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Expanded stereoscopy: Alternative aesthetics for artistic expression in 3D films

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Abstract

3D cinema has been defined by a quest for increased realism and immersion and the recreation of realistic depth perception. However, instead of merely seeing stereo vision as a visual enhancement of 2D cinema, some contemporary moving image artists explore unique types of perceptual illusions and ambiguous perceptions in their stereoscopic films. Through the experimental stereoscopic films of Blake Williams and Kazuhiro Goshima, and interviews with the artists, this paper focuses on the artists' motivations behind their works and their intended impacts on audiences. Drawing mainly on aesthetic, perceptual and technical perspectives, the paper examines how artists use experimental approaches to stereoscopic imaging and theorises the resulting aesthetics and perceptual forms for S3D films.

Keywords

3D film, experimental film, binocular parallax, expanded stereoscopy, Pulfrich effect, perceptual illusion, perception, cognition

Introduction

Stereoscopic 3D (S3D) films have generally been considered a technological novelty in the mainstream cinematic industry, with heightened interest in the form during two major waves of commercial S3D films in the early 1950s and the 1980s. The latest significant attempt to establish a viable commercial platform for S3D productions was characterised by several technical breakthroughs instigated by James Cameron's stereoscopic film *Avatar* in 2009. There has been a widespread resurgence of S3D film following *Avatar's* success, and many commercial film productions returned to the S3D format. Yet, for pragmatic and economic reasons, many prominent studios continue their existing approaches and workflows to produce 2D films, which are only later

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converted into S3D films during post-production. As such, the S3D format has, by and large, been unable to live up to its full potential in mainstream commercial productions.

The quest for greater realism and immersion has been an important driving force behind the development of 3D cinema. These characteristics also represent the key differences between S3D and 2D planar media. 2D planar media create two-dimensional, flat images. Due to their lack of depth, viewers may not feel as immersed in the experience, resulting in a feeling of detachment from the images presented. At the same time, commercial cinematic productions have consistently aimed to use S3D to create highly realistic visual experiences by giving depth to the image and creating a sense of 3D space. This helps viewers feel more engaged and involved in what they are watching, enhancing immersion. Immersion occurs when viewers feel surrounded by and embedded in the media world presented to them. Stereoscopic 3D media enable greater immersion through the additional sense of depth and dimensionality they provide. According to Miriam Ross (2012: 390), stereoscopy adds two significant attributes to the cinematic experience: the impression of depth construction[1] and the negative parallax effect, through which images can appear to protrude out from the screen towards the audience (Hayes, 1998; Paul, 1993: 333). Stereoscopic 3D is generally understood to enrich the viewer's level of spatial perception as it emulates our natural way of seeing (Mendiburu, 2009: 3). This enhancement of spatial perception through binocular vision 'supports various artistic goals such as realism, spectacle, spatial consistency across shots, and intimacy. ... [But it] also brings perceptual challenges and artefacts to the experience of a film' (Allison et al., 2013: 151).

In contrast to mainstream discourses interested primarily in increasing realism and immersion through S3D, several moving image artists, including Jean-Luc Godard, Ken Jacobs, Johann Lurf, Paul Sharits, Jodie Mack, Blake Williams, Kazuhiro Goshima, Sebastian Buerkner, Philippe Baylaucq, Trisha Baga and Ben Coonley are challenging stereoscopic perception by exploring these 'perceptual challenges and artefacts' to construct unique types of perceptual illusions and confusions in their films. These artists approach S3D as an expanded experience substantially different from 2D cinema, helping push the medium forward.

This paper examines some of the alternative potentialities of 'expanded stereoscopy' (Hattler 2019: 74) in PROTOTYPE (2017) and 2008 (2019) by Blake Williams and Shadowland (2013) by Kazuhiro Goshima. It follows indirect or constructivist theories of perception, according to which perception is indirectly constructed, and the importance of subjective viewer interpretation in shaping perception is emphasised. The focus should be on the phenomena and perceptual 'illusions' constructed and interpreted by viewers, which differs from 2D and S3D media designed to portray environments that closely resemble real-life experiences. This synchronises with Tom Gunning's emphasis on perception in his definition of 3D as a technological image, whereby 3D images are

> 'a class of images produced by a technological viewing device. Its manifestations consist in their appearance and effects rather than being embodied in a material object, such as a painting or photograph. They also require an observer, a witnessing subject, whose perception creates the image in relation to the technological device' (Gunning, 2021).

The analysis discusses, mainly from aesthetic, perceptual and technical standpoints, how the discussed artists use S3D as a unique art form to create expanded visuality, ambiguous images and perceptual illusions and examines the artists' intentions in provoking viewers' emotional, physiological and cognitive responses.

Conceptual framework

Film scholars have pointed out that S3D film provides a 'substantially different experience' (Hall, 2004: 245–246, in Jones, 2015: 171) from 2D planar media, including 2D cinema, photography and painting. As such, S3D media should be differentiated from 2D planar media because they require different types of cinematic practice and grammar, and S3D does not perform in real-life or monocular pictorial perception as the latter do. The visual experience offered by S3D media can create enhanced realism or novel visual effects unique to the medium. In the case of enhanced realism, S3D can closely portray or reproduce the spatial characteristics of an object or environment, providing a more accurate, realistic representation compared to 2D media. On the other hand, S3D can also be utilised to create novel percepts and visual effects beyond the recreation of space and realistic representation (Jones, 2015: 178–180). According to Jonathan Crary, 'there never really is a stereoscopic image' (Crary, 1990: 122) in the sense that stereoscopy should be perceived as something embodied and illusionistic other than an image, which has significant consequences for how we think about 3D cinema. The embodied aspect entails that viewers must accommodate the visual cues presented, such as converging or diverging their eyes to perceive depth. The illusionistic aspect means that illusions of depth and space are constructed in the process, which are not physically present in the real world. Therefore, Crary proposes that stereoscopy requires the viewer to actively engage in the construction of depth perception.

Stereoscopic 3D presents a unique mode of spatial representation that can be both captivating and intriguing. Nick Jones argues that stereoscopic media exert 'a strange kind of fascination' (Jones, 2015: 186), which presents a different mode of distorted representation of space that can change the meaning and content of individual film texts and the landscape of cinema more generally (184).[2] He describes this strangeness of 3D cinema as 'ephemeral yet strangely material-seeming optical illusions quite different from cinema images or real-life experiences' (Jones, 2015: 180).

The other differentiation of S3D from 2D media is that S3D work is more about the perception of viewers, their bodily engagement with a specific viewing apparatus, and their sense of presence in the space of the theatre, instead of following the standard articulation of screen frame as the window in planar cinema (Sandifer, 2011: 67, 71). For S3D media, the role of viewers becomes more crucial since the resulting experience varies not only depending on the type of apparatus used (such as polarised glasses vs active shutter glasses) but also on the level of attention viewers pay.

Therefore, stereoscopic material should aim at a different set of demonstrable properties which, according to Nick Jones, include (1) sense of subjectivity, (2) perceptually unusual distortions in the visual space and (3) tangible immateriality (Jones, 2015: 184). These attributes should be closely linked to two critical aspects of exhibiting S3D media: (1) the control of depth relationships in content and perception and (2) the positioning or placement of the audience.[3] In what follows, we will briefly discuss these three main attributes identified by Jones. The introduction of conceptual tools will then be followed by the case analysis of selected S3D films by the two artists.

