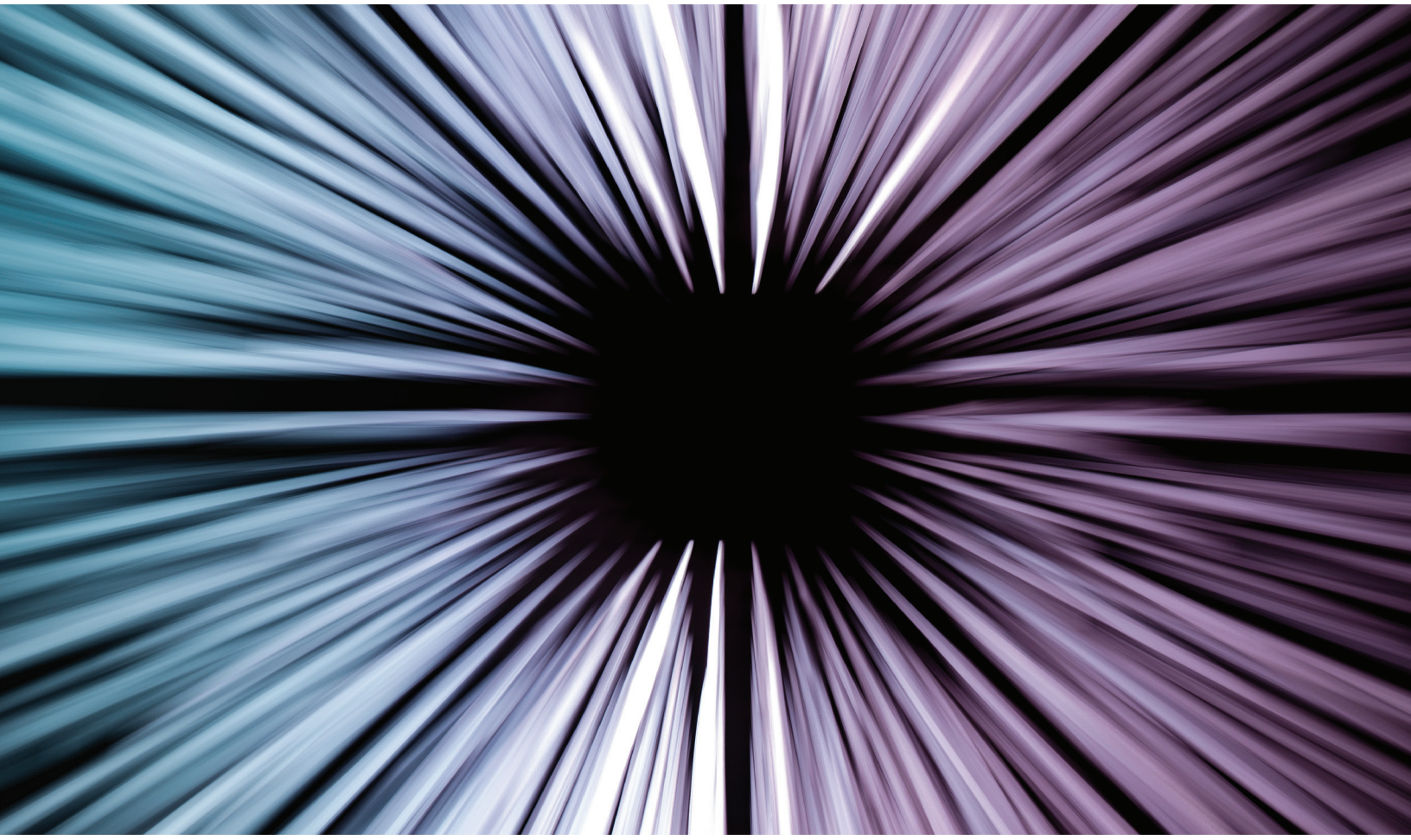
Virtual Reality In Entertainment

The State Of The Industry



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PREFACE

The British Academy of Film and Television Arts (BAFTA) is an independent charity that supports, develops and promotes the art forms of the moving image by identifying and rewarding excellence, inspiring practitioners and benefiting the public.

Currently, BAFTA promotes and celebrates the very best creative work in film, television and games, but recently VR has become the hottest two letters in our industry, with daily announcements and proclamations. However, there remain considerable uncertainties around what impact VR will have on the creative world.

In early 2017, BAFTA set up a VR advisory group, made up of industry experts and thought leaders from across the UK and the US, to explore the challenges and opportunities offered by VR, and to consider the role of VR in the context of the entertainment industry. Across the next few months, the VR Advisory Group discussed and debated questions such as the role of VR in entertainment, delivering and recognising excellence in VR content, and the challenges and opportunities unique to VR.

