme is an excellent example of a very complicated and abstract concept which would have been difficult to explain using traditional documentary techniques. This was the first opportunity I had ever had to use CGI in a documentary film, and it made me curious about the effects of this technology. CGI represents a profound change in the way filmmakers communicate with their audiences. It allows them to recreate locations and epochs never seen before by humans, to conjure up images of animals that became extinct millions of ago, to graphically represent sub-atomic matter, and to visualise massive, previously un-knowable data sets for their viewers. CGI allows the filmmaker to make the abstract tangible. This ability should have made the communication of scientific information easier than ever before. However, with this great advancement in technology there have been related consequences. Documentary has always relied on establishing a degree of trust with its audience, and much of this trust

is connected with traditional stylistic techniques. As Rodger Silverstone puts it 'The plausibility of a documentary film lies in its naturalization, in its internal coherence and in its matching of its own reality to a reality which 'everyone knows' (Silverstone 1985). CGI allows filmmakers to alter, replace and construct images on a scale never known before, and herein lies the problem. Audiences who have only ever known images of an analog nature: images which were exceedingly hard to tamper with or alter, may not be ready to fully question the authenticity of the digital images before them (Winston 1995). Furthermore, there is no guarantee that using CGI will enhance viewer comprehension, and in some cases, the opposite may be true. CGI can be crafted in a myriad of ways, and to many different ends. It can be more, or less, effective at communicating information depending on how it is integrated into a documentary and what stylistic choices a filmmaker makes about its look and feel.

Chapter 1 will cover some background information regarding CGI. Section 1.1 covers the ancestry of information graphics, and the beginnings of CGI as seen in Hollywood feature films. This history is important when considering CGI in its wider cultural context. Section 1.2 addresses the technological reasons behind CGI's shift from being the exclusive domain of large-budget Hollywood films, to a tool that is accessible to almost anyone with a basic computer. This shift is the main reason behind the widespread use of CGI in contemporary science documentaries. Section 1.3 will briefly discuss some of the functions that CGI can serve for documentary filmmakers, and Section 1.4 will cover some of the consequences of these uses. The relationship between these functions and consequences is central to this discussion.



Chapter 2 will cover several theories applicable to the use of CGI in science documentaries. The documentary 'modes' discussed in section 2.1 are an important piece of theory which allow us to place documentaries in certain categories based on their overall organisation and intentions. The initial emergence of CGI in documentaries such as the BBC's *Walking with Dinosaurs* was met with much critical contempt, and this viewpoint, based mainly in modernist theory, will be discussed in section 2.2. A more forgiving approach to the function of technology in communication is seen with Critical Theory. Section 2.3 will cover this idea, and the wider context in which it places cultural artifacts like the science documentary. Another approach to the use of CGI in documentary can be centred around theories concerning static information graphics, and Section 2.4 will highlight the similarities between this genre and documentary. These theories will also be of assistance when appraising the examples evaluated in Chapter 3. Lastly, the assumption that CGI is beneficial in terms of communication of information will be discussed in Section 2.5 and two key principles regarding the efficacy of CGI highlighted.

Chapter 3 will focus on a discussion of three documentaries which have each used CGI in very different ways. Section 3.1 looks at *The Elegant Universe*, which uses CGI in an immersive fashion in order to depict the strange world of quantum physics and the scientific theories relating to it. In Section 3.2, *Britain From Above* uses CGI to make highly abstract data sets into aesthetically pleasing animations which give its audience a different look at the United Kingdom. Finally, in Section 3.3 my own documentary, *Coming Clean* will be discussed. *Coming Clean* uses CGI to explain the government policy behind New

Zealand's Emissions Trading Scheme. Each of these documentaries see CGI functioning in a different manner, and each use of CGI has its own set of consequences.

Chapter 4 attempts to draw some lessons from this discussion of CGI. It sets out three very general questions, or discussion points, which documentary filmmakers can use to aid their use of CGI. It is hoped that these points will heighten filmmakers' awareness of the consequences of using CGI, and the ways in which CGI can be used most effectively. Once this awareness is fostered, decisions on how to best approach CGI can be made in an informed manner. These decisions will enable filmmakers to make the abstract tangible in the best possible manner, and with the fewest repercussions.

## 1.0 INTRODUCTION TO COMPUTER GENERATED IMAGERY

The entire process of filmmaking has undergone a profound transformation in the past three decades. At the heart of this change has been digitisation. In 2011, every part of filmmaking from scriptwriting to distribution can be accomplished by digital means. With the move to digital has come technology which makes it possible to create Computer Generated Imagery. This technology can run the gamut from small on-screen overlays of text and graphics to full blown Three-Dimensional (3D) photo-real recreations.

### 1.1 History of CGI

The practice of CGI may be fairly recent, but graphical representations of information certainly are not. Indeed, many written languages initially started as pictorial representations (Tversky and Bauer Morrison 2002). In 1876 William Playfair published the first statistical graphs to display data about the economy of 18th century England in *The Commercial and Political Atlas* (Funkhouser 1937). The year 1968 saw what is thought to be the first example of CGI, when a team of Russian physicists and mathematicians developed a model of a walking cat (Konstantinov 1968). This was printed out and then transferred to film. From the 1980s onwards CGI exploded in use, especially in feature films. *Looker* (1981) featured the first CGI 3D human body, and *Star Trek II: The wrath of Khan* (1982) the first fractal-based landscape. 3D animation is a type of animation that involves objects and scenes with true depth (Kerlow 2004). The first occurrence of 'photo-

realistic' CGI is debatable, but is thought to have been seen in *Jurassic Park* (1993). The huge cost of creating CGI in these early years is the main reason why it was seldom seen outside of large-budget Hollywood films, but as the costs of powerful computers has decreased, CGI has moved outside the realm of feature films.

## 1.2 Technological Origins of CGI

It must be emphasised that the increasingly widespread use of CGI since the 1980s can be linked to one main historical trend: the increasing power, and decreasing costs, of computers. The term 'Moore's Law' describes the 50 year trend which has seen the number of transistors that can be economically placed on an integrated circuit (the 'brains' of a computer) double every two years (Moore 1965). This trend has seen the average transistor count in computers grow from 2,300 in 1971 to 2,000,000,000 in 2008 (Keyes, 2009). This dramatic increase has meant that computers powerful enough to create photo-realistic CGI can now be purchased for several hundred dollars, as compared to several hundred thousand dollars in the early 1990s (Kerlow, 2004). Alongside these powerful computers has developed the software and hardware necessary to create CGI. If it were not for this rapid technological development modern filmmakers would not have the tools that they do today.