Subjectivity

The first key attribute of stereoscopic media is that they appeal to subjective experience since S3D contents require the physical presence of both viewer and media to materialise (Jones, 2015: 182; Sandifer, 2011). Stereoscopic 3D cinema can no longer be considered as an image in the same way 2D media are produced: 2D contents are usually thought to be objective representations that exist independent of the viewer's presence (Ross, 2011). Traditional 2D cinema portrays film space as a flat surface, separate from the viewer who observes passively. Stereoscopic 3D films, on the other hand, are both the object and the subject of perception as they appropriate the viewer into the media being viewed. So the viewers and the films manifest both perceptive and expressive functions (Ross, 2013a: 411, in Jones, 2015: 182). Stereoscopic 3D films engage viewers with a special kind of cinematic experience and, in the process, bring a new type of representational relationship of the space between the viewers' attention and the S3D media itself (Ross, 2013b: 407). The result is the depiction of space as a three-dimensional volume in which the viewer participates more actively.

Distortion

According to Jones, distortion is another crucial attribute of S3D media. While 2D planar media are more about the mimetic representation of reality, S3D's 'constructed spatial configurations do not have to correlate directly to our real-world experience of space' (Purse, 2013: 137) and can instead present and explore different modes of distortion in the representation of space:

> 'Stereoscopic media, then, presents something of a distorted representation of space, making space and objects flexible in ways that can join up or contrast with modes of distortion employed by planar media, but which are nonetheless quite different' (Jones, 2015: 184).

These new modes of perceptually unusual distortion can be found 'in the realms of depth, volume and shape, as well as proximity and scale' (Jones, 2015: 183). Stereoscopic 3D effects can be used for expressive or creative purposes, such as to heighten senses of volume, depth or emergence as required by the needs of the story or sensation. For instance, adjusting the binocular disparity (the difference between left- and right-eye views) can influence high proximity or close distance between an observer and the object observed. So, with the addition of depth cues, stereoscopic effects can be used to faithfully represent proximate or highly immediate content (Jones, 2015: 183).

Tangible immateriality

Thirdly, the objects and spaces depicted in S3D films offer viewers the perception of 'tangible immateriality', wherein S3D contents appear simultaneously corporeal and elusive (Jones, 2015: 181–182). Viewers are perceptually involved and can perceive the tactile and 'embodied' nature of cinematic viewing (Barker, 2009; Crary, 1990; Elsaesser and Hagener, 2010; Marks, 2000; Rutherford, 2003; Sobchack, 1992, 2004; Shaviro, 1993; Ross, 2013b: 408). Visuality can function like the sense of touch (Marks, 2000: 22) even though the content is impalpable, and the insubstantial objects and figures are merely visual illusions. Laura Marks refers to this as 'haptic visuality', where 'film (and video) may be thought of as impressionable and conductive, like skin' and the screen becomes not so much a flat object as a membrane (Marks, 2000: xi–xii).

Like 2D images, stereoscopic images first depend on optical visuality since seeing involves optical vision. Optical visuality enables viewers to see and perceive things as distinct forms in space (Marks, 2000: 162). However, viewers can employ additional types of visuality once moving images are brought to life. Haptic visuality relates vision to the sense of touch, as our eyes move over the surface of objects to discern their textures rather than distinguishing their form (Marks, 2000: 162).[4] Marks' concept of 'hyperhaptic visuality' also refers to the idea that our eyes can 'function like organs of touch' (Marks, 2000: 162), so that feeling and touch can be connected (see also Barker, 2009: 22, Jones, 2015: 181–182). Depth and dimensionality in S3D films create an illusion of tangibility, which engages the viewers' sense of bodily presence, allowing them to feel as if they can touch the images on the screen. In contrast to haptic visuality, which does not require depth

(Bruno, 2002: 250; Lant, 1995: 45–73), hyperhaptic visuality relates to this extra dimension of three-dimensional depth in the viewing of S3D images, which makes viewers perceive both the texture, as well as the desire to touch and be touched by that texture (Ross, 2012: 384). It is a unique aspect of S3D films, which heightens the sense of physical presence and the illusion of tangibility in the virtual space of the film.

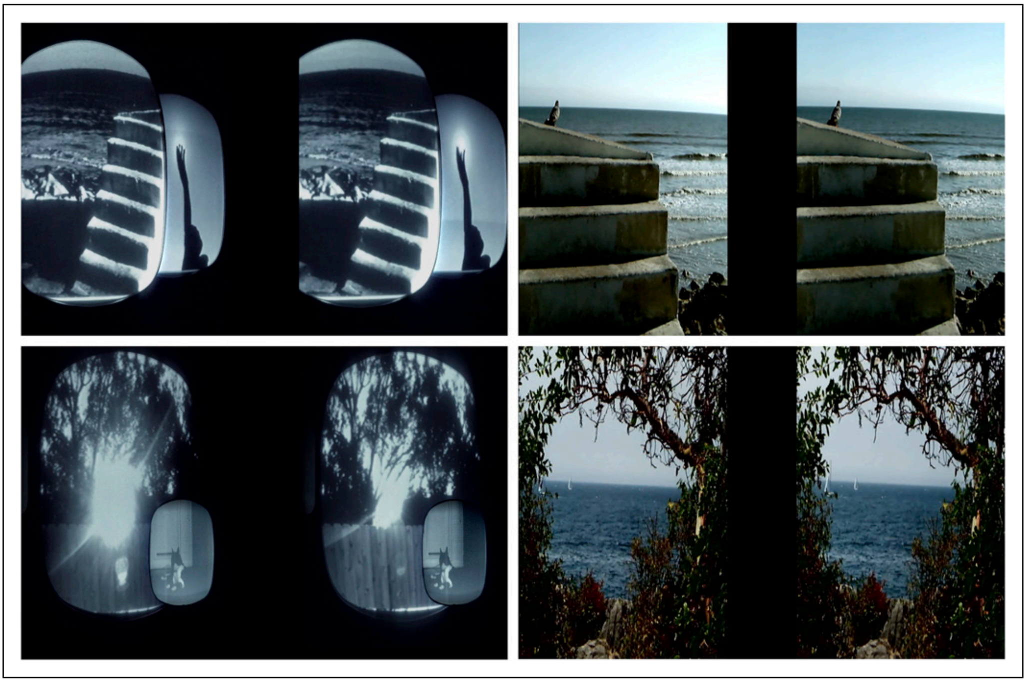
Expanded visuality and perception

Blake Williams and Kazuhiro Goshima both experiment with ambiguous perception and expanded visuality through different strategies of expanded stereoscopy. This includes stereoscopic processes that create spaces with disjointed and paradoxical depth relations and new dimensionality and visual intensity that are impossible in the real world. The first case study concerns the films of Toronto-based filmmaker Blake Williams. His journey into stereoscopic films started with experiments with Google's Street View application in Coorow-Latham Road (2011) and C-LR: Coorow-Latham Road for Those Who Don't Have the Time (2013). Since then, Williams has been captivated by experimental approaches to stereoscopic imaging, as evidenced by his experiments over the past decade, from the use of the anaglyph format's red and blue filters in Many a Swan (2012), Baby Blue (2013), and Red Capriccio (2014), to the polarised 3D format in more recent films such as Something Horizontal (2015), PROTOTYPE (2017) and 2008 (2019). The second artist examined in this study is Japanese experimental filmmaker Kazuhiro Goshima. Since 2008, Goshima has been exploring stereoscopy through films such as Tokyo Three Dimensional Suite (2010) and Shadowland (2013) and video installations including Stereo Shadow (2008), Spatiotemporal Drill (2012), t2z (2012b) and Bumpy (2016).