This paper draws on the insights from the VR Advisory Group research and discussions across the past few months, as well as several interviews with executives from across the industry. We endeavour to provide some preliminary answers to some of our burning questions, and to offer some insight into the process of leveraging VR techniques and technology to produce new forms of storytelling experience.

Inevitably, a single report is unable to capture everything that has been discussed and debated, nor can it encompass all of the excellent VR content which is already being produced by creative talent. However, we are indebted to all those who have contributed their time and expertise to the VR Advisory Group and to this report, and to the wider body of knowledge which has been produced by the group and which will provide a valuable ongoing resource to BAFTA members.

Whilst it is impossible to mention everyone who has played a part in the preparation of this report, we would like to give particular thanks to the following contributors:

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EXECUTIVE SUMMARY
WITH RECOMMENDATIONS

SECTION 1: OVERVIEW

This opening section outlines key information pertaining to VR, with the intention of providing a clear, theoretical basis for subsequent sections. Section 1 outlines the primary types of VR: Computer generated (synonymous with VR games), live action (typically denoting real-world content captured via specialist camera) and web-based (VR as a new means of interfacing with web content – social media, e-commerce, etc.).

The main platforms of VR are identified as: smartphone-based (mobile systems utilising a smartphone with a wireless headset – e.g. Google Cardboard, Samsung Gear VR) and tethered (PC-connected headsets presenting higher fidelity content but in wired, fixed spaces – e.g. HTC Vive, Oculus Rift). This section also identifies the range of tools currently available to VR developers and observes key technological breakthroughs that have facilitated VR's contemporary progress, including advances in processing power and graphics rendering, mobile/wireless technology and compact inertial measurement units (IMUs) that enable head tracking in mobile platforms.

This section continues with a brief review of key user experience features (namely immersion, presence and empathy) that are referred to regularly throughout the paper before identifying key qualities of VR that contribute towards user-perceptions of quality and an overall positive experience. The section closes with a review of the psychological and physical risks and concerns associated with VR, but also presents strategies for managing these issues.

SECTION 2: OPPORTUNITIES AND CHALLENGES FOR VR

In this section, central questions are considered, surrounding the value and meaning of VR as perceived by the global community. With regards to the entertainment industry there is a consensus that VR is the frontrunner for advancing from flat screens to become the next major entertainment medium. This assertion is based on two key factors, the ability of VR to evoke user-presence and meaningfully draw them into the virtual world to an unprecedented extent, and the potential of VR as an agent of positive societal change. A review of market

forecasts reveals the continuing exponential increase in the VR industry's worth and influence. It is also revealed that VR is of substantial value to a range of other industries (from retail and real estate to healthcare and engineering, and beyond), identifying VR as a highly diverse revenue generator.

Section 2 continues with a supported argument for VR as a means of social good, reviewing several key VR titles that address issues ranging from the persecution of immigrants to the realities of living in a war-torn country. Particular attention is paid towards the trajectory for social and communal VR and it is asserted that one of VR's most powerful features is its capacity to bring people from all across the world together within shared, collaborative spaces. Socio-economic factors and limited physical ability are identified as central accessibility concerns in VR and this section includes details on these points alongside information regarding how the industry is seeking to address them. Section 2 closes with the finding that, overall, awards bodies across the globe are steadily beginning to recognise the importance of VR as a unique technology, creative platform and experience. Here it is concluded that it would not yet be appropriate for VR to be a standalone class of BAFTA awards, but that incorporating VR entrants into existing awards is both timely and appropriate.

SECTION 3: VR IN ENTERTAINMENT

The purpose of this section is to lay the foundation for the closing assertions made in Section 4, pertaining to determiners of excellence in VR. Section 3 commences with a review of VR in entertainment. Here it is asserted that the unique capacity of VR to evoke user-presence is what separates it from more traditional media. This section also identifies the diverse range of professional roles relevant to VR production, from conceptual artists and actors to computer programmers and user-interface designers. It is also noted that VR production creates jobs comparable to some of those found in traditional film, television and video game production, but also requires various VR-specialist roles that include VR technologist and VR interaction designer. Section 3 also covers best practice pertaining to general production, narrative and location-based VR. Key points of best practice documented within this section include (but are not limited to): building the project around the central goal of evoking presence, appreciating the numerous unique aspects of VR development, ensuring individual components of the work (script, acting, visual design, sound design, etc.) are themselves of high quality (not relying on the novelty of VR to carry the work), and striving to create an experience that is bespoke-to-VR (an equivalent experience could not possibly be created in any other medium).

