Edgy Colour

Digital Colour in Experimental Film and Video

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This essay stems from thoughts concerning my own colour field videos, from *Colour Bars* (2004) through to *Iris Out* (2008). My main intention is to unravel some of the implications relating to the aesthetic characteristics of colour that is processed as digital data. The first part of the essay is about differences between film colour, video screens, digital processing and the relation between these technologies and the neurophysiology of colour perception. There are sections in this part that are slightly tentative, as I am quite lost when it comes to the finer points of electronic engineering and neuroscience, but it strikes me that some understanding of these fields is important. I have also written about colour from a more empirical perspective, from the point of view of someone concerned with trying to describe the immediate effects of certain artists' films and videos, including my own. In this regard, the essay deals with the use and effect of colour in a number of experimental films and videos, focusing on form and time-based structures that concern the sequencing of frames on a filmstrip and the more intricate matrix of the pixels, lines, fields and frames of a video signal. The examples that are covered also contextualize my own work, which is discussed towards the end of the essay.

Paul Sharits' *Ray Gun Virus* (1966), which I will discuss first, calls to mind the minimalist colour field paintings of artists such as Barnet Newman or Ellsworth Kelly – the entirety of the screen is consumed by colour – but the aesthetic is absolutely filmic. The most obvious and significant point is that the colour fields in *Ray Gun Virus* are time-based and sequenced. Another factor, which I will come back to in different ways, concerns the material characteristics of the colour stimuli. When one is looking at a painting it seems as if the colour is there on the surface of the canvas, though it might be more proper to say that it is a particular patch of paint under given lighting conditions that constitutes the colour stimulus. In contrast, the materials that give rise to the phenomena of colour in film – in the interaction between film print, projector and screen – are composite and less easy to pinpoint. The way in which colour is produced in video, which I come to later, is even more complex.

While many of Sharits' films involve iconographic imagery, *Ray Gun Virus* is one of his most abstract works. It begins with a pattern of alternating black and clear frames. Subtle tonal variations are introduced and then colour. The film involves a myriad range of colours, from pastel shades through to saturated hues, in varying and complex sequences. In some passages of the film there are periods of uninterrupted monochromatic colour. There are also sections in the film where colours fade in/out or steadily dissolve. These passages are particularly intriguing if one looks at the filmstrip itself. Fades and dissolves evidently result from incremental differences between individual frames - but at what point does one colour become another in sequences such as these; and what of the colours in between?

The sections of single colour and fades or dissolves are the antithesis of the flickering sequences in *Ray Gun Virus*, which are more striking visually and indeed physically. The speed at which the single frames of colour alternate in these periods of the film (projected at twenty-four frames per second) makes for an additive form of colour mixing that is distinctly optical. In the passages where the sequence of frames are of a similar hue the colour mixing that occurs effectively blends frames, but in a sequence of red and green frames (or otherwise equally clashing colours) the contrast keeps the frames from fusing. These sequences heighten one's awareness that film is a medium consisting of discrete frames; the perceptual effect of clashing frames makes a conceptual point about the materiality of film. In certain passages of the film two modes of colour mixing - the fades/dissolves and the flicker of alternating colour - come together. These are the most dynamic and complex passages of the film. In some sequences the colour of every other frame remains constant while a dissolve between two different colours occurs over the intermittent frames; other sequences involve interwoven dissolves. There are very few films that explore a form of frame-based colour mixing in such an expansive and thorough manner.

Fig. 1 Three sections from *Ray Gun Virus* Paul Sharits (1966, 16mm, colour, sound, 14 mins.) USA. Courtesy of the Paul Sharits Estate.

In watching *Ray Gun Virus* the viewer is encouraged to reflect on the mixture of colours that they see on the screen in relation to the pattern of frames running through the projector. The colour in a projected film image is produced by light shining through the dyed medium of a semi-transparent filmstrip, and it will be affected by the hue of the projector bulb and the scale at which the image is projected, but it is the colour in the filmstrip that constitutes the primary reference. In contrast, the colour in a video image has no immediate reference. Unlike the medium of the filmstrip, the video signal is colourless. In fact a video signal is not just colourless but invisible. (The amplitude of a video signal can be measured but one cannot exactly see a video signal). The difference between colour in film and video, and where it seems to inhere, reflects one of the most significant differences between the two mediums. In contrast to the colour in a projected film, the colour in a video image is a product of the output technology rather than the video signal per se. And while the production of colour in a filmstrip is a subtractive process (in which incidental light has been filtered by different layers of light sensitive emulsion) the range of colour in a video image is produced by the additive mixture of separate sources of red, green or blue light that emanate from the technology of the screen. The optical mixture of red, green and blue light can produce any colour in the visible spectrum.[1] Looking closely at a video image on a cathode ray tube, or a flat screen monitor, one can clearly see the clusters of small closely spaced red, green and blue cells that make up its surface.[2]