In the subsequent sections, the selected films of both artists will be scrutinised in relation to the above concepts and attributes of the S3D medium. The first two sections are related to Nick Jones' 'subjectivity' attribute, the third and fourth sections are associated with 'distortion', and the fifth section connects to 'tangible immateriality'.

Creating subjective perceptual illusions

A perceptual illusion usually refers to 'the mismatch/disagreement between the geometrical/physical domain and the phenomenal one' (Pinna, 2013: 317). Both Williams and Goshima intend to construct such illusions by creating visual worlds that perceptually deviate from or are mismatched with actual, lived reality. For instance, in *Shadowland* and *Tokyo Three Dimensional Suite*, Goshima captures the 'ordinary' Tokyo and presents it through his 'strange' stereoscopic decoding method of creating parallax from an artificial time difference between the images of left and right eyes. It does not matter to him whether this information decoding is correct because he regards everything we perceive as an 'illusion'. To Goshima, 'our senses and perceptions are indirect, and from vague evidence, we are only aware of the model of the outside world', and, as such, 'reality is a fictitious concept that we expect to be equally aware of' (Goshima, 2020a). By creating perceptual illusions, the familiar environment becomes unfamiliar, and ordinary scenes change to extraordinary, poetic views. His stereoscopic films transcend the scenes he portrays and move beyond the mere representation of objective reality. Through this, Goshima allows his viewers to engage subjectively with the pleasure of aesthetic experience, akin to what Tom Gunning calls the audience's delighted perception of 3D images at play (Gunning, 2021). Such positive perception in Goshima's works is delivered to viewers by drawing their attention to the very moment and specific action of watching a film, making it a conscious process, resulting in their immersion in imagery that



Figures 1–4. Frames with side-by-side views of scenes from PROTOTYPE (2017, Blake Williams). Images courtesy of the artist.

invites them to discover hitherto unseen perspectives in familiar cityscapes.[5] The visual illusions, created by Goshima through stereoscopic time difference, achieve this by creating a sense of depth that differs significantly from how it is usually objectively perceived in the everyday. To Goshima, such unique perceptual illusions can engage viewers and evoke ‘carnival feelings’ (Goshima, 2020a), or what Gunning refers to as ‘the cinema of attractions’ (Gunning, 2006), a mode of filmmaking that foregrounds visual spectacle and novelty of the medium, and emphasises visual experience through illusions, tricks and visual effects.[6] Goshima artfully and subtly emphasises these elements of S3D to bring poetic pleasure to his viewers by creating unusual senses of depth and dimensionality.

Williams’ images in *PROTOTYPE* create feelings of mystery and cognitive dissonance between what we know existed in the past and what exists in the present, shown through comparative shots of two types of images mapped onto cathode-ray tube television (CRT) screens on the one hand, and images directly displayed to the viewer without any framing on the other (Figures 1–4). Both are created with horizontal parallax resulting in a strong sense of depth so that viewers can compare the visuality of the two types of images. Viewers are reminded that they are occupying two spaces – both the imaginary identification with the illusion and the connection to the optical machine – which means they are at once protagonists within a fantastical, dreamlike scene and spectators outside of the screen. For Williams, the notion of ‘fantasy’ is a crucial element in his illusory films: His films are fantasies. Williams describes fantasy as ‘a desired reality that does not (yet) exist (…) [and which is neither] reality [nor] metaphor’ (Williams, 2020a).[7] Stereoscopic films per se can attract viewers’ attention to the fantastical appearance of their image and their magical or illusionary depictions of reality (Paul, 1993: 345). For Williams, proximity to reality is essential in his films, making the deviations feel more radical.

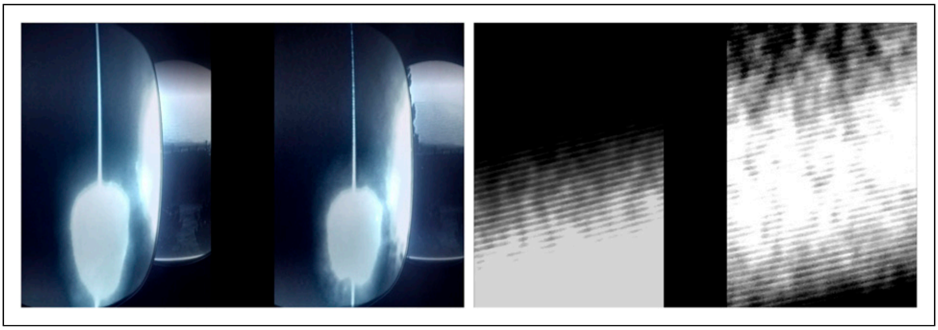
Active instead of passive viewing experience

Scholars have emphasised different aspects of perception in the process of watching films, such as viewers' interpretation of films (Arnheim, 1957; Bordwell, 2004 (1979)), subjective viewing experience and cognitive processes, including memory and attention (Carroll, 1988), active information pickup from the environment (Gibson, 1979), or active and participatory roles of the viewer (Crary, 1990). These concepts of film perception are relevant to understanding depth and motion perception in S3D films. 3D media represent a kind of ethereal visual illusion which is actively created by viewers' perceptual experience in a way that is qualitatively different from both the experience of 2D cinema images and real-life experiences (Jones, 2015: 180). Studies of perceptual illusions have also shown that perception is active (Berthoz, 2000) and that the perceptual system is not only based on the passive reception of stimuli (Pasquinelli, 2006: 201).

In our case study, both artists see viewers as *active* in that perception, cognition and sense-making all happen in the viewer's brain. Williams expects viewers to process his ambiguous images actively and at least partially decode them. Goshima's films also require viewers to interpret the provided visual information, while a 'huge illusion or magic' (Goshima, 2020a) is created in their minds. As Vivian Sobchack remarks, viewers can be active participants in both perception and expression of cinematic experience, and the lived body of viewers should always be 'perceiving expression and expressing perception' (Sobchack, 1992: 123–43). For S3D images, both perception and expression are part of the viewing process which takes place in the viewers' minds. For instance, viewers of Goshima and Williams' works cannot perceive objective reality in the artists' films but instead perceive illusory images as 'a product of our own mind which binds the pictures together' (Munsterberg, 2002: 129). Viewers must depend on their active interpretation, feelings and emotions, memory, imagination and attention. In short, viewers have to interpret the images actively.

The artists in this study both emphasise the importance of subjective viewer interpretation, in line with indirect or constructivist theories of perception, where perception is indirectly constructed, and the importance of experience in shaping our perceptions is emphasised (Rock, 1983). Seen in this way, the S3D works help to create 'illusions', which are constructed and then interpreted by viewers. The focus is not on representing objective visual reality but on phenomena inside the head.