SECTION 4: THE ROLE OF VR IN THE MISSION OF BAFTA

This section draws upon all of the preceding information to present an informed consensus pertaining to the missions of BAFTA, namely identifying excellence and sharing insights into the creative craft of VR. How to differentiate outstanding VR titles is discussed, with key findings fed into a set of criteria that, looking forward, could be used by BAFTA as a starting point to build an assessment framework for determining titles worthy of award nomination. The eight criteria are: visual design, audio/music design, narrative, interactions, integration (the extent to which the components of the experience react to one another and work effectively as one), vision (the extent to which the experience is unified towards a distinct intention), overcoming limitations (overcoming the technological and user experience issues of VR) and impact (the extent to which the experience can promote progress, either in terms of VR itself or in another aspect of societal advance). The criteria also share several broader points of excellence that include implementation of cutting edge and originality. These criteria are then exemplified by a range of current VR titles widely regarded as excellent. This section also identifies the current top-

selling VR titles, identifies institutions across the US, Canada and the UK in which VR education is taking place and presents a comprehensive list of titles that are highly recommended as ideal for introducing individuals to VR.

Finally, we present our recommendations to BAFTA, based on the consensus of the VR Advisory Group. VR is here to stay, and, although still an emerging platform which presents a number of challenges, it is a unique storytelling medium which warrants serious consideration. We suggest that BAFTA retain a VR advisory group, with a view to forming a VR committee in the near future.

01 OVERVIEW

1.1 PLATFORMS AND TECHNOLOGY

1.1.1 TYPES OF VR

The definition of virtual reality is the subject of much debate. The main differences in opinion relate to whether the content is 360 camera filmed VR (henceforth "live action") or computer game-engine generated (henceforth "CG"; and whether the viewer is able to interact with the experience.)

COMPUTER RENDERED VR

CG VR generates an interactive three-dimensional digital world, with a sense of spatial presence. Objects within the world have a location in three-dimensional space relative to the position of the viewer. This type of experience creates a "sense of oneself inside of things" rather than merely "pictures of things".

CG content creators generally work with game engines such as Unity, Unreal, or CryEngine, to render—in real-time—a virtual world that can be made interactive. The engine renders changes in lighting, motion, distance and time. CG VR can take advantage of the 6 degrees of freedom (DOF) enabled by full body motion tracking. The companies behind the major game engines have realised the potential of their technology to develop VR and AR applications and content, and have already been giving major support to editing tools designed for native VR and AR development.

A drawback of CG vs. live action is the "uncanny valley thesis," which posits that people find renderings of natural features to be appealing—until they look almost, but not exactly, like the subject they're mimicking. For example, it is comfortable for us to watch a cartoon animation of a human, but if that image gets too close to a human, it feels weird, until it reaches exact representation—which it rarely does. AAA game developers have still not reached the point of quality where character models and video game environments can fully defeat the uncanny valley.

LIVE ACTION VR

Unlike computer-generated VR, live action VR refers to the capture of live events into a navigable experience, in which the viewer can explore the physical space of the piece. In the past, live action VR was subject to limited range

CG VR generates an interactive three-dimensional digital world, with a sense of spatial presence.

of motion, in which users moved their heads to explore a space— but couldn't move forward to navigate their environment. This is changing as more advanced "stitching" (the editing of VR files to form continuous, seamless files) has added the "Z-Axis" into live experiences, enabling user-controlled movement through the captured footage. The development of volumetric scene capturing technology will further evolve the capabilities of this medium.

WEB VR

WebVR will be the future of browsing, emailing, shopping and socializing. WebVR enables fully immersive content to be viewed on a mobile device, desktop computer, or in a VR headset via web-based applications.

A-Frame is the first open source library, pioneered by Mozilla for web developers, to use for building websites with VR viewing capabilities using as little as one line of HTML code. It eliminates the need for the complex WebGL 3D API otherwise required to code an experience to life. Other open source libraries with similar aims have been created since A-Frame including Vizor, PlayCanvas, BabylonJSor, Primrose VR, ZeoVR, and Oculus' own ReactVR.

WebVR is currently supported by all major web browsers, as well as those compatible with Oculus Rift, HTC Vive, Samsung Gear, and Daydream VR. WebVR is likely to be the fastest way for virtual reality to proliferate and will enable seamless movement throughout experiences.

1.1.2 MOBILE PLATFORMS

There are many VR platforms available. These platforms are highly diverse in form and functionality. On the lower-end of the spectrum are smartphone VR, and on the high-end is tethered VR, powered by high-end personal computers. They each have pros and cons. Smartphone VR has a very low barrier to entry due to its portability, low cost, and massive install base of smartphone users. However, the quality of these experiences suffer from lower quality graphics, reduced computer processing power, minimal or absent input control systems, and lower screen resolution.

360 VIDEO AND SMARTPHONE VR

Smartphone or mobile VR leverages the limited but rapidly advancing graphics processing capability and display screen of a mobile phone, to deliver VR content via a lightweight head-mounted viewing device. Experiences range from passive viewing of low-quality graphical content —known simply as "360 video", to higher-quality interactive games and applications. Worth noting is that minimally interactive, lower-quality 360 video seems to have gained the most traction to date: about 50% of time spent in mobile VR, which has the highest distribution among all VR platforms, is dedicated to 360 video.