The processed video signal determines the intensity of each of the cells, often referred to as pixels, and colours are mixed when one is far enough back from the screen. Projection technologies such as LCD (liquid crystal display) and DLP(digital light processing) mix colours additively as well, but in a different fashion. In the former, the light of the projector bulb is split three ways by a prism and each beam of polarized light is sent through one of three LCD panels that corresponds to either the red, green or blue component of the video signal. The pixels in the surface of each of these panels are opened or closed to allow more or less light through at each point in the plane of the image. The resultant red, green and blue light is then recombined and cast onto the screen through the lens. In the latter, a three-chip DLP projector works in the similar way except that each beam of polarized light is reflected, or deflected, by the microscopic mirrors on one of three panels. In a single chip DLP projector there is only one panel of micromirrors, which display the three separate colour components of the video signal in turn. A spinning colour wheel in front of the lens, timed to coincide with this cycle, produces three separate images of red, green and blue in sequence. In theory this happens at a high enough rate that the viewer perceives a full colour image. In practice the spinning colour wheel often produces a red, green and blue flicker effect.[3]

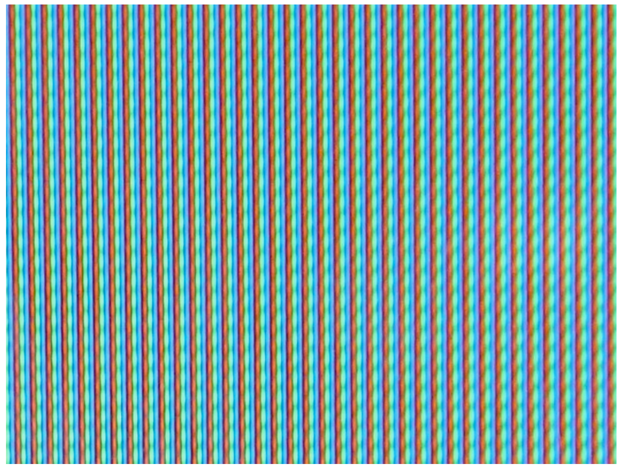

Fig. 2 Close-up of a Sony Trinitron CRT screen.

Colour is an even more complex affair at the level of signal processing. A digital video image is sampled in three respects: the time axis is sampled into frames; the vertical axis of the picture is sampled into lines; and a number of equidistant points, or pixels, are sampled along each line. For example, the standard definition signal in the UK operates at 25 frames per second, and has 576 lines devoted to the vertical axis of the picture, each of which are sampled 720 times. In a greyscale image each pixel represents a value associated with the brightness, or rather luminance, of that point.[4] A colour image effectively requires three different signals that reproduce the proportion of red, green and blue at any given point in a picture. But rather than process separate red, green and blue values for each pixel of the sampled image, digital video is often encoded in relation to $Y'C_BC_R$ coordinates, which entails a further level of abstraction. A $Y'C_BC_R$ signal encodes a 'luma' component (Y') associated with the luminance of the image, and two colour difference components (C_B and C_R). Y' is the weighted sum of the red, green and blue information, while C_B and C_R represent the Y'

minus blue and Y' minus red information respectively. The benefit of $Y'C_BC_R$ encoding is that it allows for chroma subsampling - a form of compression whereby values for C_B and C_R are sampled less frequently than (Y') - resulting in a signal with a lower data rate than that of a full *RGB* signal. (Values for C_B and C_R might be sampled at two thirds or even half as many times as that of Y'). Note that C_B and C_R are not colour indices, but calculated figures from which colour information can be reproduced. Imagery that is encoded in $Y'C_BC_R$ is translated back into an *RGB* colour space when it is displayed in the red, green and blue lattice of the video screen, as described above.[5]

The extent to which colour is codified in the realm of digital media might seem extraordinarily abstract, but $Y'C_BC_R$ processing is in fact analogous to the way in which luminance and colour are processed by the neurophysiology of the eye and brain. In a phrase that resembles a description of chroma subsampling Margaret Livingstone explains that, "in the retinal ganglion cells the three cone signals [sensitive to red, green and blue] are transformed into two color-opponent signals... and a luminance signal that represents the sum of the activity in all three cones" (2002: 88). Seemingly our means of perceiving the world have evolved in such a way that it is more useful or efficient to analyse luminance and colour information separately: colour information contributes to the recognition of shape and the perception of colour per se, but it plays no role at all in the perception of depth, three-dimensionality, movement and spatial organization, which are all cued by information regarding luminance (Livingstone, 2002: 46). It is difficult to visualize or imagine the intricacy and complexity of the neurological processes associated with colour vision, and an added difficulty that one might have with a neurological account of perception in general is that it's bracketed off from the range of theories concerning constructive processes or ecological factors. The study of neurological activity does describe certain effects of particular phenomena, but it doesn't necessarily account for the particularities of an experience (Gordon, 2004: 111). Some comprehension of the relationship between neurophysiology and video technology is crucial because the medium in question has obviously developed in such a way as to take advantage of the capacity (and limitations) of the eye and brain.