Williams aims to create compelling, mysterious and poetic experiences that evoke feelings and responses which affect the audience on a physiological level. His films stimulate viewers' cognitive impulses while challenging their physiological responses to engage them in a more multimodal sensory process of perception. While Williams does not expect the audience to deeply engage with his subjective thinking or concepts behind a film during the viewing process, he assumes a present-tense, active engagement between viewer and film in a very physical way: 'My film at least will entertain both aspects of the viewing experience: it will sometimes speak more to your body, and at other times, it will speak more to your brain'. (Williams, 2020b) The brain processes information from different sensory modalities simultaneously, enabling the audience to form a complete and accurate understanding of their environment. Multimodal perception involves integrating information from multiple sensory modalities, including vision, hearing, touch, taste and smell, to create a unified perception of reality. For instance, we rely on cues such as facial expressions, lip movements, voice and context during a conversation to understand what the speaker is saying. Multimodal perception is also critical to experiencing Williams' S3D films, where sensory cues such



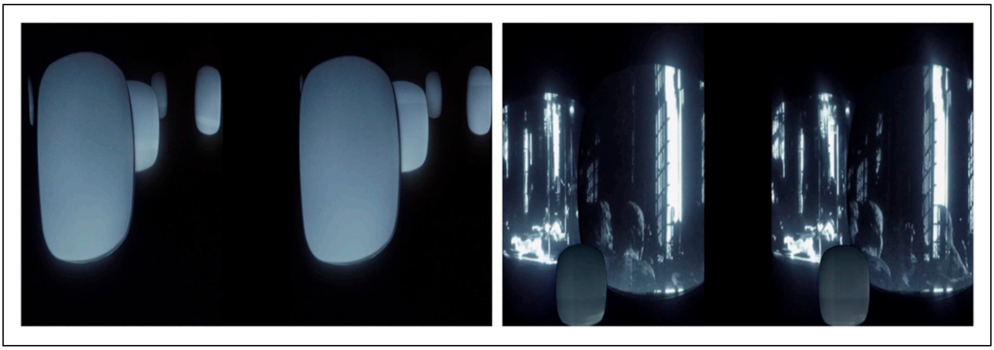
Figures 5–6. Frames with side-by-side views of close-ups of television screens in Blake Williams' *PROTOTYPE* (left) and *2008* (right). Images courtesy of the artist.

as sight and touch are integrated to create a more immersive experience. Aspects of Williams' intention towards physicality can be explained by Jonathan Crary's (1990) concept of the reciprocal relationship between sight and touch wherein 'the desired effect of the stereoscope was not simply likeness, but immediate, apparent tangibility', and such sense of touch is further transformed into a visual experience (Crary, 1990: 122–124), what Laura Marks (2000) calls haptic visuality, or in the case of stereoscopic images, hyperhaptic visuality.

Williams' work with stereoscopic images aims to stimulate viewers' sensory apparatus and heighten their spatial awareness. He insists that physiological responses such as claustrophobia and spatial disorientation can be induced by the extreme close-up shots of television screens in *PROTOTYPE* and *2008* (Figures 5–6). He uses representational images to activate viewers' cognitive impulses to decode their meanings while keeping other images abstract and resistant to words and vocabulary (Williams, 2020b). Therefore, instead of only presenting representational imagery, Williams is more interested in unfolding the film before the audience in a way that sustains a sense of mystery, which prompts recipients to engage more actively in the reading of the work and question themselves as they view the images.

Experimenting with ambiguous perception

According to Giuseppe Caglioti, visual-perceptual ambiguity can be 'defined in terms of coexistence, at a critical point, of two aspects or schemes of reality which are mutually exclusive and which have become physically observable' (Caglioti, 1992: 17).[8] In his films, Williams experiments with creating ambiguous perceptions. For example, he isolates different objects or parts of the same object. He assigns different depths to each of them, resulting in conflicting perceptions, such as intentionally breaking or playing with principles of perspective and size by overlaying multiple CRT TV screens of different sizes in *PROTOTYPE* (Figures 7–8). As a result, the coexistence of two or more mutually exclusive or conflicting aspects of reality becomes observable to viewers. Many scenes in *PROTOTYPE* show these CRT TV screens not following expected perspectival size cues, as the screen closest to the viewer is not always the largest, and those farther away appear larger at the back. Viewers perceive depth from horizontal parallax,[9] with the smaller TV screens at the far back moving closer to the audience and out of the screen plane and the large TV screen at the front appearing to move backwards and behind the screen plane. Knowing that the sizes of all TV screens should be the same, this inconsistency in depth cues[10] makes the images ambiguous. It creates a



Figures 7–8. Frames with side-by-side views of overlapping TV screens in PROTOTYPE (2017, Blake Williams). Images courtesy of the artist.

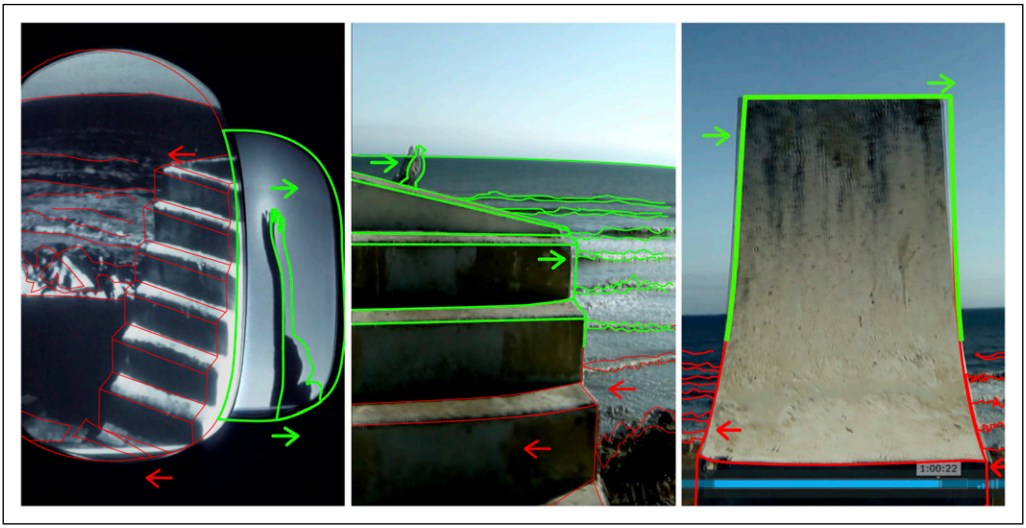
strange experience for viewers who, as a result, might be confused by the 'reality effect' of some of these images.[11]

Occlusion is another powerful depth cue which occurs when objects overlap (an object partially hides another object behind it). In stereoscopy, the occluded parts of a background object might then only be seen by one eye (Mendiburu, 2009: 18). However, since Williams has applied different directions of horizontal parallax to the objects in the foreground and background, occlusion depth cues can be seen to be overridden by binocular depth cues such as convergence. As a result of these conflicting size and depth cues, it becomes difficult for viewers to immediately comprehend which TV screen is in front of the other. Williams' images appear ambiguous and strangely illusive, with a confusing and distorted sense of depth, resulting in a surreal, dreamlike viewing experience.

Other examples from *PROTOTYPE* can be seen in Figures 9–11. The left-eye views are used as a reference and compared with their right-eye counterparts represented by the green and red outlines of objects to indicate movement. For instance, in Figure 9, the TV screen in front shows a staircase near a beach. There is an inconsistency in depth cues as the TV screen in front is indicated by an occlusion depth cue, while the relative size of these screens simultaneously appears wrong. Moreover, the artist further manipulated the image by using conflicting parallax compared to the right eye's image, applying positive parallax to the TV screen closer to the viewer, shifting the image to the left as indicated by the red lines, and negative parallax to the further-away screen, shifting to the right as indicated by the green lines. This can be done by isolating (or rotoscoping) the TV screens and assigning conflicting depths to each image.

Other, even more ambiguous and confusing scenes can be found in Figures 10 and 11. Here, Williams manipulated the stereoscopic sequences by applying conflicting horizontal parallax to the top and bottom parts of the same right view frame. In Figure 10, the right-eye view on top (as indicated by the green outlines) is shifted to the right, which then appears to move towards the viewer. At the same time, the bottom part (indicated by red outlines) shifts to the left. The ambiguity of this uncanny viewing experience confuses its recipients as the top part of the staircase is supposed to appear further away than the bottom steps. Similar effects are applied to the concave cement block in Figure 11.