> WebVR will be the future of browsing, emailing, shopping and socializing.

CARDBOARD

Most people's first VR experience will come through a Cardboard-enabled headset. Since 2014, Google has distributed over 10 million "Google Cardboard" headsets, with many others distributing cardboard as well. These are smartphone holders that mount over a mobile phone, similar to a pair of binoculars. Others have manufactured variations of Google Cardboard made of plastic, or other materials at a very low price point, from free to $15. Cardboard is smartphone agnostic; the user downloads an app from companies like Within or Jaunt or from the Google Play Apple App stores, or streams directly from the growing selection of YouTube 360 videos. Cardboard enables the most basic and free VR experiences, and it is laying the groundwork for the mass adoption of VR in the nearterm.

GOOGLE DAYDREAM

Composed of both hardware and software, Daydream is a higher-tech cousin of Google Cardboard. The device is an end-to-end mobile VR system compatible with the generation of smartphones running Android Nougat. While Cardboard works with almost any smartphone, Daydream is currently only compatible with phones including Google Pixel, Motorola Moto Z, Huawei Mate 9 Pro, ZTE Axon 7, and ASUS Zenfone AR. More Daydream-ready phones are on their way. The components of these phones offer a smoother, lower latency experience than would be possible with a software-only update to alternative smartphones. The Daydream HMD and its accompanying wireless controller retails for $79, plus the price of the phone.

SAMSUNG'S GEAR VR

By keeping hardware compatibility exclusive to their own devices, Samsung has positioned themselves at the forefront of mobile VR. They sold a total of 4.51 million units in 2016, outpacing every competitor. The second iteration of Gear VR is backwards compatible with Samsung's earlier S6 and S7 devices, includes a wireless controller, and enables an enhanced interactive experience. Features include built-in sensors and smartphone-compatible controls, as well as focal and latency adjustment, and even a cooling fan. Facebook's Oculus is providing content support by working with developers and growing the Oculus Store. The price is around $130, however, the Gear VR experience also requires the purchase of a compatible high-end Samsung phone, typically around $700.

1.1.3 TETHERED PLATFORMS

Tethered VR offers greatly expanded resolution, quality and navigational options—but is expensive, cumbersome, and requires much more room. Tethered experiences often have more involved storylines and mechanics, sharper graphics, and may offer hours of continuous gameplay or viewing.

PLAYSTATION VR

PSVR sold roughly a million units in its first 6 months, making it the best-selling high-end HMD to date. As a reference point, the original iPhone sold 1.4 million units during its first 3 months on the market, and it is considered one of the most successful tech products of all time. PSVR sales are therefore a very bullish sign for the industry.

The success of PSVR is due to the previous install base of 65 million PS4 worldwide. PS4 owners could add VR for $400, instead of buying or building a VR-capable personal computer plus a $600-$800 Oculus Rift or HTC Vive.

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PSVR comes with a 5.7 inch OLED display panel, 1920×1080 resolution, a refresh rate of up to 120Hz, and a 100° field of view. The LEDs around the PlayStation VR headset, on the DualShock 4 wireless controller, and the PlayStation Move motion controller are tracked by the PlayStation Camera, providing precise capture of natural movement in virtual space.

OCULUS RIFT

Oculus' $2 billion acquisition by Facebook rocketed it to stardom, and it quickly became the face of high-end VR. The Oculus Rift was the first headset to provide developers with software/content creation kits (SDKs), and active support of third-party content development by sharing technical upgrades and best practices, and in some cases, even financing development.

The Oculus Rift comes bundled with a positional tracking sensor and Xbox controller. Oculus Touch is being offered for an additional $200, and functions as both a gamepad and motion sensor. It tracks hand movements to allow users to more fully interact with their environment, which provides more intuitive control than a standard gamepad. Facebook and Oculus are working to make the Oculus Store the leading destination for VR content, and the leader in marketing virtual experiences.

The strong visibility of the Oculus brand and the deep financial resources of Facebook provided Oculus with an opening advantage in the marketing, production and distribution of Rift, although this is now being strongly challenged by a range of competitors.

HTC VIVE

The HTC Vive was developed by Valve and HTC as a push for creation of VR content. and wider-spread adoption of VR. It initially distinguished itself from competitors by adding the milestone of room-scale tracking. It was released in April 2016, its 15,000 pre-orders selling out in 10 minutes. Currently the cost is $800 for the HMD, two motion controllers, and Steam VR tracking system. These, in tandem with the Vive's front- facing camera, allow precise tracking of the location and movement of the headset and controllers. For an additional $100, the Vive Tracker can attach positional tracking to any real-world object.