To return to the specifics of processing colour as digital data, one ought to ask what it means that colour can be plotted in terms of a precise mathematical model, where every colour within the gamut can be defined by a set of coordinates. One answer to this question is that white and black are specific numerical coordinates located in opposite corners of the three-dimensional cube that describes an *RGB* colour space. In a $Y'C_BC_R$ colour space luminance (the greyscale between white and black) is actually one of the axes. Similarly, if one pictures the colour bars on a waveform monitor white and black represent opposite ends of the video spectrum. White and black are therefore colours and not only qualities of light and dark.[6]

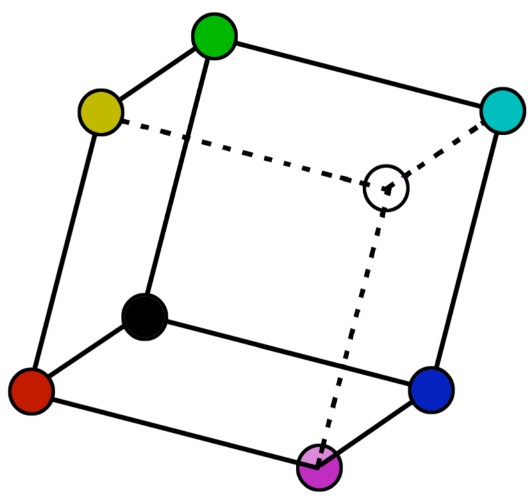

Fig. 3 RGB colour space can be mapped onto a three dimensional cube. Red, green and blue values are represented by the three primary axes that originate at black and reach saturation at their end points. If this cube displayed an 8-bit colour model, which reproduces 256 gradations of red, green and blue, the numerical value attributed to red would be (255, 0, 0) green (0, 255, 0) and blue (0, 0, 255). The values for black and white would be (0, 0, 0) and (255, 255, 255) respectively.

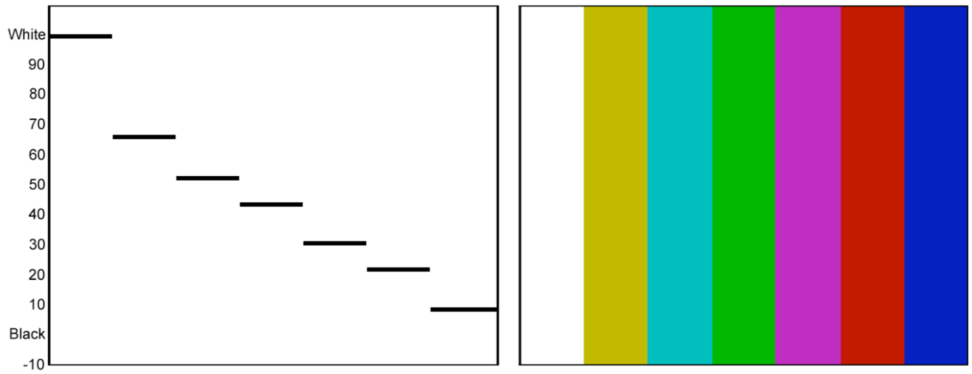

Fig. 4 A waveform monitor image, measuring luminance, corresponding to the seven stripes of the colour bars' test signal. (nb. White is a mixture of green, red and blue; yellow is a mixture of green and red; cyan is a mixture of green and blue; and magenta is a mixture red and blue.) The downward staircase shown in the waveform monitor image of the colour bars is explained by the fact that green makes the greatest contribution to the luminance portion of a video signal followed by red and blue.

Besides the aesthetics of colour mixing per se, the following sections of the essay deal with the ways in which certain works construct an experience of colour that is mathematically coded. Many of the videos that are discussed involve processes and structures that produce an experience of colour that would seem to be at odds with the precision implied by digital imaging. Broader questions might be raised if one were to deal with videos that incorporate camera-recorded imagery, but in this instance I have sought to concentrate on works involving computer-generated colour.

There are numerous video artists that used colour in a bold fashion in the analogue era, experimenting with processes that might generate vibrant hues and contrasts. In Britain the early videotapes made by Peter Donebauer, including *Entering* (1974), involved a complex technological setup to produce swathes of colour that sweep across the screen in hypnotic feedback patterns. Some of George Barber's irreverent Scratch videos, such as *Tilt* (1984), with its chroma-keyed geometric planes of colour set against plundered and then saturated television footage, are another good example. But analogue video didn't allow for a subtle or assured use of colour: there were visible differences in image quality, for example, when one made copies of a work from one tape to another.[7] Now that video is a fully digital medium it comes with a colour palette that has a precise frame of reference: 8-bit colour will reproduce 256 gradations of red, green and blue, making for a palette of 16,777,216 colours (256 x 256 x 256), each with a unique numerical value. In theory digital video provides for colours that are infinitely reproducible and highly controllable. In what follows I will compare the use of colour in a number of digital video works, beginning with two very early pieces: Stephen Beck's *Video Weavings* (1976) and Woody and Steina Vasulka's *Digital Images* (1978).[8]