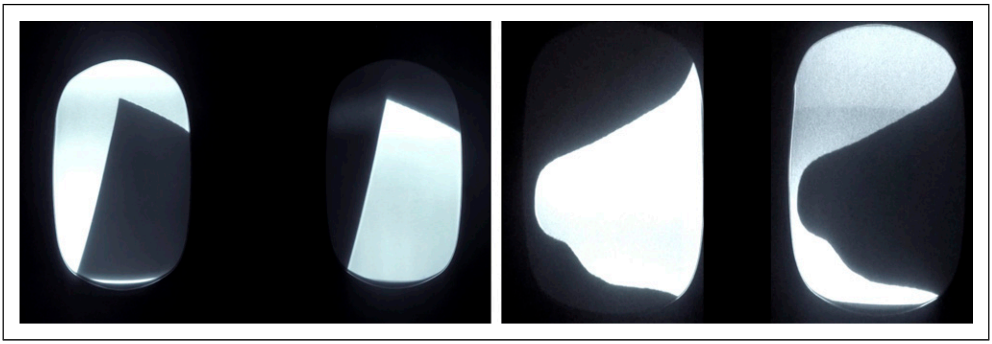
Williams also uses other stereoscopic visual effects, such as flicker, lustre, and binocular mixture or rivalry, to create illusory and ambiguous perceptions and to challenge his viewers' cognitive-perceptual apparatus. For example, the use of flicker in the second half of *PROTOTYPE* was created



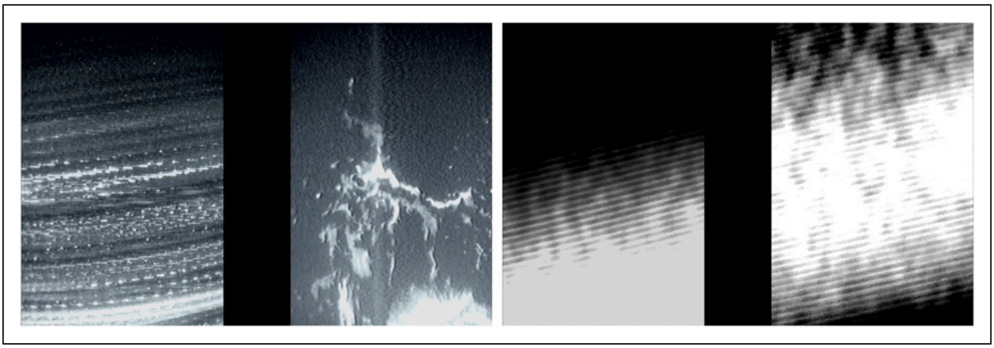
Figures 9–11. Different parts of the right view images with horizontal parallax in different directions, producing an ambiguous sense of depth in PROTOTYPE (2017, Blake Williams). Images courtesy of the artist, overlaid line art by the authors.

from a mismatch of the TV's refresh rate and the director's camera framerate when filming the TV screens, which was then embraced as an aesthetic feature in the film. There are also examples of binocular lustre (Figures 12–13), which creates a metallic impression for the viewer and is achieved by combining positive and negative images in the two eyes (Wade, 2021: 12). The viewers experience hitherto unseen colours of shimmering lustre, stemming from the fact that 'one eye will be shown the negative version of what the other eye sees' (Williams, 2020b).

When disparate images are presented to each of the viewer's eyes, vision will either be stereoscopically fused through 'stereopsis', allowing for 'the perception of depth and three-dimensional structure (…) on the basis of visual information deriving from two eyes' (Howard, 1995), or alternated through 'binocular rivalry', leading to a breakdown of 3D vision. While in stereopsis the images for left and right eyes are only slightly disparate, within an acceptable tolerance level for the audience where perceptual side-effects are avoided, binocular rivalry involves competition between the stimuli presented to the two eyes (Figures 14–15). 'When the images are very different, binocular rivalry occurs' (Breese, 1899), resulting in perception that 'oscillates between one eye's image and the other's' (O'Shea et al., 1997: 175). The resulting alternately competing visual perceptions can cause pain and discomfort in the viewer (Breese, 1909). Blake Williams considers stereopsis the standard from which more extreme deviations become the most meaningful. Binocular rivalry, to Williams, is a rather radical and uncomfortable strategy that only becomes meaningful when used in opposition to and in combination with stereopsis. While Williams acknowledges his preference for stereopsis, he sometimes uses binocular rivalry to create strong effects. In the opening shot of *2008*, he shows the audience the process of separating and reconnecting the split images of the two eyes, separated and moved back into stereopsis, which is not dissimilar to a key scene in Jean-Luc Godard's film Goodbye to Language (2014).[12] Through this, Williams intends for the audience to understand that human vision can be disoriented, and images can radically disagree – by showing an image in one eye that has, in a way, nothing to do with the image in the other eye (Williams, 2020b).



Figures 12–13. Frames with side-by-side views of images producing a lustre effect in PROTOTYPE (2017, Blake Williams). Images courtesy of the artist.



Figures 14–15. Side-by-side views of extreme close-ups of the TV screens in *PROTOTYPE*. Non-identical, competing images are presented to the left and right eyes in each frame, resulting in the experience of binocular rivalry. Images courtesy of the artist.

Following these examples in Williams' work, we can see how filmmakers can alter stereoscopic images. By using techniques such as rotoscoping, displacement maps, binocular mixture or rivalry, and other effects in post-production image editing (for more details, see Wright, 2011: 275–276), artists can create seemingly impossible and illusive images which promote ambiguous perception, with a mixture of both positive and negative parallax effects in the same scene. According to Kristen Whissel (2016: 233), stereoscopic images with positive parallax are tied to the desire to see and know, or what Martin Seel (2005: 172) refers to as 'epistemic seeing', and images with negative parallax connect to a mode of perception organised around heightened emotion and emergence effects, or what Seel calls 'affective seeing'. Rather than opposing each other, these two modes of seeing or perceiving are '*joined together* along the continuum of the *z*-axis by the haptic quality of the stereoscopic 3D image' (Whissel, 2016: 235–236). Filmmakers can make perceptually unusual and unrealistic distortions in the visual space by applying different techniques to alter or deform the image. Viewers might perceive the result as disorienting or challenging as they try to reconcile the conflicting visual information presented. Alternatively, they might find the experience novel and exhilarating – the effect will always, to some extent, depend on the individual responses and

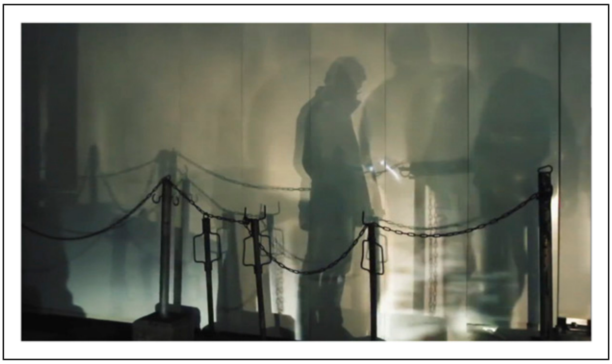


Figure 16. Shadowland (2013, Kazuhiro Goshima). Image courtesy of the artist.

positioning of the viewers. In any case, we can see that there is much more potential for artistic experiments to create new illusions and perceptions through expanded approaches to stereoscopic imaging.