## 1.3 Functions of CGI in Science Documentaries

As shall be discussed, the uses of CGI in the science documentaries are many. Occasionally it may be used solely for the purpose of entertainment: to keep the audience enthralled. Most often though, entertainment is a byproduct of good science communication, and so CGI is usually not used for this purpose alone. One area where CGI has been used extensively is in recreations. This may be the recreation of a former time or place, or of a scene beyond that which current camera technology allows us to see. Or it may be the animation of an animal or person who no longer exists. Allowing the audience to glimpse something which their eyes, or a camera, may never be able to actually look upon is an incredibly powerful tool for filmmakers. Working in the 'explanatory' mode of documentary, another use of CGI can be in the visualisation of abstract data sets (Nichols 1997). Computers have enabled measurement and collection of data on a massive scale, but a tool such as CGI is required in order to arrange this data in a way which is comprehensible to an audience. A third use of CGI, also explanatory, can be in the visualisation of abstract concepts. This is often in a form similar to static information graphics. Human beings are very good at understanding and interpreting remarkably dense and complicated representations of information, as long as this information is presented in an appropriate fashion (Tufte 2006). This is the basic theory behind CGI.

#### 1.4 Consequences of CGI

The advantages of CGI are not without certain consequences. As has already been mentioned, when representations of reality are created, truth becomes a problem. This is not a new issue, and is as old as the documentary genre itself. One of the first documentaries made, *Nanook of the North* (Flaherty 1922) has been accused many times over of misrepresenting reality (DelGaudio 1997). The fact is that every documentary makes some kind of 'truth claim', and this has been true since the genre began (Renov 1986). A documentary audience expects to be told the truth, and for the most part are exceptionally trusting of what is being shown on-screen (Winston 1995). In truth, the simple act of pointing the camera at one subject and not another is enough to distort reality to some degree, but this issue has been amplified many times over through the use of CGI, which allows photo-real representations of objects or places that may never have even existed. Andrew Darley takes particular issue with this phenomenon, as will be discussed later.

It is also important to point out that the problems arising from creating filmic representations of that which does not exist in a concrete 'real-world' form existed in the time before CGI. Documentary filmmakers have always used techniques 'to show the imperceptible and to render the invisible imaginable, television producers, from the very onset, have wielded an array of visual and rhetorical strategies to visualize and narrate what science can never show and tell' (Van Dijck 2006). Accordingly, there have been many different techniques adapted to overcome this problem. A classic example is seen with the 1981 BBC *Horizon* programme *The Death of the Dinosaurs* (Silverstone 1984). This show used paintings to depict the dinosaurs which, for obvious reasons, were unable to be

filmed (Darley 2003). Other techniques before the arrival of CGI included the use of miniatures, often in combination with stop-motion animation. These techniques are no less vulnerable than CGI to the problems already discussed. Also widely used (and still in use today) have been devices of metaphor and analogy to describe that which cannot be filmed. These have also been criticised by theorists (Van Dijck 2006). This is because analogies and metaphors are never neutral: they always have attached meanings and any attempt to graft them onto scientific theories or assumptions can run into problems.

## 2.0 THEORIES CONCERNING CGI AND SCIENCE DOCUMENTARIES

There are several different threads to theoretical thought on CGI in science documentaries. Firstly there is the approach from communications theory, which draws on more modernist and post-modernist thinking. There is also a strong counter-argument to many of these ideas. It is also possible to apply much of the theory built around information graphics to CGI.

### 2.1 Documentary Modes

Although it does not refer specifically to CGI, it is important to make mention of Bill Nichols' modes of representation. In *Representing Reality* (1991) Nichols identifies four modes which 'stand out as the dominant organisational patterns around which most texts are structured' (Nichols 1991). Documentary in its *expository* mode attempts to take historical information and interpret this in a new way (DelGaudio 1997). The *observational* mode tries to moralise less than the expository mode, and is less intrusive on its subjects. It tends to avoid narration or explicit interpretation by the filmmaker. *Interactive* documentary attempts to involve the filmmaker, their views and their story more in the narrative. Finally, the *reflexive* mode arises from a desire to 'challenge the impression of reality which the other three modes normally conveyed unproblematically' (Nichols 1991). The reflexive mode tries to be more honest about its style and techniques, while questioning 'the fabricated nature of the image as a mere function of the text



itself' (DelGaudio 1997). These classifications work well for traditional documentaries but things become more complicated when we factor in CGI. Sybil DelGaudio has tried to tackle this issue in the article 'If Truth be Told, Can 'Toons Tell it? Documentary and Animation' (DelGaudio 1997). She points out that 'since an animated film 'exists' only when it is projected - there is no pre-existing reality, no pro-filmic event captured in its occurrence - its classification as documentary can be problematic' (DelGaudio 1997). She posits that CGI and animation in documentary is a form of recreation that serves as 'compensation for the camera's non-presence' (DelGaudio 1997). DelGaudio does not make any broad assumptions on where CGI and documentary fit into Nichols' modes of representation, instead concluding that CGI can be used well in the reflexive mode, where it pushes the viewer to question all assumptions about representations of reality (DelGaudio 1997). In addition to Nichols' modes, Van Dijck believes that the 'realist paradigm in science documentary has been compromised each time innovative (tele)visual styles and expansive narrative modes were pushed to the fore' (Van Dijck 2006). She sees a new 'speculative' mode emerging with this shift. Also closely related is a new 'reconstructive' mode. Neither of these modes require 'real-life' footage, and can utilise technologies such as CGI in order to create accompanying visuals. They also do not necessarily require wholly validated scientific claims as their narrative basis: hence the term 'speculative'.

## 2.2 The Modernist Approach

Andrew Darley has analysed the BBC series *Walking with Dinosaurs* (1999), which is an almost entirely CGI-based series that attempts to recreate scenes from the Mesozoic era (Darley 2003). Darley contends that while *Walking with Dinosaurs* is a massive shift in the way science documentaries are produced (due to its CGI nature), because it adopts many of the traditional stylistic techniques that documentary has built up during its lifetime. These techniques include the simulation of a wobbly, handheld camera with focus pulls and an omnipotent narrator. Darley calls this a 'representative reality', one which is 'technologically sophisticated but rhetorically naive' (Darley 2003). He believes this is done to try and gain the trust of the audience, and to give an instant form of credence to the series. This is termed *simulation*. He also addresses another concept known as *pastiche*. This has more to do with the narrative style of the series, which includes undeniably 'constructed' drama, in an attempt to heighten the tension in the narrative and excite the audience. To this end Darley focuses on the narration script, which is laced with the stylistic hallmarks of traditional BBC fare. In summary, Darley is exceptionally suspicious of this incarnation of the traditional science documentary. He goes as far as dubbing the style 'edutainment', and does not attempt to hide his contempt for it (Northcut 2007).