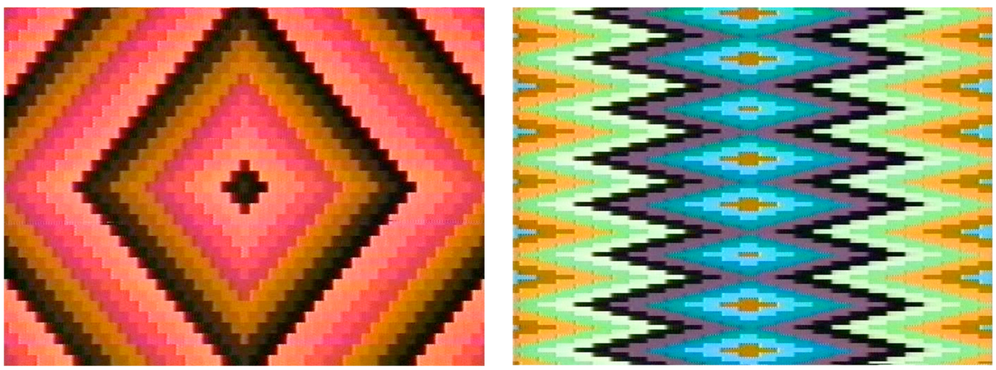

Fig. 5 Two stills from *Video Weavings* Stephen Beck (1976, video, colour, sound, 10 mins.) USA. Courtesy of Steve Beck Archives, Berkeley, California © Copyright 1974-2009 by Steve Beck All Rights Reserved. www.stevebeck.tv.

In light of the account of video technology and colour coding above it is significant to note that both Beck and the Vasulkas had a hand in building their own processing tools and technologies, allowing them to affect the coordinates of the video image including its colour.[9] The video synthesiser that Beck designed and developed to produce *Video Weavings* allowed for the processing of algorithms, in real-time, that would generate patterns analogous to those of woven textiles. The scanning line of the video signal could be seen as equivalent to the warp and weft of a weaver's loom (Beck, n.d.). The coloured squares and rectangles, which are the basic components of the work's evolving patterns, are elementary digital forms that were produced by the digital processing of the analogue signal. The small blocks of colour in tessellated patterns produce chevrons, diamonds and other shapes that traverse the screen in horizontal, vertical and diagonal ripples, or radiate from its centre in a wonderful array. One thing that is particularly intriguing about the work is the degree to which the colours seem to mix. It is impossible to tell whether it is the colours of the shapes that transform, or the expansion/diminution and disappearance of the shapes themselves that make it look as if the colours are dissolving.

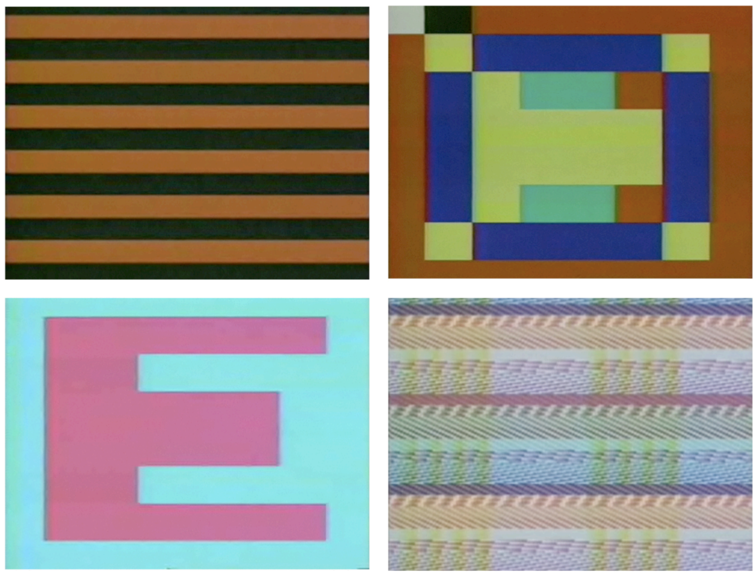

Fig. 6 Four images from *Digital Images* Woody and Steina Vasulka (1978, video, colour, sound, 24 mins.) USA. Courtesy of the artists.

Many of the Vasulka's videotapes, from the early 1970s onwards, document the aesthetic possibilities resulting from image processing tools. *Digital Images* is an explicitly didactic piece that explains the parameters of digital processing by using the Digital Image Articulator designed by Jeffrey Shier, who also appears in the video.[10] In the first part of this video Shier demonstrates how a binary division of the raster results in a scalable grid. The description is fascinating and instructive in terms of its explaining the fundamental concept of digital image processing, which is as relevant to contemporary digital imaging technology. In the opening section of the video horizontal stripes are used to display the divisions of vertical axis, and vertical stripes are used to display the divisions of the horizontal axis. The bars that demarcate these divisions are black and red, but their colour is arbitrary; any two colours could be used to illustrate the same point. In a later passage complementary colours are used to display a range of simple geometric shapes and patterns: one example is a pink 'E' shape on a cyan background. Here the choice of colours is less arbitrary as complementary colours show the pattern most vividly, though any complementary colour pair could be used to the same effect. A series of these shapes in quick succession, using different pairs of colours, makes for an intriguing effect, but the video does not explore optical phenomena per se. Instead it highlights the formal characteristics of images that result from technological intervention. In a later section of the video, the output of the Digital Image Articulator is plugged into the input, forming a feedback loop that results in multi-coloured horizontal, vertical and diagonal bars, lines and dashes that create a crazy shifting tartan pattern. The hovering colours are unpredictable and the relationship between form and colour is randomized and made completely unstable. The advantage of digital imaging is that form, colour and sequencing are made calculable, precise and reproducible, but in this passage the logic of the Digital Image Articulator, and digital processing in general, is thrown off kilter.