Distorting dimensions with the Pulfrich effect

Goshima's *Shadowland* takes the viewer on a journey of immersion from 2D flatness to 3D depth, unveiling the subtlety of depth formation through the language of shadows created by the headlights of cars projecting onto walls and passers-by (Figure 16). Strong binocular depth is achieved through post-production stereoscopic editing of sequences of images captured with a monocular camera. As the moving beams of light travel across the surfaces of Tokyo's built environment, a transient, dreamlike stereoscopic image emerges, where only the shadows take on a three-dimensional form while the city itself remains flat. This creates poetic, unnatural scenes that are impossible in reality and invites the audience to subjectively feel, perceive and discover something hidden and mysterious emerging from the stereoscopic images.[13] As such, Goshima adds a new dimension to the city by disjoining and animating space and time 'before the viewers' very eyes' (Goshima, 2020c).

In *Shadowland*, Goshima emulates the Pulfrich effect to generate 3D depth. The Pulfrich effect was discovered in 1922 by German physicist Carl Pulfrich, who described how a delay in processing the signals from one eye by placing a neutral-density filter in front of one of the eyes can result in binocular stereoscopic depth perception of non-stereoscopic lateral motion for example in a moving pendulum (for more details, see Harris and Jenkin, 2011: 34–35). Reducing the amount of light reaching the covered retina introduces a temporal delay in transmitting visual information from that retina to the visual cortex. As a result, the viewer sees a moving pendulum at different positions for the two eyes: the uncovered eye sees the pendulum at one position, and the eye with the filter sees it at a different position slightly further back in time. This horizontal difference between left- and right-eye images corresponds to binocular parallax and creates stereoscopic depth perception in the viewer (Carney et al., 1989; Mansfield and Daugman, 1978).

In *Shadowland*, Goshima mimics the Pulfrich effect by converting time differences between left and right eyes into spatial depth information. Instead of, but analogous to, reducing the amount of light for one eye, Goshima introduces temporal difference between the eyes through video editing. He filmed the shadows of the Tokyo cityscape with one (monocular) camera and subsequently duplicated these images for left and right eyes. He then introduced a slight time delay (of two to five frames) between the left- and right-eye channels,[14] which, for the viewer, results in a combined,

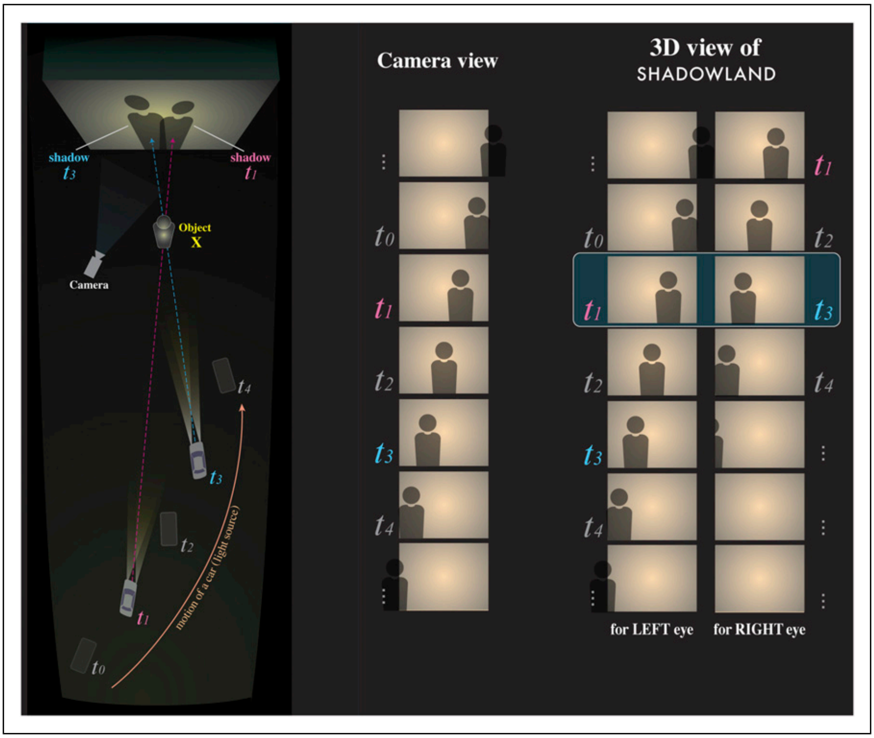


Figure 17. The technical mechanism behind the appropriated Pulfrich effect in *Shadowland*: Perspective view from the top, camera view and side-by-side 3D view. Image courtesy of the artist.

stereoscopically fused image that creates an artificial sense of depth. In other words, the temporal delay is converted into an artificial horizontal disparity, resulting in spatial depth information (Figure 17).

Since the images are delayed between the left and right eyes in each stereo pair throughout *Shadowland*, the film becomes immersive to viewers due to the resulting horizontal disparity. Since only the shadows move, it is the shadows that take on a spatial persona as they lift off the cinema screen, while the rest remains two-dimensional, in what Goshima calls ‘complex 3D harmony’ (Goshima, 2020c). The separation of the constantly moving shadows from the background in the scene creates a sense of space and perspective that is impossible in traditional 2D films. Through the 3D depth created, the audience can feel as if they are ‘inside’ the space of this film rather than simply watching it from a distance.

Goshima particularly chooses his scenes and movements to create the desired effect. The strength of the stereoscopic depth, which is determined by the amount of binocular parallax, is influenced by the speed at which an object moves on the screen and the difference in the number of frames between the left and right eyes. If moving objects (shadows in our case) have variable, non-constant speeds, then the resulting disparity also changes over time, which introduces false motion-in-depth cues (Woods et al., 1993: 9). In addition, Goshima strives to maximise binocular parallax within the limits of human ability to provide viewers with the pleasure of aesthetic experience while avoiding discomfort. Dramatised parallax can engage viewers with a stronger sense of depth and the three-

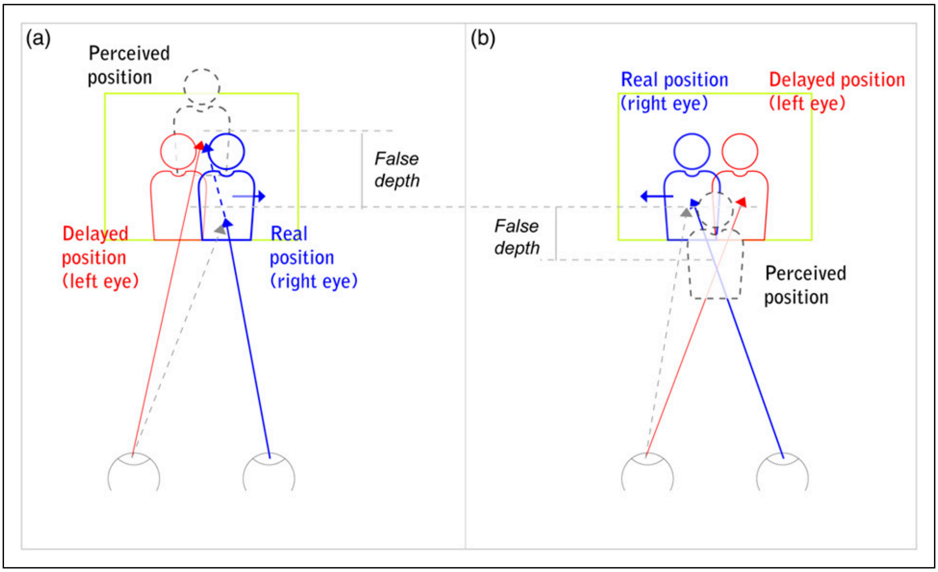


Figure 18. (a) and (b). Pulfrich effect on a stereoscopically viewed horizontally moving shadow of a person. The individual eye images (for left and right eyes) are colour coded. The right-eye image represents the actual image-space position of the person's shadow (blue), and the left-eye image is perceived as delayed (red). This results in the final percept being shifted in depth (black). (For more details, see Kellnhofer, 2016: 8–9).