### 2.3 Critical Theory

Following the same line of thought as Darley, but coming to different conclusions, is Andrew Feenberg. He is of the opinion that critics such as Darley construct too much of an opposition between humans and technology (Northcut 2007). The basis of this opposition is in an idea that humans and the natural world are sacred, and technology is an evil

which attempts to undo us (Feenberg 1991). Feenberg feels that technology is merely a tool, which humans use to their own ends. He contends that there is nothing inherently evil about technology. However he also indicates that these tools can have effects which are hard, if not impossible, to predict. Technologies tend to shape societies and cultures rather than the cultures ruling the technologies. Once these first two ideas are accepted and accounted for, Feenberg thinks it is possible that a state could be arrived at where 'humans control the technologies and deploy tools in positive ways, toward desirable ends' (Northcut 2007). This is known as 'Critical Theory'. If we are to re-evaluate *Walking with Dinosaurs* from this perspective, the outcomes are rather different to those of Darley. From the standpoint of Critical Theory, *Walking with Dinosaurs* is at worst misguided, and is basically a well-meaning use of technology. Any pitfalls associated with the use of CGI are not the fault of technology, they are the fault of the humans using of it. Works such as *Walking with Dinosaurs* become technological artifacts of our culture, and will be viewed this way in hindsight (Northcut 2007). They are not an attempt to deceive or mislead in any serious manner. At the heart of Feenberg's thinking is the idea that we need to be more conscious of the ways we use technologies in communication. As this relates to CGI, it would be desirable for filmmakers to sit down and carefully consider their reasons for using it in any given instance. Questions might be asked as to whether CGI was being used for education or entertainment, what the factual basis for any reconstructions were, or how audiences might misinterpret or be misled by a given piece of CGI. Feenberg's ideas are more constructive in that they present a solution to Darley's problem. They set out a way for filmmakers and people in all forms of communication to double check what they are doing, and hopefully improve the way CGI technologies are utilised.

## 2.4 Tufte and Information Graphics

Coming from the viewpoint of static information graphics, Edward Tufte has some interesting insights which are very relevant for CGI. Tufte is a statistician by training and believes 'that quantification is a skill which can be mastered' (Northcut 2007). He also believes that making an 'evidence presentation' (his terminology for using data to support an argument) is a moral activity as well as an intellectual one, and that ultimately the presenters of this information should be ethically responsible for the information which they show and tell (Tufte 2006). He has little sympathy for the misuse of graphics and believes that 'if information graphics are properly developed, with a complete understanding of the data and the relevant generic conventions, then such graphics can be produced correctly; otherwise they are flawed' (Northcut 2007).

Tufte believes that visual representations should be thoroughly integrated within the pieces of work they relate to rather than in an appendix, an area where documentary would seem to be at an advantage compared to the limitations inherent in print technology. Tufte also believes in reducing the information presented down to the bare essentials, and regards 'clutter' in information design to be unacceptable, calling it 'a failure of design, not an attribute of information'. As a proponent of matching visual data and the images to which it relates (as in the overlaying of data onto a photograph), Tufte uses the term 'Visual Mapping' to describe what he sees as being one of the most useful ways to display information. This is because the audience can relate directly to the data

being shown and its relationship with the real world, rather than there being a disconnect between the data and the subject.

Tufte also has an opinion on the use of labels and arrows in diagrams, another area which readily relates to the display of information in documentaries. He feels that arrows are too often homogenous in their appearance, even though multiple arrows in a single diagram can have completely different meanings. In this way the focus on causality (usually the main reason why arrows are used) is lost and the information not communicated in the clearest way possible (Tufte 1991). The same stands for labels, whereby an overabundance of information is made even worse by a lack of distinction between labels. In both cases the solution in Tufte's opinion is to use colour, form, annotation and structure to make the communication of information more precise. Interestingly, he also believes that the same person should do both the research and the design for information graphics because this amplifies the content and ensures quality.

Finally, Tufte also examines the role of the 'confection' in information graphics. A confection is 'an assembly of many visual events, selected from various Streams of Story, then brought together and juxtaposed on the still flatland of paper... combining the real and imagined, and telling us yet another story' (Tufte 1997). This is an interesting way of approaching the role of information graphics in storytelling. He views this role as being most important when condensing a large amount of information (perhaps over time, or over various layers of complexity) down into a form which can be quickly, and more importantly, easily digested. This is an incredibly important factor in documentary, where

time constraints are often more pressing than for mediums such as print, and also where the audiences may be broader and therefore more explication needed. Tufte gives us some important insights into how the use of CGI can be made more efficient in science documentaries.

## 2.5 Efficacy of CGI in Communication

To discuss the role of CGI in making the abstract tangible, we must first establish that CGI is an efficient way of communicating scientific information. Any kind of judgement in this regard comes with many caveats, but is nonetheless possible. Tversky and Bauer Morrison (2002) are interested in this very question. They posit that CGI is beneficial in most cases, but that there are some situations where it can impair communication. They begin with the basic assumption that:

‘Graphics provide an additional way of representing information; two codes, pictorial and verbal, are better than one. Graphics may be aesthetically appealing or humorous, attracting attention and maintaining motivation. Graphics, as the saying goes, may save words by showing things that would otherwise need many words to describe.’ (Tversky and Bauer Morrison 2002)

Because CGI often involves temporal and spatial manipulations of information, this is assumed to be of assistance to viewers because it reduces the burden of both processing and memory when understanding certain concepts (Tversky and Bauer Morrison 2002). Tversky and Bauer Morrison make a division between two specific types of visualisations: those that portray ‘visuospatial’ information, an example being maps, and those that

'represent things that are not inherently visual, like organization charts, flow diagrams, and graphs' (Tversky and Bauer Morrison 2002). They mention that there is often a heavy reliance on visual metaphors when non-visuospatial concepts are being visualised. Also highlighted is the fact that visualisations of subject matter that is 'essentially visual' are a tradition as old as language itself as many languages started as pictorial representations. From this it follows that CGI can be a highly effective way of communicating information.