Both Beck and the Vasulkas could be seen as latter day constructivists, investigating and working with the component parts of the medium and its technology. The major difference between the two is that Beck's is an applied and highly decorative art: digital processes have been designed and implemented by the artist to produce a particular pattern that might be used in numerous ways.[11] In contrast, much of the Vasulkas' work is analytic and represents a quasi-scientific endeavour. It is in this vein that Woody Vasulka has characterized his work as "anti art".[12] In *Digital Images* the component colours are used to define the formal structures of the image and demonstrate the capacity of digital processing. Though the feedback patterns in the later section are the antithesis of the earlier geometric shapes, they are the result of the same kind of technological enquiry. In *Video Weavings*, the shapes and colours are absolutely specific to the patterns generated by the processes of the work. In this light, *Video Weavings* fits the West Coast tradition of abstract cinema that goes back to Oskar Fischinger via John and James Whitney.[13] Irrespective of their differences, the work of Beck and the Vasulkas represent key examples of early video art that were ahead of their time in the exploration of digital aesthetics. Similar formal patterns of quadrilateral shapes, in varying colour combinations, have been explored in more recent digital video work, as has digital distortion. Abstraction serves different ends again however, especially because digital technology is now practically ubiquitous.

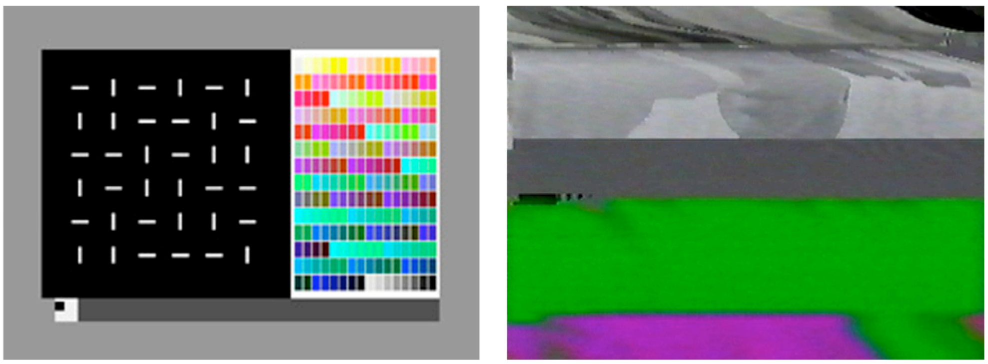

Fig. 7 *36* Norbert Pfaffenbichler and Lotte Schreiber (2001, video, colour, sound, 2 mins.) Austria; and *uta zet* reMI (2001, video, colour, sound, 5 mins.) Austria/Netherlands. Courtesy of the artists.

The videos *36* (2001) by Norbert Pfaffenbichler and Lotte Schrieber and *uta zet* (2001) by reMI (Renate Oblak and Michael Pinter) represent two contrasting approaches to colour digital imaging in recent work. One thing that both of these pieces have in common with the earlier work of Beck and the Vasulkas is that they were produced by directly engaging with the technology - though it is a matter of programming rather more than building hardware. *36* plots the parameters of digital imaging in a manner that is akin to the first passages of the Vasulkas' video, which cycles through the permutations of form and colour within a given grid. The flat graphic composition of the piece is organized in terms of a rectangle that is set in from the edge of the frame by a grey border and split into three sections: a black square, a white lattice, and a stripe that runs along the base of the rectangle that is effectively a time signature. These shapes are static forms upon which the algorithms of the piece are played out. Thirtysix white dashes sit on the black square, while the white lattice holds a palette of colours from across the spectrum of an 8-bit digital colour palette. The piece begins with the white dashes being set in motion, traveling across the black square along horizontal and vertical paths. On the right-hand side of the image, the colours begin to weave through the white lattice, and newly mixed colours appear in each swatch. The movement of the dashes on the left of the screen makes for different alignments. At various points the horizontal and vertical dashes cross paths, pause and mark specific coordinates. The video develops in a manner that is thoroughly systematic: the horizontal and vertical dashes eventually coalesce and form six white squares; and the weave through the white lattice stops once all the colours in the palette have been mixed. It is the right hand side of the screen that is of most concern here. Once the piece is in motion it is ablaze with colour mixing, producing innumerable hues. The colour swatches shift horizontally and vertically though the lattice, which almost disappears when the weaving is at its most intense. At the same time the colour mixing is still contained by the white lattice and the fact that it is set in from the edge of the screen. In this respect the video offers something of a theoretical demonstration of the colour combinations that might be produced by the technology. As far as the logic of the work is concerned the optical nature of colour mixing is neither here nor there.