1.1.4 RECENT TECHNOLOGICAL BREAKTHROUGHS

We are witnessing "Moore's Law" unfold in all areas of significance relative to VR, with an almost exponential growth in the capabilities of the technology. Recent breakthroughs in graphical rendering (GPUs), computer processing (CPUs), screens and resolution, game engines, streaming and cloud-based solutions, motion-tracking, binaural and object-based 3D audio, sensors, and portability all contribute to the rapid proliferation of VR. Recent developments in Inertial Measurement Units (IMUs), a system that measures linear and angular motion usually with a triad of gyroscopes and triad of accelerometers, is also a major contributor.

Further, these technologies have been integrated into high-end mobile phones, enabling them to deliver powerful experiences, ensuring that smartphones will continue to play a major role in the development and success of VR.

One challenge facing the VR industry is that consumer expectations based on 4k resolutions and 8th generation game consoles are extremely high. A consequence of our being exposed to information about recent advances in technology at ever-increasing speeds is that our attention span is shortened—things become relevant and irrelevant at proportionally increasing rates. Put another way, we hear or read about new processing or wireless capabilities, and we want them immediately. In reality however, it takes substantial time to scale out such implementations. This is especially the case with emergent "1.0 technology" because people are accustomed to their legacy operating systems and hardware that are on their nth iteration.

Moreover, it is detrimental to the ecosystem to turn around new hardware and software iterations too frequently. New platforms can catch content creators on their back foot: just as they are getting comfortable creating stories with one set of tools, an entirely new toolset and workflow comes along that requires time to learn and resources to spend on upgrades. Therefore, the VR industry, like all markets, cycles through periods of expansion and contraction-- growth and stability. It is during the periods of stability that creatives can hone their craft as they experiment with, and push the boundaries of, the medium as they are all "caught up" with the technological growth that had occurred prior, also inevitably lying ahead.

1.1.5 KEY CREATION AND AUTHORING VR TOOLS

Creating compelling content in VR requires a diverse and technologically savvy skillset. Though VR is a digital medium, VR's current creation processes are akin to the specialized, complex, and tedious processes inherent in the early days of film. The tools and platforms available to develop content are always limited at the outset of a new medium. In the early days, developers needed to know HTML, to build webpages. Eventually, editor tools came along, making the coding less labour intensive. Publishing platforms like Squarespace and Wordpress were the next evolution which made it possible for anyone with basic computer knowledge to create a site without any coding knowledge. The same parallel exists within VR, in that processes will become much friendlier to the specialised and less-technically minded over time.

VR creation is divided into two baseline components: authoring and capture tools. Game engines such as Unreal Engine, Unity, Crytek, and Amazon's Lumberyard are currently key authoring tools for VR. Developers working in one of these environments, have at their disposal millions of lines of pre-written code. This frees game designers to focus on making a compelling story and environment for the user to experience.

Game engines such as Unreal Engine, Unity, Crytek, and Amazon's Lumberyard are currently key authoring tools for VR.

Other authoring tools lend themselves more specifically to CGI. Software such as Maya, 3DS Max, Blender, zBrush, and Adobe Suite are widely used in the industry to generate and render graphics, textures, and more.

On the capture side, there are two categories. Low cost 360° video capture systems like Samsung Gear 360, Ricoh Theta (SC), and 360Fly are among many viable consumer solutions. They generally offer livestreaming capabilities, 4K HD recording, automatic stitching, and optimized ergonomics. These consumer-friendly solutions are limited to a single 360° point of view, and thus extremely limited interactivity.

On the high-end are volumetric and light field capture and delivery systems. Examples of these premium CG and live-action crossover systems are Microsoft LightStage, Lytro, 8i, HypeVR, OTOY. A key component to these systems is sophisticated motion-capture techniques that allow natural human movement to be captured and rendered in a virtual space. Motion capture technology has evolved to enable full renderings of human bodies into VR, creating extremely detailed models that can be walked around and interacted with in full 6 degrees of freedom. In the case of volumetric video capture, data points are captured by a camera system, then that data is fed into a game engine to be processed and visualized. Audiences are then able to interact with life-size, computer-generated characters.

One step beyond volumetric capture is light field capture, which utilizes a camera system that captures data of all light in a space, and translates that data into a game engine, allowing for the manipulation of individual pixels from the scanned environment. This synthesis of the real and virtual— digitizing a physical environment in its entirety, and being able to manipulate it at the tiniest level of the pixel— is the "Holy Grail" of VR and AR creation. It will enable the generation of completely new universes.