The second part of this analysis posits that 'graphics are not always effective, or put differently, not all graphics are effective in all situations' (Tversky and Bauer Morrison 2002). This conclusion is reached by comparing static and animated CGI information graphics which contain the same information. In one example a graphic representing Newton's laws of motion was compared to an animated one. Tversky and Bauer Morrison conclude that because the static graphic had accompanying text and labels which showed the written form of the laws, the static graphic was more efficient in terms of communication. However the animated version was simply an animation of the static graphic without the supporting explanatory text. It could easily have been enhanced by the addition of some metaphorical device that could have aided comprehension. As this idea relates to documentary, it may be that a live-action sequence showing a soccer ball being kicked would assist comprehension more than a subtly animated information graphic showing the laws of motion in diagrammatic form. This is known as the 'Congruence Principle' (Tversky and Bauer Morrison 2002). Tversky and Bauer Morrison also address several other problems, such as animated CGI encouraging notions of natural systems as being made up of discrete steps and smooth motions when in reality they are

highly 'analog' in nature. Another problem they perceive with animated CGI is that it lacks interactivity. This is a problem because interactivity can help to overcome problems involving perception and comprehension and is known as the 'Apprehension Principle' (Tversky and Bauer Morrison 2002).

Tversky and Bauer Morrison conclude that while there are many caveats to assessing CGI, there are some simple conditions which can ensure it is utilised effectively. In relation to the Congruence Principle, CGI needs to show a correlation between temporal changes and changes in the 'essential conceptual information to be conveyed' (Tversky and Bauer Morrison 2002). This highlights the difference between static and animated information graphics. It also explains the difference between a static graphic being repurposed for documentary versus a live-action metaphor, as seen with the Newtonian example. CGI may not be the most effective method of communication in some situations. In order to satisfy the Apprehension Principle, CGI needs to be paced appropriately and be presented in a clear fashion. This allows the audience to comprehend temporal changes and understand the meanings arising from these changes. Interestingly, for this reason it is suggested that CGI 'lean toward the schematic and away from the realistic' (Tversky and Bauer Morrison 2002). Tversky and Bauer Morrison's principles will be useful when analysing the use of CGI in the examples which follow.



### 3.0 THREE DIFFERENT APPLICATIONS OF CGI IN SCIENCE

#### DOCUMENTARIES

Documentary filmmakers have been swift to adopt CGI technologies, and examples of this can be seen in many films. The following two documentaries have been chosen because they use CGI in very different ways. Following this I will discuss my own film.

#### 3.1 String Theory Comes to Life: *The Elegant Universe*

‘The decision to use animation, to use a lot of it, was completely essential to the process, because when you’re doing that project about string theory, when you’re talking about things that really cannot be seen, that can only be imagined, I don’t know any other way to do it than through metaphor and animation.’ (Paula S. Apseil, senior executive producer of *The Elegant Universe*, cited in Van Dijck 2003)

*The Elegant Universe* (PBS) may well be one the most interesting examples of a series that made the abstract tangible. Created in association with the show NOVA, the series takes its name from a book published by physicist Brian Greene. Greene also acts as the host for *The Elegant Universe*. The programme attempts to guide the viewer through the concept of string theory and the world of quantum physics. Not only is the subject matter so abstract as to be totally unobservable by traditional means, the approach taken by the series is rather novel. Throughout the show, Brian Greene is manipulated by digital

means. He will begin a shot talking directly to the viewer while superimposed over traffic in New York's Times Square, only for the camera to pan around and reveal him still talking while seen on a billboard in the distance (Van Dijck 2006). By these very literal means the show is attempting to depict how different the world of quantum physics is to our own known existence: quantum theory posits 11 different dimensions. CGI in *The Elegant Universe* is in this sense a very long way removed from traditional documentary CGI, but it would seem that its intentions are still related. Where more traditional uses of CGI strive to make sense of known data so that the viewer may consume it more easily, working in the speculative mode, *The Elegant Universe* attempts to thoroughly confuse the viewer in order to communicate to them how unbelievably different the rules governing the world of quantum physics really are. It seems the producers of *The Elegant Universe* decided this was the best way to acquaint their audience with the theories contained in the show.

*The Elegant Universe* also manages to use analogies and metaphors in a completely different and novel way. These are used to explain difficult theories, as seen when Greene uses a cup of coffee and a donut to explain different shapes (Van Dijck 2006). But these are not the straightforward analogies common in traditional science documentary. Instead, CGI is used continuously to warp, animate and confuse. In the same sequence Greene's head appears on a piece of bread and then a coffee cup warps itself into a donut (Van Djick 2006). *The Elegant Universe* manages to make the abstract tangible and viewable in the most literal of ways. It is difficult to quantify the effectiveness of this style, although some indicators can be found in the academic reactions to Greene's book. The series uses many

of the same metaphors as the book, albeit visualised through a different medium. Critics such as Rachel Edford have praised Greene's use of metaphor, an example being his use of string instruments in explaining vibration and string theory (Edford 2007). This same metaphor appears numerous times during the PBS series. Jon Turney also praises it, but does mention that Greene's metaphorical strings 'are not much like a violin string or a rubber band, but these analogies are pretty much all we have to go on' (Turney 2004). In relation to the actual CGI visualisations, Tversky and Bauer Morrison's approach to CGI can be utilised. In relation to the Congruence Principle, *The Elegant Universe* is consistent in its visualisation of metaphors through CGI, and does not at any point attempt to use CGI to construct literal portrayals of the laws of quantum physics. However it cannot be said that the style of CGI in *The Elegant Universe* steers towards the 'schematic' as suggested by Tversky and Bauer Morrison (2002). Instead, the series opts to use CGI in a very realistic, almost hyper-realistic manner. However, this may be the most appropriate choice considering the subject matter. In terms of pacing and clarity *The Elegant Universe* is not always consistent, but again, this is most likely a conscious decision by the filmmakers and one that is attempting to portray the 'weirdness' of the world of quantum physics. At the very least there can be no doubt that these techniques give the viewer a good idea of how bizarre the world of quantum physics is.

Josè van Dijck (2006) contends that the style used by *The Elegant Universe* actually misrepresents some of the arguments at hand. Being a relatively new branch of physics, there is some disagreement among quantum physicists about theories. CGI assists in the creation of a rather fantastical world which features only the viewpoint of Greene and his

associates, ignoring others and glossing over a lot of the disagreements within this academic community. CGI helps to paint a picture of a more harmonious subject than that which actually exists. This point is especially important when we recall that most of quantum physics is speculation, and Greene admits as much when he tells us that there is no real way in which to verify these theories (Van Dijck 2006).

Furthermore, CGI manages to make mere hypotheses into feasible on-screen creations (Van Dijck 2006). The fact that many of these theories are unproven was apparently of no concern to the producers. The speculative mode of documentary is of course nothing new, but when filmmakers have the power to visualise anything they like it is given new impetus. An audience who does not know better could be easily forgiven for thinking that the CGI in *The Elegant Universe* is a representation of fact rather than an as-yet unverified scientific claim. For example, in an attempt to illustrate the laws of electromagnetism Greene is shown jumping off a tall building and then landing on both feet (Van Dijck 2006). This is not supposed to be taken as a reality, but the use of CGI to visualise a claim in such a hyperbolic fashion could be interpreted as being misleading. Examples like the one just given also point to a certain 'Hollywood' influence at work during parts of the show: spectacle seems to trump everything else. This is not to say that the analogies used by Greene are not effective, only that they tend towards entertainment rather than being strictly educational.