While the formalist aesthetics of *36* partially resemble the first section of *Digital Images*, the randomized colour patterns in the latter section of the Vasulkas' video resonate in several pieces by reMI. Many of reMI's videos, including *uta zet*, use sampled feedback, glitches and distortion to act out an assault on the surface composition of digital imagery. In contrast to the calculated plotting of digital screen space in Pfaffenbichler and Schrieber's work, reMI bombard the viewer with strobing imagery and disruptive patterns, which apparently result from overloading the technology. In *uta zet* rolling bands of analogue video distortion make for glitching fields of saturated pink and green, interrupted by pixellated waves, which are orange and blue, or black and white, echoing the clicks and cuts of the soundtrack. Towards the end of the video deformed television imagery also creeps into the mix. reMI's work is aggressively anti-digital in the sense that it counters the rational interfaces of new media technology (which *36* evokes) and the seamless aesthetics associated with digital compositing and high definition video. It is set on the degradation and deformation of the video image and implies a critique of the medium. In seeking to unravel the weave of the video image, the destructive impulse in this work is the antithesis of Beck's *Video Weavings*. The colour in *uta zet* is as brilliant and vibrant as that in *Video Weavings*, but it certainly isn't decorative; nor is it used to map or highlight the formal-technological principles of video imaging as in the Vasulkas' work. In many respects the colour is a by-product of processes that have been implemented to distort and degenerate the video signal. In contrast to the era in which Beck and the Vasulkas made their first digital video works, *36* and *uta zet* were made at the cusp of the present period in which moving digital imagery is everywhere. *36* restated the underlying patterns of digital imaging, and *uta zet* stood in reaction to it.

Fig. 8 Still from *Colour Bars* Simon Payne (2004, video, colour, silent, 7 mins. 35 secs.) UK.

Each of the videos that I have made since *Colour Bars* (2004) has drawn on the same limited palette of primary and secondary colours that constitute the standard test signal image.[14] The only colours that I have used are yellow, cyan, green, magenta, red and blue, plus black and white, but they appear in different configurations and shapes, and often alternate at the rate of twenty-five frames per second. The arrangement of vertical stripes in *Colour Bars* adopts the basic pattern of the test signal image. Sometimes there are only two colours on screen at any one time because the width of the bars has been expanded. For the most part the full complement fills the screen, though they have often been shifted horizontally one way or the other. In *Thirds* (2006), which is a piece for two projectors, only one colour at a time appears from each of the projectors.[15] The light projected by each beam, at any one moment, is a solid block of digital colour. These colour fields are the antithesis of high definition video imagery - where millions of pixels per frame offer the capacity to distinguish minute differences in the detail of a picture - because each pixel is of an equivalent value to every other pixel within the same frame. In this regard, it makes very efficient use of the chroma subsampling process described earlier in the essay.[16] The overlapping projection beams in *Thirds* make for widescreen proportions, but the two pieces that I made subsequently, *New Ratio* (2007) and *Iris Out* (2008), explicitly deal with the move from the standard definition aspect ratio of 4:3 to the widescreen aspect ratio of 16:9.[17] In *New Ratio*, the rectangle at the centre of the screen involves a concentration of colours in sequences that overlap, producing an intermittently brighter palette. At the same time the full frame alternating background colour fields reinforce and exercise the edges of the screen. *New Ratio* is the first of the videos in this series of pieces to have a soundtrack. In the first instance I appropriated the standard 1KHz test tone that comes with the colour bars. I halved its pitch to make the lowest tone that I would use, and then produced tones at equal intervals between these two points assigning each tone to one of the colours between yellow and blue, in descending order. The pulse of the looping colour fields and sound sequences propel the rhythm of the piece. In *Iris Out*, the circles that expand and contract refer to a form of transition that is sometimes used at the start or end of film scenes. In certain passages of the video, the combination of circles and ellipses also resembles an eye, returning the gaze of the spectator.

The colours in each of these pieces are mixed in different ways. Some sections of *Colour Bars* comprise two layers of video - which were superimposed in the timeline of the editing software that I used to construct the piece - making for a palette of possibly twenty-eight colours. In compositing these sections the colour values of the pixels in each layer were added together. In *Thirds*, it is the two overlapping projections that produce the effect of superimposition. Different cycles of the eight basic colours are projected by each beam and in the overlap a third lighter set of colours are mixed. This is a truly additive mode of colour mixing, which results from the direct mixture of light when the piece is projected.[18] There are two further modes of additive colour mixing that occur in each of the videos from *Colour Bars* through to *Iris Out*: the red, green and blue pixels in the surface of the projected image mix to produce the full palette of colours that are perceived when one stands back from the image; and then there is the mixture of colours that occurs when the colour fields alternate every frame. This last form of colour mixing is due to the persistence of vision and the effect of positive and negative afterimages. R.L. Gregory refers to the persistence of vision as the "inability of the retina to signal rapidly changing intensities" (1998: 116).[19] An optical mixture of colours is produced by the inability to differentiate between the several colours that pass before the eye in quick succession. Positive and negative afterimages are also contributory factors. Positive afterimages come in the first few seconds after the eye has been exposed to a bright light, especially when viewed in darkness; negative afterimages occur subsequently and are more visible against a light surface (Gregory, 1998: 57). Livingstone refers to colour afterimages in her account of opponent colour coding that I referred to earlier: "If you stare at a red spot you will see a cyan afterimage, if you stare at a blue spot you will see an yellow afterimage, and so on" (2002: 92). The effects associated with the persistence of vision and afterimages are suggestive, but to what degree can they account for the colours that one sees when the stimuli come in varying sequences at 25 frames per second?