1.2 USER EXPERIENCE

1.2.1 IMMERSION, PRESENCE AND EMPATHY

VR has the power to immerse its users and, in them, evoke intense feelings of presence and empathy. This facet of VR is the primary way in which it currently distinguishes itself from its technological and artistic cousins in cinema, television and video games. This "affective bridge" between content, technology and user is also a significant factor in drawing individuals into the production of VR, their interests piqued by the potential to experiment with completely new avenues of creative practice and to emotionally engage audiences in ways previously unexplored.

Whilst the definitions of immersion and presence continue to be debated throughout the scientific community, the following represents the most widely accepted contemporary theories. By immersion, we are describing the objective and technical features of a platform that physically surround the user in some form, but also have the potential to psychologically surround. This description highlights the key technical features of contemporary VR: (1) head-mounted displays that stretch across the human field of view whilst occluding any other visual information; (2) visuals that respond to head and (in some cases) body movements; (3) noise-cancelling headphones that obscure any real-world audio and; (4) interactivity, connecting the user to the virtual world via action and feedback.

In contrast, presence can be best understood as the primary user experience goal of immersive design. Presence is the previously mentioned psychological surrounding effect, where the user feels a deep connection to the virtual world. Presence can extend to narrative, characters and gameplay/interaction, but it is most commonly interpreted in terms of location – the user feels as if they are actually there – and it is this form of presence that (at least for now) has the most relevance to VR. Feeling a sense of physically being there is what connects presence to the unique immersive designs of VR. As the physical world is shut out and the user is presented with a new and engaging virtual world in which they can interact in deep and meaningful ways, they are increasingly likely to feel that they have (at least partially) left their physical world behind and been transported to the VR world.

Lastly, empathy completes a three-stage process that is itself a powerful explanation of VR. Just as immersion facilitates presence, presence facilitates empathy. In essence, the feeling of being there provides the user with a pseudo-first-hand experience. Whether they are transported to a migrant camp or a town in the aftermath of a natural disaster, the user is up close and personal with the content, and the sensation of presence has the considerable potential to evoke a powerful empathetic experience.

Immersion ➡ Presence ➡ Empathy

Presence and empathy are both recurrent terms that appear throughout this paper. They underpin many of the issues pertaining to how the global population perceive VR and the extent to which the platform should be officially recognised as separate from other forms of media.

1.2.2 FACILITATING A COMFORTABLE AND POSITIVE USER EXPERIENCE

Comfort issues in VR can be broadly split into three specification classes: computing/display performance, experience design, and hardware side-effects.

Maintaining comfort for the user throughout the experience is a central issue for VR. Whilst other factors can draw user in, comfort becomes exponentially more crucial for every few minutes spent in VR. If felt, discomfort becomes the most likely reason a user will exit the experience. At present, several key comfort issues remain in various contemporary VR systems, highlighting the importance of discovering solutions lest VR experiences be constrained to last for only short periods of time.

Comfort issues in VR can be broadly split into three specification classes: computing/display performance, experience design, and hardware side-effects. Computing/display performance specifications relate primarily to nausea and simulator sickness effects. The underlying issue is frequently due to asynchrony between the visual and vestibular system, in which the user is moving their body through space at one rate, but the visual confirmation of that movement in the display moves at a different rate. A steady minimum frame-rate of 90 frames per second is widely acknowledged as the target specification but this is not simply a case of ensuring the computing power is sufficient, as a highly detailed and/or poorly optimised VR experience (virtual environment development) can limit the frame rate of even high-powered modern systems.

Experience design describes ways in which the game/experience is crafted can impact upon user comfort. In ergonomic design for example, the positioning and operation mechanics of a user interface (UI) or heads up display in VR can have a significant impact upon eye strain (e.g. if the UI is too close to the user) and neck strain (e.g. if the UI requires the user to repeatedly crane their neck to see and select the interface objects). A well-placed stationary reference point (such as a horizon) can help mitigate nausea, whilst the scale of a virtual space can have significant effects on user comfort depending on any claustrophobic or agoraphobic tendencies. Further issues include the duration a user is required to stand, the extent to which users need to outstretch their arms or hold particular poses, and the intensity of the virtual lighting and colour scheme.

Lastly, hardware side-effects include various issues relevant to the design and construction of VR-HMDs, particularly those for mobile VR. Currently, prolonged use of any HMD will cause markings across the face due to the pressure required to maintain stability and receive a focussed image. This pressure can become increasingly uncomfortable over time. Tethered VR systems, despite significant recent advances, continue to be of a significant weight that, over time, causes discomfort in the neck for most users. Although mobile VR systems enjoy being of lighter construction, the heat generated by the phone can not only be uncomfortable, but also typically causes the lenses to steam up, obscuring the image and forcing the user to remove the headset.

Whilst several of the above comfort issues cannot be entirely removed by good design, an outstanding VR product will nevertheless demonstrate comprehensive awareness of these issues and deliver an experience that is both developed with comfort best-practice in mind, and that successfully circumvents hardware and computing issues through intelligent design.