*The Elegant Universe* is a fascinating example of CGI in science documentary. Indeed, as abstract subjects go, it would be hard to find one more so than quantum

physics. Furthermore, without CGI the series would barely have been possible. As Van Dijk points out, without CGI the whole notion of string theory would not be possible: it was imagined using digital imaging techniques and multimedia devices (Van Dick 2006). Setting aside the caveats already mentioned, it would seem that *The Elegant Universe* points towards a fascinating new path for science documentary in general, one where just because a subject is un-film-able and highly complex does not mean it is considered beyond the scope of a general audience. It is not just that *The Elegant Universe* merely uses CGI, it is the way in which it uses it that is special. The CGI is so tightly wound into the structure of the series that it creates a slightly surreal world for the audience; one which is not too far off the bizarre world of quantum physics. In this instance CGI has created an entertaining exploration of a captivating new area of science. This series has proved to be a major advance in our ability to tell stories which had previously been discounted as being too abstract in nature.

### 3.2 From Database to Screen: *Britain From Above*

*Britain From Above* (2008) is a 6 part series produced by the BBC and hosted by the journalist Andrew Marr. The series is technically sophisticated, featuring high quality CGI and utilising highly refined production techniques which lend a visual complexity and lustre to the production. It attempts to visualise life in the United Kingdom, quite literally, from above. This involves a large amount of CGI in combination with live-action footage, and is a very clear example of CGI being used to make the abstract tangible.

Since much of *Britain From Above* qualifies as information graphics, it makes sense to discuss it in that light. The visual approach employed in *Britain From Above* is consistent with Edward Tufte's concept of 'Visual Mapping' (Tufte 2006). In one particular example, the programme uses Global Positioning System (GPS) data from 380 London taxis over a 24 hour period (BBC 2008). One can only imagine what this dataset would look like in its raw form - an unintelligible list comprised of millions of numbers - impossible for any normal human being to fathom. The programme does manage to make this highly abstracted data digestible. Using CGI the routes of the taxis are mapped out in a time-lapse fashion over 3D satellite images of the city. This is very much in keeping with the main concept of Visual Mapping. Because it is easily comprehensible even the most cursory glance at this sequence can reveal interesting details to the audience such as the way the taxis begin to take backstreets as the city's main transport arteries become clogged in the mid-morning or the routes taken by the taxis as they circle the inner city looking for fares. Having this data overlaid on actual satellite photographs makes it far easier to absorb, and much easier for the audience to understand and relate to. In a similar vein as the taxi segment, but far more dramatic, is the sequence from *Britain From Above* featuring the flight paths of the 7500 planes that fly over the country every day. Here the audience gets to understand the smoothly orchestrated flight paths that see aircraft circling in spiral patterns over main airports before heading off around the globe on long-haul flights. *Britain From Above* also satisfies the Congruence Principle. All of the visualisations discussed show temporal change in a very straight-forward manner, one which almost any audience could comprehend. The style of the CGI used tends towards realism in terms of the maps and background images used, but is more schematic when displaying the actual

data in question. In terms of pacing and clarity, the series is well structured and moves at a relatively slow pace in comparison to *The Elegant Universe*.

*Britain From Above* is more difficult to critique than the other documentaries discussed because it has no obvious agenda and is not speculative in any sense. There are no scientific claims to be verified and the whole series works very much in the reflexive mode, discussing its own motivations and techniques as it goes. The data and theories behind the visualisations are not speculative, rather they are real-world data sets gathered by empirical means. The CGI present exists as entertainment, but it allows the audience to see things that previously only existed as sets of numbers. While *Walking with Dinosaurs* and *The Elegant Universe* require their audiences to make a large leap of faith because the basis for their claims is sometimes less than well established, *Britain From Above* encounters no such problems.

However, one criticism that could be levelled at the show is that it does not dig deep enough into the data which it explores. Rather, the series is made up of highly sophisticated, aesthetically pleasing, but ultimately meaningless pieces of CGI. This is a shame because while *Britain From Above* manages to make abstract data at least visually tangible, it does little to explore what these visualisations mean and in what ways they are significant. What do the routes taken by the taxis actually tell us about transport usage and issues like fuel consumption? How do the altitude and flight paths of these aircraft affect the greenhouse gases they emit? Admittedly, these kinds of questions are probably far beyond the modest scope of the series, but they highlight an interesting problem in that

while the programmes use of CGI is inoffensive, it is, arguably, not contributing as much to the audience's understanding as a programme which uses CGI in a more contentious manner like *Walking with Dinosaurs* or *The Elegant Universe*. Taking a 'birds eye' look at the nation could have provide an opportunity for some interesting introspection, as it provided a different and novel view of Britain for almost all of its inhabitants. *Britain From Above* is successful in terms of communication: it satisfies Tversky and Bauer Morrison's Congruence and Apprehension principles with ease, but does not attempt to go any further with this information. Looking at *Britain From Above* from the perspective of Andrew Feenberg's Critical Theory, it seems as though this is one use of CGI that, while inoffensive, has not managed to contribute a great amount to human knowledge. Perhaps it is not always the shift from abstract to tangible that is most important, rather, it is what filmmakers choose to do with this means of visualisation once it is in their hands.

### 3.3 Bringing Policy to Life: *Coming Clean*

My documentary *Coming Clean*, completed as the major component of my Masters of Science Communication thesis, has similarities to both *Britain From Above* and *The Elegant Universe*. For the most part it uses CGI to visualise abstract concepts, particularly elements of government legislation relating to New Zealand's Emissions Trading Scheme. It also spends a short amount of time using CGI to explain the scientific concepts behind the carbon cycle: the exchange of carbon between different reservoirs on earth and the ways in which the burning of fossils fuels affects these reservoirs. The issues relating to the Emissions Trading Scheme seemed to me to be most appropriately explained using CGI.