A neurological explanation of perception also falls short when one considers the relationship between colour and movement. As outlined earlier, the perception of movement is cued by luminance signals, rather than colour. The eye and brain apparently detect motion by tracking edges that entail a contrast in luminance; shape has nothing to do with it and nor does colour.[20] However, in recognizing and describing motion one cannot help but attach it to objects. The same is true of colour. And to say that we perceive the trace of edges with a high luminance contrast, rather than the movement of coloured objects, seems counterintuitive. But in *Colour Bars*, *Thirds*, *New Ratio* and *Iris Out* it is certainly not the motion of coloured shapes that one sees because the change in the position and size of each shape – be they stripes, rectangles, or circles – is radically different from one frame to the next. The perception of movement really does become a matter of following edges, rather than colour and form. At the same time it is impossible to separate one's sense of movement from that of form and colour. We do see in colour after all. In this regard, there is a tension between colour, shape and movement in each of these videos.

In many ways the aesthetics of my videos have been informed by forerunners who were filmmakers rather than video artists. The structure in each piece is based on sequences of frames predominantly, and likewise the basic unit is usually the frame rather than the pixel, the line or the signal. There are numerous films that I could cite as having been influential, stretching back to the classic abstract films of Hans Richter and Walther Ruttmann made in the 1920s. In thinking about the way that I have used colour in particular, I have often come back to Sharits' films, though the difference between the colour in his films and my videos - including consideration of the way that colour is reproduced in these two mediums - is as important as any surface similarity.[21] In this light it is the use of computer-generated colour that makes my work specifically digital. The colour that I have used from *Colour Bars* onwards has a particular quality that is different to colour in film and indeed analogue video: it is bold, substantive and opaque.[22] Furthermore, it is also the product of an ideal palette that is a mathematical construct. Each colour has a specific value that nominally relates to a mixture of red, green and blue light. But there is no accounting for the shades or intensities of colour that one might actually see in these videos. One of the things that I have been most keen to explore in my work is the conflict between the apparent precision of digital colour coding and the complex objects of visual perception.

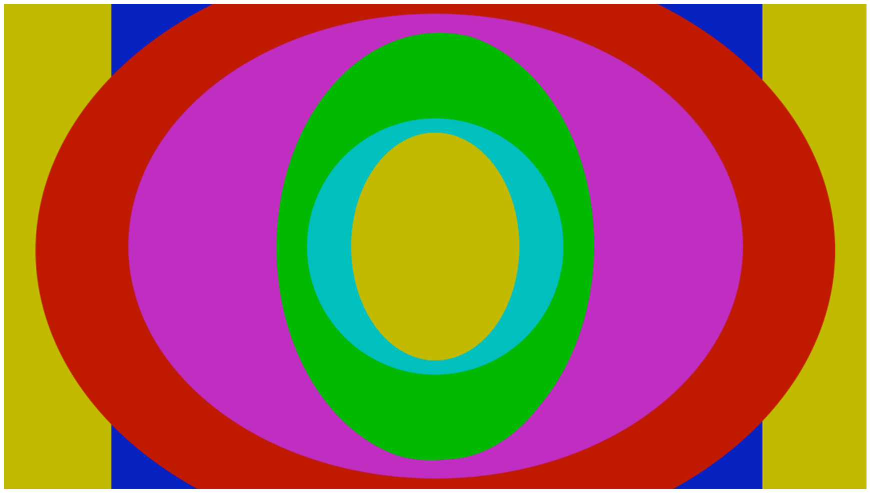

Fig. 9 Diagram for *Iris Out* Simon Payne (2008, video, colour, sound, 10 mins) UK.

Notes

[1] For a concise account of the correspondence between the wavelength of visible light and the pigment in the cone cells of the retina see (Gregory, 1998: 121).

[2] Besides referring to Leo Enticknap's *Moving Image Technology* (2005) for this section on screen and projection technologies, Roger Smith, senior projectionist at the Cambridge Arts Picture House, has explained the finer points of video projectors as have technician colleagues at Anglia Ruskin University.

[3] Some of the earliest experiments in film colour used processes of additive colour mixing that were quite similar. The Kinemacolor process first exhibited in 1908, for example, involved shooting and then projecting through alternating coloured filters (Enticknap 2005: 80). The "motion fringing" that often occurred is not unlike the flicker effect produced by single chip DLPs.

[4] Strictly speaking brightness is a subjective judgement, whereas luminance refers to the relationship between the sensation of brightness and the amount of light that is actually radiated from the surface in question (Poynton 2003: 11). This point might seem pernickety but it highlights the distinction between the

subjective experience of light (and hence colour) and the scientific interpretation of perceptual phenomena.