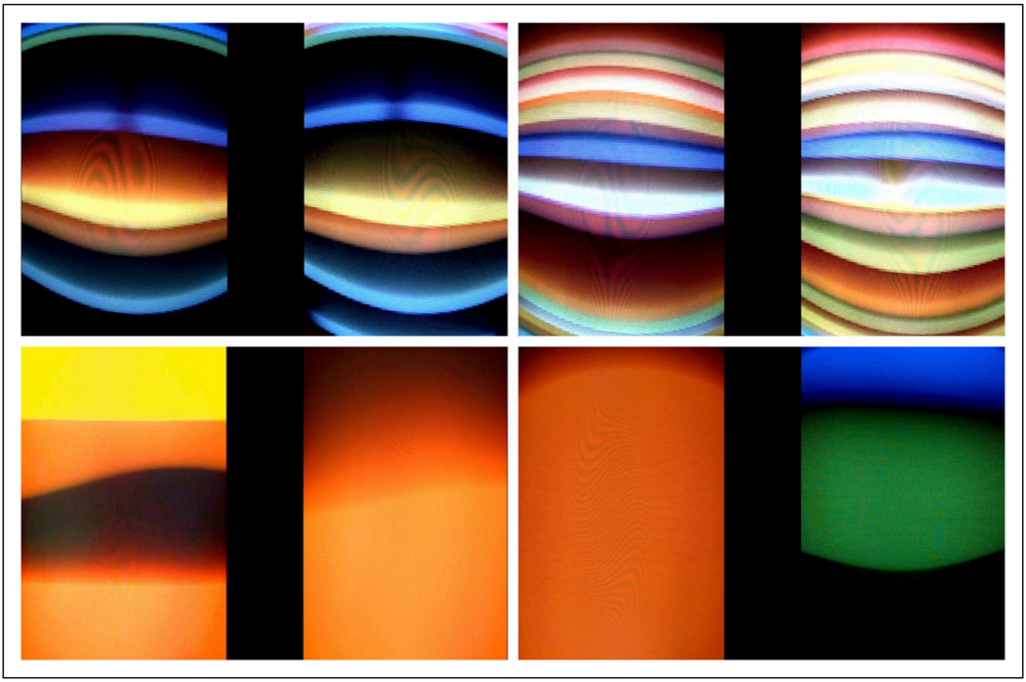
dimensionality of otherwise flat protagonists in the form of shadows caused by the lights of moving cars (Goshima, 2020b).

If a shadow moves on the screen from right to left (Figure 18(b)), when the shadow in the right eye has already moved farther to the left, the brain at this point also processes the delayed moving shadow in the left eye's scene. Since the eyes must cross more to focus on the shadow, this results in the illusion of the shadow being closer to the viewer. Therefore, with a delayed left-eye image, things that move faster to the left appear closer (Figure 18(b)), and things that move faster to the right appear farther away (Figure 18(a)).

With this artificial sense of depth created by the Pulfrich-like effect, the originally formless and flat shadows now become illusive, as they appear to incorporate solidity, volume and depth, and in the process, become unfamiliar and fascinating – and entirely different from their appearance in reality. Such a 'strange kind of fascination' (Jones, 2015: 186) can only be created and processed in the viewer's brain, making it a subjective viewing experience between the viewer's attention and the S3D media itself. Goshima's use of technical strategies highlights the potential of S3D cinema to enable viewers to infuse their own subjective emotions, attention and imagination into the process of interpreting the stereoscopic images, thus leading to the creation of novel ways of portraying everyday scenes as unfamiliar, disorienting, strange and bewildering.

Immateriality and tactility in close-ups and textures

The concepts of immateriality and hyperhaptic visuality discussed above can also be illustrated by the use of extreme close-ups in Williams' films. Proximity is crucial in creating immersive visual



Figures 19–22. Frames with side-by-side views of different colours on a TV screen in 2008 (2019). Images courtesy of the artist.

media, allowing smaller elements to occupy a more significant portion of the viewer's visual field (Jones, 2018).

In *2008*, Williams re-photographed flashing colour fields of a television screen to create extreme close-up scenes (Figures 19–22). Williams used two GoPro Hero7 Silver cameras (one for each eye view) and a Fujifilm FinePix Real 3D W3 camera to capture the unique aesthetics of a CRT colour television, with 'hundreds of different colours flowing across the screen' (Williams, 2020a). The captured images are mainly used how they were recorded, with only minimal post-production.

> 'Naturally, I wanted the film to be true to that particular kind of colour set that the TV screen offers, and so when I was editing, I just wanted it to look how it looked to me when I was looking at it with my own eyes' (Williams, 2020a).

As we have seen, the simultaneous use of different images for left and right eyes can lead to binocular rivalry. One use of subtle binocular rivalry is colour rivalry (Figures 21–22), the 'presentation of a different colour to each eye [which] usually produces alternating percepts of the two colours or, in some cases, a colour mixture' (De Weert and Wade, 1988; Ikeda and Sagawa, 1979). At the same time, different colours presented to the two eyes can appear to occupy different depths when 'long- and short-wave colours (such as red and blue) are placed near to one another [– this is] called colour stereoscopy or chromostereopsis' (Wade, 2021: 15).[15] These effects result in ambiguous and fluctuating colour and depth perceptions.

Another scene with extreme close-ups of textures can be found in *2008*. Here, Williams is interested in expressing the 'double-texture' of two types of textured surfaces – the smooth glass

Figures 23–24. Frames with side-by-side views of flowers and cherry blossoms on a TV screen in 2008 (2019). Images courtesy of the artist.

surface of an obsolete televisual device and the soft textures of flowers and blossoms (Figures 23–24). Since the images of flowers, cherry blossoms and luminous fields are re-photographed from the screen of an old TV monitor, the resulting images show two competing textures and tactile surfaces, which can trigger overlooked complexities and significances in aspects other than visual, aural or narrative (see Barker, 2009: 25).

Such examples of extreme close-up scenes of flashing colour rainbows and textured images can be understood in terms of hyperhaptic visuality, where the close-up shots can 'invite an involved and sensory response to the films' content' (Ross, 2012: 383) and draw attention to the 'skin' of the film (Marks, 2000). Viewers are engaged with all the senses, including vision and bodily engagement. In hyperhaptic visuality, our vision functions like the sense of touch, which is heightened through the extra dimension of depth, even with the impalpable content of S3D. The use of depth and dimensionality in S3D imagery creates an immersive visual experience in the virtual space of the film, which intensifies our sense of touch or bodily presence compared to 2D cinema. Therefore, our experience of S3D content can become not solely cognitive or emotional but also embodied. This approach effectively 'embodies' the concept of beauty within the film, aligning with Williams' aim to challenge perceptions through the sublime. He specifically seeks to create a sense of beauty and the sublime by overwhelming viewers' senses with fantastical imagery, provoking new and unfamiliar ways of engaging with the images presented before them (Williams, 2020a).