Not only is the scheme complicated, it has been largely ignored by New Zealand's mainstream media and as a result very few people have a proper understanding of it. Add to this the costs which it imposes on New Zealand's taxpayers, its relative inefficiency at reducing greenhouse gas emissions and the government's lack of public education about the policy and I felt that it was an important topic to address. Coming to an understanding of the policy itself involved me in several weeks of research, and the time involved in that process highlights the main reasons why this issue has not been widely canvassed – it is complex and convoluted. However, the problems posed by time, complexity and convolution can be solved through the careful use of CGI. Those weeks of reading were condensed into a 25 minute programme, around 12 minutes of which were created using CGI. The use of CGI meant the information was delivered efficiently and allowed me to sidestep traditional documentary techniques such as 'talking head' interviews to explain the concepts. CGI also allowed me to largely avoid the narrative use of metaphors and analogy when explaining the scheme because CGI could communicate these concepts directly. *Coming Clean* spends most of its time working in an expository mode. However, there are several important instances where it shifts into a speculative mode, mainly in relation to forecasted figures involving taxpayer costs, and also when discussing climate change. It is interesting to note that early drafts of the script included several highly reflexive moments such as when the narrator interacted with and talked to the visuals. These were later dropped from the script due to time constraints. Although feedback so far has been positive, with viewers reporting that they now understand the scheme thanks to the documentary, I have some misgivings about the style of the CGI which I decided to use.

Figure 1 - Static frame from *Coming Clean* (2011) showing paper models.



Parts of the CGI found in *Coming Clean* have background images which were created in-camera, an example being the small grey paper-fold factories seen throughout the documentary which stand in as shorthand for 'polluters' and occasionally as symbols for heavy industry. The factories and trees seen in Figure 1 are constructed from paper and then shot as single images using a stop-motion technique. These single frames are then assembled into a video file. These video backgrounds are then overlaid with CGI in the form of graphs, clouds, text etc. The CGI strokes have an organic look to them and were programmed to give a slight wiggle several times a second in an imitation of hand-drawn cell animation. This was mainly an aesthetic choice, but it may also have unforeseen repercussions. Because this style of animation relies so heavily on the traditional look of cell and stop-motion animation it is a kind simulation of the sort discussed by Andrew

Darley (2003). Both stop-motion and cell animation existed long before computers: stop-motion being shot on film cameras, and cell animation being done with various media on paper or acetate. In contrast to those methodologies, my techniques were purely digital. The metaphorical trees and factories may have existed in their paper real-world form, but the capture of their image was done using a digital camera. The images were then manipulated using several pieces of software before the final video file was produced. Specifically: the frames were often shot in sets of 2 identical frames with a chroma pink background behind the main object(s) in one of those 2 frames. This technique (known as 'checker boarding') allowed me to separate the foreground and background objects in each shot for the manipulation of timing, colour, the addition of new objects or the duplication of existing ones etc. As well as this the colours of all the objects were manipulated and generally enhanced. Hence, although the stop-motion style may be associated with a more traditional form of animation, my technique veered away from traditional methods. The same goes for the CGI overlays which are used to present graphs, figures, labels, etc. The wiggle that is often associated with cell animation comes from the misalignment of pieces of paper or acetate used by the animator when the images are photographed. This wiggle is traditionally regarded as an error in cell animation but has found fashion recently because of the more 'organic' look that it can lend to digital animations. My animations, however, were created entirely in a computer, and need never have had any wiggle in them at all as computers allow for pixel-perfect alignment. Again, this was a purely stylistic decision.

As discussed, these decisions were made for purely aesthetic reasons. However, in hindsight it may be that other factors were at play. As highlighted by Andrew Darley, we tend to associate traditional techniques be it in music, photography, or painting, as being better and more worthy than their modern, digital counterparts simply because they are traditional (Darley 2003). They are perceived as being from a simpler and more wholesome time, and are viewed as trustworthy. This kind of nostalgia is why the BBC chose to use a traditional style of narrative in a documentary (*Walking with Dinosaurs*) that was in other respects totally different to any documentary that had come before (Darley 2003). The BBC seemed to want to make every possible effort to accommodate their audience with a style that would be inline with the traditional natural history documentaries to which they were accustomed (Darley 2003). It was a style which had been used for decades and would be easily accepted by their audience. In the same way *Coming Clean* uses this type of pastiche. I chose to use a visual style which harks back to a time which many people may associate with credibility. In retrospect, this may not have been an entirely accidental decision, but the decision making was certainly subconscious. Because the documentary deals with issues of climate change and government policy, I surmised that its audience was most likely to fall in the 20+ age bracket. I suspect (from purely anecdotal evidence) that this may actually be closer to 30+. Accordingly, I knew when I began my film that bright neon colours and fast moving CGI were less likely to appeal to my target audience, and herein lies the reasoning behind the aesthetic approach that I chose to adopt. I wanted a more homely look, one that would resonate with older viewers and would elicit a trusting response for the content. Just as the BBC may not have set out to deceive people with the style it used for *Walking with Dinosaurs*, I did not wish

to deceive anyone with *Coming Clean*, but it may be that in a stylistic sense at least, the CGI in my documentary grew from a desire to develop a trusting relationship with the audience in order to better communicate the science. For *Coming Clean* the end result of these stylistic decisions is essentially the attempt to build trust, and much of what is relevant in Darley's critique of *Walking with Dinosaurs* would relate to the aesthetic decisions I made for my CGI, albeit, I hope, to a lesser degree.

Figure 2 - Static frame from *Coming Clean* (2011) showing animated pie graphs.