1.2.3 PSYCHOLOGICAL AND PHYSICAL RISKS AND CONCERNS

Currently, since the industry is so nascent, there is a lack of longitudinal studies that can come to bear on the psychological impact of long-term immersion in VR. Adverse psychological effects do indeed remain a possibility with VR, as its realism tends to be very confounding to the instinctual, "reptilian" parts of our brain. False memories, dissociation from reality, and negatively impacted behaviour, attitudes, and opinions are all potentialities. Further, the risks afforded to the general population may be compounded in children. The negative effects of VR on children could include all the aforementioned, as well as a higher probability that they may spend too much time in virtual worlds as opposed to the real world. This however is already seemingly the case, albeit to a different degree, as adolescents, teens, and young adults are spending increasing amounts of time online via their smartphones and computers. There are also risks associated with a distorted perception of space and its effects on the hippocampus. In this, there may be potential links to Alzheimer's, stroke, depression, epilepsy, and post-traumatic stress disorder.

Cyber sickness, similar to motion sickness, is also an intermittent side-effect occurring on an individual basis... It is thought that this upset is caused by a sensory conflict in the brain.

In regards to physical risks and concerns, we know that, as with staring at any screen for prolonged periods of time, eyestrain is bound to occur. With VR, it is perhaps even more relevant because of a user's proximity to the screen. That is why it is highly recommended to take breaks in between games and experiences.

Cyber sickness, similar to motion sickness, is also an intermittent side-effect occurring on an individual basis. Symptoms include nausea, disorientation, pallor, headaches, sweating and potentially vomiting. It is thought that this upset is caused by a sensory conflict in the brain, with a mismatch between the visual information and that the signals coming from body position and movement. To reduce the risk

of cyber sickness, the VR should run at a minimum frame rate of 90FPS, be well-calibrated, and have smudge-free lenses. Creators of a VR experience should refrain from jerky motions as to not unsettle the sensitive viewer. A common navigation mechanic that has proved effective to mitigate nausea is user controlled teleportation, minimising the acceleration/deceleration phases of motion. However, it should also be borne in mind that some VR experiences intentionally recreate real-world situations which would naturally induce discomfort, such as roller coasters and zero-gravity simulations. In these cases, we should actually expect VR to recreate the discomfort or disorientation associated with these experiences.

There are other physical risks associated with VR usage such as tripping over wires, colliding with (unseen) objects in the physical space, or losing one's balance and falling. There are techniques for mitigating these risks, including clearing obstacles from the vicinity of the users, mapping physical objects into the virtual space, or offering seated VR experiences. Some headsets also now offer a "see-through" mode which allows users to have some awareness of their physical surroundings during the VR experience.

Further, all VR headsets are in direct contact with the skin of the face, and are often swapped from person to person. This raises concerns around hygiene, but with good practice they are easily managed. One prevalent method is that every user of a VR system is given a disposable mask liner prior to putting on the HMD. Alternatively, VR HMD operators can wipe down the HMD and controllers with antiseptic wipes after each use.

Lastly, general societal dangers remain a possibility. VR is certainly not immune to broken human nature, and these large-scale concerns such as moral panic, instant gratification, pornography, "virtual migration" (less use of physical body), and crime (virtual abuse, sexual harassment) have come to bear on all preceding media. It will be up to regulatory bodies to police VR spaces, as they have done with radio, film, television, and the internet.

OPPORTUNITIES AND CHALLENGES FOR VR

2.1 THE SIGNIFICANCE AND VALUE OF VR

VR Advisory Group members agree that VR represents the next great entertainment medium. They cite VR as the next major advancement in the technology of the screen. As one member notes, "We, as humans, like screens. We function with them and carry them with us all day long in the modern world. But they have inherent limitations. VR at its core begins to remove those limitations when we are able to track our visual experience, remove the border of the visual experience, and put ourselves inside and around the visual experience." Some see VR as an agent of positive change in how humans connect with each other to share information and experiences.

2.1.1 MARKET FORECASTS

Many 2016 predictions on VR sales contributed towards the resulting "trough of disillusionment," when the nascent industry could not grow quickly enough. That said, in 2016, according to Dutch bureau BOM.nl, Samsung sold over 1 million Gear VRs; HTC Vive shipped 420,000 units; Google sold 260,000 Daydreams; Oculus was significantly hampered that year by components shortfalls. Perhaps the most important platform statistic is Sony's ability to sell over 1 million PSVR units in well under a year.

In its recent Virtual Reality Industry Report: Spring 2017, Greenlight Insights forecasts total virtual reality revenues to reach $7.2 billion globally by the end of 2017, of which, head-mounted displays (HMDs) will account for $4.7 billion. Their revenue projections by 2021 are $74.8 billion for the entire VR industry. Others are a little more cautious in their predictions. Statista projects a hardware/software market of $40.4 billion by 2020.