Conclusion

This study has shown how experimental filmmakers employ 3D film to extend stereoscopic aesthetics beyond the 'realism' of dominant cinematic practices. Kazuhiro Goshima and Blake Williams disrupt and expand stereoscopic perception by exploring perceptual challenges and artefacts to construct unique types of illusions in their films. Their S3D artworks and the stereoscopic techniques involved aim at a different set of properties than those found in 2D planar media, including a heightened sense of viewer engagement and subjectivity, perceptually unusual distortions in the visual space, and tangible immateriality.

Both artists intend to create visual worlds which deviate from objective, lived reality, and require viewers to interpret them actively. Goshima transforms the ordinary through his 'strange' decoding method to give birth to unfamiliar, poetic views. Williams creates mystery and cognitive dissonance to conjure up 'fantasies', desired realities that do not exist, which are neither reality nor metaphor.

Both filmmakers employ stereoscopic techniques to engage viewers visually, cognitively and bodily, and utilise S3D media to create subjective perceptual illusions, which require the physical presence of both viewer and media to materialise. In this sense, their works facilitate the emergence of new positionings of the audience in the realm of spectatorship, encouraging viewers to be more active in the viewing experience and engaging their faculties of reason and reflective judgement. Goshima and Williams present viewers with ambiguous perceptions that might disorient and overwhelm some viewers. However, both artists carefully select their settings and depth relationships and attempt to balance their artistic explorations and the possible adverse effects on viewers' experiences, such as distraction or physical discomfort.

Are the studied artists trying to break the hegemony of stereoscopic realism? For many artists, one of the goals of art is defamiliarisation so that we can gain new perspectives and see the world with fresh eyes. In this sense, their works move towards this direction as they create new perspectives in their works, which offer alternative approaches to the ontological question of S3D cinema. As mentioned, a focus on active versus passive viewing and subjective versus objective reality is particularly crucial in understanding the significance of this kind of stereoscopic filmmaking. In contrast to conventional uses of S3D in the service of narrative and mimesis, Williams pushes a more formal investigation in his experiments to engage more directly with the tactile strangeness of 3D technology. Goshima creates new depth and dimensionality that defamiliarise the mundane and highlight stereoscopy's potential for new modes of cinematic expression and storytelling. As such, their works must be understood as ways of subverting the dominant modes of S3D cinematic representation.

To conclude, the expanded stereoscopic films of Goshima and Williams can be seen as supporting evidence for the claim that 3D has rich potential as an experimental art form, which, rather than being merely a visual enhancement for increased realism, can create and instigate new experiences, new worlds and new knowledge. Their works help us recognise that the capabilities of stereoscopic imaging should not be limited to providing 'realistic' portrayals of perspectival depth but should also be viewed as creative opportunities for artists and filmmakers.

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Notes

1. Charles Wheatstone (1838) proved that a realistic impression of depth can be obtained by presenting two separate images to the two eyes, drawn from two viewpoints corresponding to the interocular separation (Braunstein, 1976). The random dot stereograms studied by Béla Julesz (quoted by Braunstein, 1976; Julesz, 1960: 15) later contributed to our knowledge of the role of binocular disparity in depth perception, and he found that disparity can indicate depth even in images with random dot patterns.
2. According to Nick Jones (2015: 184), the making of such unusual, unique spaces and objects in S3D media is flexible in ways that can simultaneously incorporate or contrast with other modes of distortion employed by 2D planar media.
3. In expanded stereoscopic artworks, the placement of the audience can also entail the physical exhibition settings. An examination of the role of spatial arrangement for spectatorship is explored in the paper 'Into the Vœrtex: Case Study of a Stereoscopic Abstract Animation Installation' (Hattler and Cheung, 2021), which focuses on how the exhibition setup of S3D art installation Vœrtex (2021) engages viewers through an interactive viewing experience.
4. For further aspects of distinction between haptic and optical images, see scholarly works by Alois Riegl ([1927] 1985, quoted in Iversen 1993: 170, 77) and Laura Marks (2000: 162).
5. Tom Gunning (2021) made related remarks about the viewer's role when he discussed how Ken Jacobs' work offers another way of seeing by opening up the space between spaces and inserting an awareness of our role as image receivers into the viewing of cinematic images.
6. William Paul compares the use of 3D to what Tom Gunning (2006: 382) called the 'cinema of attractions' of films of the 'primitive' period, which dominated cinema until about 1907. Paul points out that the superseding of interest in narrative by an 'exhibitionist nature' might be found in the medium of 3D, which was, however, dominated by the institutionalised aberrational style during the first wave of 3D cinema in 1952–54. 'Gunning has described the "cinema of attractions" as promoting "exhibitionist confrontation rather than diegetic absorption"' (Paul, 1993: 321–322).
7. For Williams, reality refers to 'an agreed-upon way that things are', and he refuses to use the word 'metaphor' since viewers might think of it as something that represents something else (Williams, 2020b).
8. In psychology, there are some notable examples of ambiguous perceptions, such as the Necker Cube (see Gregory, 1998: 205–206), the Young/Old Woman (see Gregory, 1998: 206), the Face/Vase (see Schumann, 1987: 21–34), and Schroeder's staircase (see Prueitt, 1975) which all demonstrate that our interpretation can keep switching even though the visual input remains the same.
9. In humans, each eye observes a slightly different image, determined by the distance between the eyes or interocular distance. Horizontal parallax refers to the resulting difference in distance between the observed images, which are presented as a horizontal shift in the positions of the same object (Wheatstone, 1962).
10. Depth cues refer to the information about depth arising from a specified stimulus feature (Howard and Rogers, 2012). The binocular depth cues are parallax and convergence. Monocular depth cues include occlusion, motion, relative size and lighting (Brooks, 2017; Mendiburu, 2009).
11. Realism is not just about mimicking the surface appearance of reality. It is also strongly shaped by how techniques are used, the context of production, and the relationship between the image and the viewer. So, 'reality effects' point to this more complex construction of realism in creative media such as film. For the meaning of 'reality effect', see Lev Manovich's article, 'Reality' effects in computer animation (1997), which summarises three definitions of realism. For Andre Bazin, cinematic technology and style aim at a 'total and complete representation of reality' (Bazin, 1967: 20). For Bazin, realism is found in the space between reality and a transcendental spectator. Bordwell and Staiger are satisfied with Goldsmith's definition of realism as 'the production of an acceptable semblance of reality' but note that realism in film should be connected with the industrial organisation of cinema. Comolli sees realism 'as an effect,

produced between the image and the historical viewer and continuously sustained through the ideologically determined additions and substitutions of cinematic technologies and techniques' (Manovich, 1997: 7). Manovich approaches the problem of 'realism' in computer animation based on these accounts of realism in film theory.
12. According to Michael Koresky, the most dramatic instance in Godard's Goodbye to Language (2014) is a technically virtuosic but conceptually simple split in which the image breaks apart so that the right and left eyes perceive two different camera and character movements in the same scene. The reconnection of the two eyes' images confirms the film's inherent stability (Koresky, 2014).
13. As Greg M. Smith explains, poetic films 'do not "make" people feel… [but] extend an invitation to feel in particular ways. Individuals can accept or reject the invitation… [and they] can accept in a variety of ways' (Smith 2003: 12).
14. This means that one eye sees the shadow at one position and the other at another, about two to five frames apart.
15. For more details about colour stereoscopy, see David Brewster's article 'On the vision of distance as given by colour' (1848: 48) and Johann Wolfgang Goethe's book *Theory of Colours* (1810).

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