[5] Several sections in Charles Poynton's *Digital Video and HDTV* (2003) and John Watkinson's *An Introduction to Digital Video* (2001) informed this section on colour coding in digital video and chroma subsampling.

[6] Whether or not black and white can be classified as colours has been a recurrent question for artists and scientists alike. See (Gage, 1999).

[7] Speaking from my own experience, this was certainly the case when one went from a Beta SP master tape to a more widely used format such as U-Matic or VHS. And if one wanted to superimpose more than two layers of video imagery the process would require numerous transfers from one tape to another, which also entailed degeneration. In the art colleges where I made my first video work the transition from high-end analogue editing to digital systems happened during the late 90s. Chris Meigh-Andrews' *A History of Video Art* (2006) offers a thorough account of the relationship between the aesthetics of video art and the development of video technology.

[8] The earliest public performances of *Video Weavings* date from 1973/4. See Beck's own notes regarding in "Video Weavings (1973-76)" (n.d.).

[9] According to Yvonne Spielmann, the essence of video is the bare electronic signal, which can be processed and output in numerous ways. The standard presentation of the video image is an arbitrary arrangement of the video signal - or one governed by convention rather than necessity. See her recent book *Video: The Reflexive Medium* (2008). Woody Vasulka's *C-Trend* (1974) is a prime example that shows the extent to which the video image can be contorted. In this piece the signal was processed in such a way as to skew and apparently tilt the raster to produce what looks like a three dimensional map with the lines of the image tracing contours.

[10] To view a clip from *Digital Images* see http://www.fondation-langlois.org/html/e/page.php?NumPage=457.

[11] In 1982, Mitsubishi licensed *Video Weavings* to show on it giant Diamond Vision plasma screens at the New York Mets baseball stadium. See (Beck, n.d.).

[12] This was during a talk at the Candid Arts Centre, London, in 2004.

[13] Beck expressed his keen interest in the films of Oskar Fischinger in conversation with the author. For an account of what I've called, in shorthand, the West Coast tradition of abstract cinema see William Moritz's essay "Non-objective Film: the Second Generation" in *Film as Film: Formal Experiment in Film 1910-75* (1979). An additional note here is that the Vasulkas and Sharits share some common ground in their having taught in the Department of Media Study at the State University of New York at Buffalo. See the weighty catalogue for the *Buffalo Heads* exhibition (edited by Woody Vasulka and Peter Weibel) that took place at ZKM in Karlsruhe.

[14] To view a clip from *Colour Bars* see:
http://www.simonrpayne.co.uk/pages/videos/colour-bars.php.

[15] To view a clip from *Thirds* see:
http://www.simonrpayne.co.uk/pages/videos/thirds.php.

[16] Chroma subsampling is effectively a form of intraframe compression. Rather than storing the discrete value of every pixel in a frame, intraframe compression economizes by calculating and saving the differences between pixels. In contrast, interframe compression saves space by storing the difference between pixels in subsequent frames. While *Thirds* et al. can be compressed very efficiently using intraframe methods, the alternating colour fields make interframe compression incompatible. In so far as high definition imagery is often fetishized, and video is primarily a time-based medium, this seems quite fitting to me.

[17] To view a clip from *New Ratio* see:
http://www.simonrpayne.co.uk/pages/videos/new-ratio.php and to view a clip from *Iris Out* see:
http://www.simonrpayne.co.uk/pages/videos/iris-out.php.

[18] The impact of projection is key for all of these works. When they are projected, the screening space and the viewer are affected in numerous and dynamic ways.

[19] It is the persistence of vision that makes for the illusion of continuity between frames in film and video. If projection/scanning were to take place any slower there would be a visible flicker and one would be able to see the intervals between frames.

[20] Fascinating examples of motion perception have been collated and examined by Professor George Mather online. The example referred to as "four-stroke apparent motion" is particularly striking and shows that it is edges of contrasting luminance rather than shape that directs the perception of movement. See http://www.lifesci.sussex.ac.uk/home/George_Mather/Motion/index.html.

[21] There are aspects of Sharits' approach and thinking about film that could be described as proto-digital. In his essay "Words per Page", for example, Sharits describes the filmstrip as a "vector" or "continuous" form, and the frame-rate of the projector as instigating a "modular" form (1978: 35). The same distinction could be used to describe digital video: the video signal is a continuous stream while the pixels along each line are akin to modular units. Despite this analogy colour is produced by completely different means in film and video, as I have already suggested.

[22] The colour on the surface of a filmstrip is transparent, but film colour also has an air of transparency on screen. Digital video colour, by comparison, seems more opaque. "Is there any reason why video colour, in your piece particularly, looks more opaque than film colour – more like gouache rather than watercolour?" This was a question posed by film historian David Curtis after a screening in Edinburgh in May 2008. One answer to this might be to do with the evenness of colour in the pixels of a digital video image where there are areas of unvarying colour. In contrast, the randomised pattern of grain in a film print means that apparently uniform surfaces of colour are in fact quite animated.

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