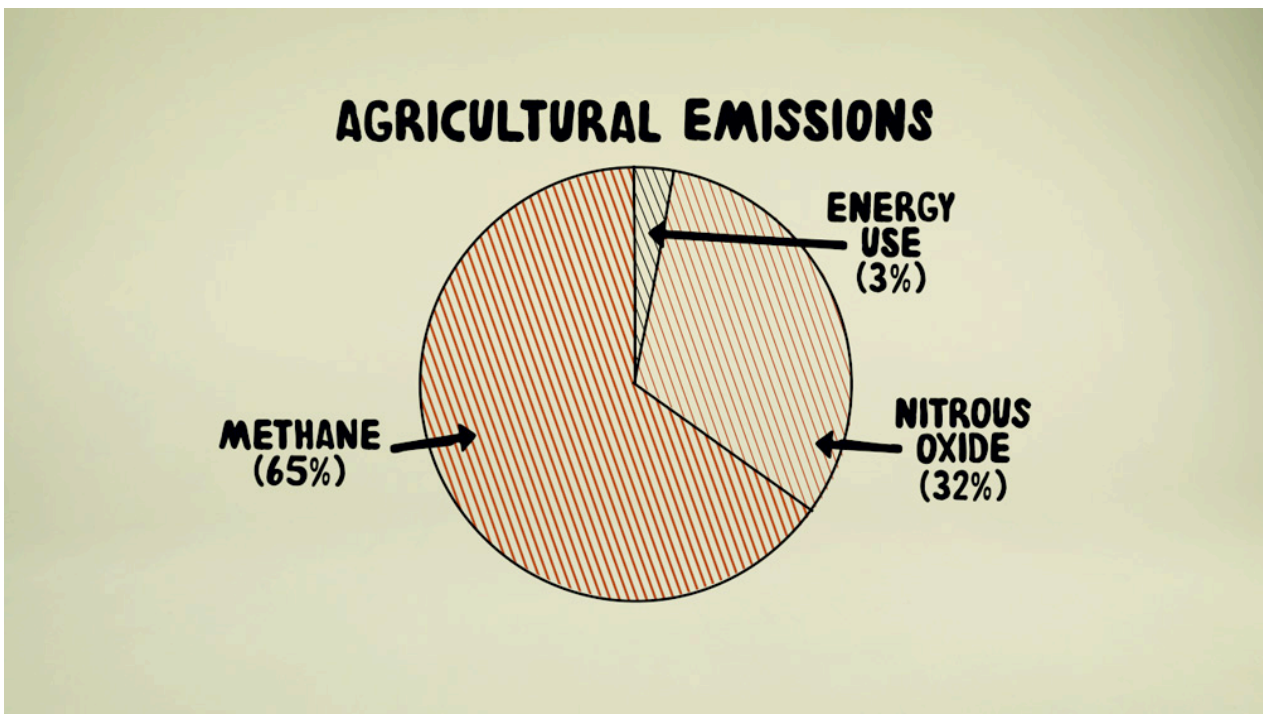
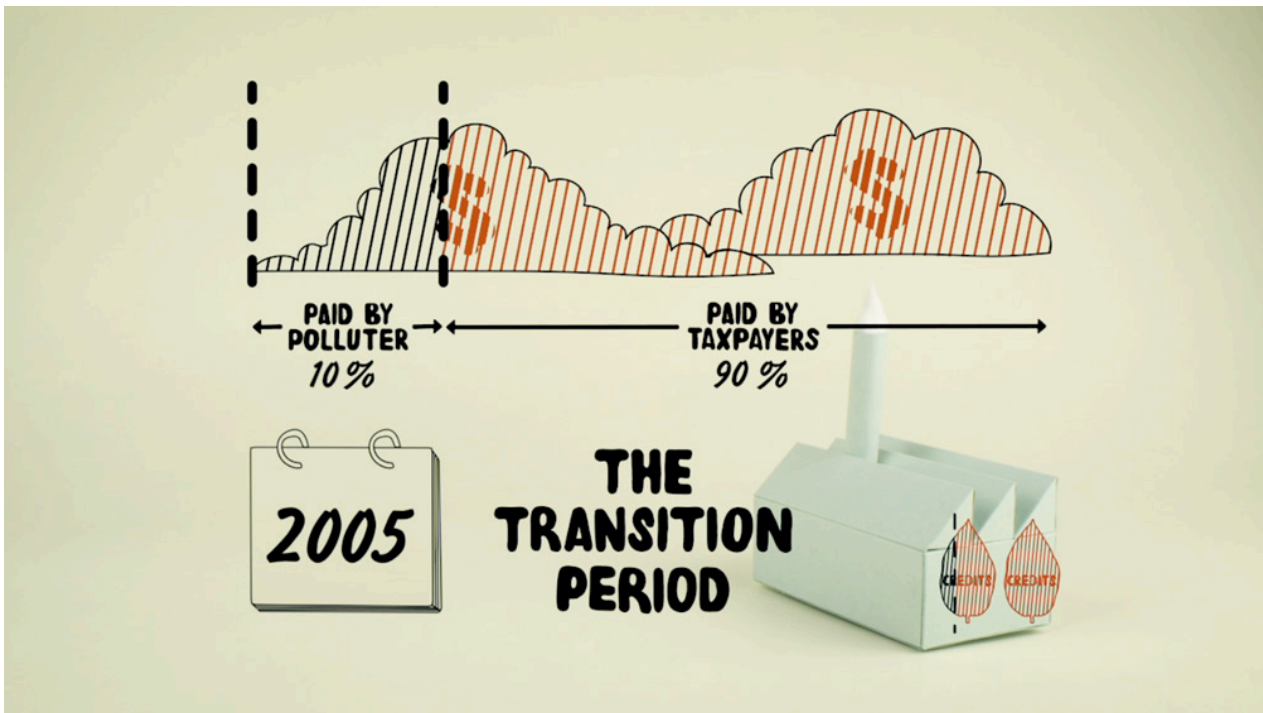


Figure 3 - Static frame from *Coming Clean* (2011) showing 'ETS in NZ' CGI.



Viewed in light of Tversky and Bauer Morrison's guidelines, *Coming Clean* would appear to operate in accordance with the Congruence Principle for the most part. There are sections of CGI which are less effective, for example, the graphs seen at 17:23 are merely animated versions of static pie charts (see figure 2). These are possibly not as efficient in terms of communication. However, there are other sections such as the 'ETS in NZ' chapter (beginning at 8:25 and shown in Figure 3) which do use CGI to efficiently show temporal change, and these changes work as an aid to the comprehension of the information being presented. One area of the Congruence Principle where *Coming Clean* excels in is the style of its CGI. As per Tversky and Bauer Morrison's suggestions this style is highly schematic. It also aligns with their assumption that metaphors are widely used when creating non-visuospatial visualisations. One reoccurring metaphor in *Coming Clean* is the black clouds that are used to represent 'emissions'. The pacing of the CGI in *Coming*

*Clean* is not always as slow as I would have liked, an example being seen with the aforementioned graphs at 17:23. This is the result of attempting to fit a lot of information into a relatively short space of time (25 minutes). I am unsure whether these pacing issues are an actual hinderance to comprehension, but they exist nonetheless.

This discussion essentially leads back to the idea of Critical Theory. Every single time technology is engaged in communication, the communicator needs to assess the reasons for, and results of, it's use. In the case of *Coming Clean* the technology was CGI , and was an essential part of communicating the government policy of the Emissions Trading Scheme to my audience. It is hard to judge whether or not the stylistic decisions which went along with this CGI are deceitful. Because *Coming Clean* spends most of its time working in an explanatory mode, the style of the CGI was mainly devised as an aid to understanding. There are however several sections where the documentary moves into a speculative mode. As mentioned, one example is where predictions are being made about the long term costs of the ETS to taxpayers. These figures are drawn from reliable sources but like any prediction they rely on a certain amount of guess work particularly in the statistics relating to New Zealand's total greenhouse gas emissions and the market price of carbon. This is one scenario where I feel less comfortable about the style of my CGI. While I am confident that the predictions the documentary makes are accurate, I certainly hope the stylistic decisions I made did not lead my audience to be any less skeptical of the information relating to this topic than that which is usually fed to them through the evening news.

#### 4.0 SUGGESTIONS FOR FILMMAKERS UTILISING CGI

The adoption of CGI by documentary filmmakers is a relatively new practice and there is of course a 'teething period' that comes with this adoption. There will be mistakes made, and hopefully, these will prove to be valuable learning experiences for those involved. What is important is that CGI be used in a practical and responsible fashion. To that end I wish to discuss some questions that filmmakers should seriously ponder when contemplating the use of CGI. These questions are largely prompted by the work of Andrew Feenberg and his Critical Theory of Technology. Of all the theories discussed this is the most constructive, as it encourages filmmakers to step back and view their decisions from a distance. Criteria for the analysis of information graphics can also be helpful in some instances, but they are usually too specific to be of value in a general discussion such as this. These points would also work well in association with the principles outlined by Tversky and Bauer Morrison (2002).

Critical Theory works well as a basis for assessing the effects of CGI. It reminds filmmakers that their work exists in a larger cultural space, and that they have certain responsibilities to their audience (Northcut, 2007). The first thing that needs to be considered is the narrative mode in which the CGI will be working. Is it explanatory or speculative? As soon as CGI is used in the speculative mode a filmmaker needs to ensure they are making the most appropriate decisions. The burden of proof always lies with the filmmaker but when working in the speculative mode they must be sure that the stylistic



devices being used are not deceptive. This is no easy task as objectivity is, arguably, a nearly impossible goal. For this reason it is more appropriate for filmmakers simply to assess whether or not they are doing anything that is obviously deceptive. For example, are they using a traditional visual or narrative style where there is no need for one except to limit the skepticism of the viewer? This was an issue discussed in Chapter 2.2, in relation to *Walking with Dinosaurs* and to a lesser extent with my own film *Coming Clean*. Are they using CGI to create fantastical worlds which gloss over differences of opinion and verify untested claims as is the case with *The Elegant Universe*? These sorts of misdemeanors are not necessarily committed in a conscious fashion, and this is why stopping, deliberating and asking these significant questions is important. As I discovered with *Coming Clean*, it can be easy to make stylistic decisions without comprehending the end effect they might have. Feenberg's thinking reminds filmmakers that it is they who are in charge of CGI, and not the other way around.

Another question that a filmmaker must consider during the production process relates to the function of the CGI within the documentary. One of its prime functions is as an aid to understanding, as discussed with Tversky and Bauer Morrison (2002). There are a myriad of ways in which this can be done, including helping to make highly abstract concepts tangible, the recreation of un-filmable scenes and the visualisation of highly abstract data. However, if the purpose of a piece of CGI is merely entertainment, then perhaps there is cause for concern. 'Entertainment' in this sense may not necessarily exclude it from assisting the narrative, but if the CGI is only being used to enliven a poor storyline then it may be that it is an inappropriate approach to use. As was discussed with

*The Elegant Universe*, showing the presenter jumping off a tall building and then landing on the ground below, unharmed and on two feet, may be impressive, but may also overshadow the information that the filmmaker was trying to communicate (Van Dijk 2006). Science documentary is, after all, focussed on the effective communication of information and concepts, and anything which hinders this objective needs to be avoided. Shifts in the way programming has been delivered over the last couple of decades has meant that attention spans have shortened, and the internet as a form of distribution has only exacerbated this trend (Kilborn 1996). As a result science documentary makers have endeavoured to raise the entertainment quotient of their programmes in an attempt to retain viewers, as seen in Richard Kilborn's study of British natural history programming (Kilborn 1996). CGI is a useful tool which can assist in this attempt to retain viewers as it can create visual spectacles that traditional means of filmmaking cannot replicate. This does not necessarily detract from the programme unless it overshadows or interrupts the communication of information to the audience.

A further question that documentary filmmakers should ask would relate to what they do with their visualisations once they have been constructed. *Britain From Above* is the obvious example here. If time, energy and money is being put into the creation of CGI, it would be wise for the filmmaker to utilise the CGI in every way possible. If the abstract can be made tangible and engaging, it seems a waste not to use this opportunity and visualisation further, especially when, as shown by Tversky and Bauer Morrison (2002), it can be of great help to a viewer's comprehension. CGI spectacles which are aesthetically pleasing but ultimately empty are the domain of feature films and music videos, not

science documentaries. Filmmakers need to push past the aesthetically pleasing and use their CGI creations to create real insight for audiences. CGI should be used as a tool for enhancing understanding and spurring discussion. A failure to do so is not a total 'disaster', but it is a lost opportunity.

It is of course easy to criticise the various ways that CGI is currently being used in science documentaries, but this is not a constructive way of approaching the problem. With a little more forethought about the impact of their decisions, filmmakers can attempt to use CGI in effective and constructive ways. This is for the benefit of all as it means enhanced comprehension and understanding for the audience, and a higher quality end product for the filmmaker

## CONCLUSION

Possibly the simplest conclusion to this discussion comes from Nichols: 'Documentary is continually evolving and is without clear boundaries' (Nichols, 1997). Computers and their related technologies have improved on a scale that few could have predicted, and this has impacted on every part of our culture. As discussed, documentary filmmakers have gained tools and techniques that were unimaginable only a few decades ago. One of the most notable of these tools, CGI, has changed both the nature of the stories that can be told and the way those stories can be constructed and presented to an audience. No longer are filmmakers limited to what the camera can see, or how far they can stretch an analogy. This is an important development in the evolution of the science documentary, and CGI is one of the tools which will enable this genre to move far beyond its more drab tradition style.

CGI allows the abstract to be made tangible for audiences everywhere, and this can only be a positive step for the world of science communication. Of course CGI can, as we have seen, be misused. However it is my hope that once this technology becomes a more natural part of the filmmaking process, rather than being a novelty used for entertainment or aesthetic embellishment, its creators will step back and start to think more about its effects. The guidelines that I have proposed for filmmakers are very general in their nature, but they make a good starting point. Once it is realised that a technology like CGI is just a tool to be put to good use by humans, and that its use can significantly improve the impact and understanding of a documentary, then documentary makers should be

able to use the technology in a more conscious and considered manner. This will result in the creation of better documentaries, ones which engage their audiences and excel at communicating scientific knowledge.

*Coming Clean* was my first attempt at using CGI to explain abstract concepts in a science documentary. Initially I was blind to the consequences of this technique and to a small degree I feel this may have had a detrimental effect on my film. I have come to realise that the use of nostalgic stylistic techniques in documentary filmmaking can be dangerous as they can create a false sense of trust with an audience. In future I will be far more conscious of the stylistic techniques I use when I next endeavour to integrate CGI into a documentary. CGI is a powerful tool for documentary filmmakers, a tool which must be used carefully.

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