"We, as humans, like screens. We function with them and carry them with us all day long in the modern world. But they have inherent limitations. VR at its core begins to remove those limitations when we are able to track our visual experience, remove the border of the visual experience, and put ourselves inside and around the visual experience."

Exclusively in regards to VR entertainment (not including games or live events), Goldman Sachs has predicted revenues of over $3B per year by 2025.With 25 million headsets in the marketplace that would translate to $120 per year in spending per VR headset. If the live events category in the Goldman Sachs estimates are coupled, this more than doubles the opportunity, to over $7B in virtual reality entertainment revenues per year by the year 2025.

As the price for hardware decreases, the adoption curve will increase dramatically.

Hardware sales expectations— other than PSVR— should probably err on the side of conservatism, since the devices on the market are still 1st generation, consumer-level devices. In the words of one VR Advisory Group member: "We could tie historical success to other completely ubiquitous tech like the first three years of VHS, DVD, or Blu-ray, and look at the price curve vs adoption curve - and we'd see that VR is fitting these same sales tracking models".

As the price for hardware decreases, the adoption curve will increase dramatically. From a software standpoint, many developers are already profitable from their VR content; some VR titles have already hit $1 million in sales.

The top 10 VR games on Steam (as of 5th September 2017) are as follows:

Star Trek Bridge Crew (Owners 37,848 +/- 6,519)
Superhot VR (Owners 777,496 +/- 29,526)
GORN (Owners 22,885 +/- 5,069)
Onward (Owners 74,816 +/- 9,166)
Gunheart (Owners 2,641 +/- 1,722)
Raw Data (Owners 91,833 +/- 10,155 – NOTE: Raw Data had a free play weekend in May, so numbers may be skewed)
Arizona Sunshine (Owners 79,803 +/- 9,467)
Paranormal Activity (Owners 14,083 +/- 3,977)
Virtual Desktop (Owners 146,991 +/- 12,847)
Audioshield (Owners 123,813 +/- 11,791)

2.1.2 THE ROLE OF VR IN SOCIETY

VR stands as a prominent candidate for the anticipated replacement of flat screens/monitors, to become the primary means with which we consume information. Analysis of the present situation highlights VR's clear role in entertainment (particularly in social communications, gaming and 360° video) but also acknowledges its significant and ongoing impact in non-recreational applications (education, skills training, visualisations, journalism and healthcare all being prominent examples). VR distinguishes itself from flat screens primarily by way of key user experience factors, namely heightened immersion (in both the explicit content and its underlying narratives), greater presence (a feeling of being there) and, by proxy of the other two, a greater capacity for empathetic experience. Reviewing this question also raises a further question regarding what is arguably one of the most critical things to consider when seeking to predict the future role of VR: To what extent does VR have the capacity to become mainstream, and what are the main obstacles to this?

The multi-application functionality of VR is arguably one of its greatest assets and whilst we may debate the potential of VR in contexts such as replacing flat screens for entertainment, social and informational purposes, the wider uses of the technology are already far more established and stable. Recurrent themes in "developing VR impact" largely present entertainment as VR's primary application. However, wider industries are gaining significant traction. Prominent examples include education, Defence, sales and marketing, healthcare, travel and architecture. Across these industries, VR reveals its distinctive advantages over existing alternatives, which include: real-time visualisation that can enable complex data and concepts to be communicated more simply; increased presence within a shared virtual space that can offer a more engaging experience and enhance the emotional connection between the user and the content; and interactivity, enabling users to act within the environment and receive feedback - an essential requirement for practicing skills. It is important to note that the creative potential in VR is such that applications pertaining to design, learning, communication, and showcasing have relevance to arguably every industrial sector that is currently in operation.

2.1.3 VR FOR GOOD

Whilst new areas of application for VR are steadily emerging, it is clear that VR has huge potential for social good and positive change. From healthcare and training, to generating empathy and understanding of social issues, VR is already demonstrating that it can be a force for good.

Whether it is for the purposes of fundraising, or raising awareness about a societal issue, VR places people in an environment where they can look around and interact with events as they would be in the real world. In some of these, the viewer can literally assume the perspective of the subject of the experience, enhancing the potential to feel empathy and increase understanding on a very personal level. These kinds of experiences make one think differently about that specific situation, giving people a chance to see the world's issues in a fundamentally altered and perhaps more meaningful way. There are numerous VR experiences with a goal of tangible social changes. Examples include:

Notes on Blindness is an inspiring VR film that puts the viewer in the place of a blind man. It centres on the sensory and psychological experience of blindness, with deeply expressive 3D audio and animations. Each scene addresses a memory from the blind man's audio diary, to create an immersive experience in a 'world beyond sight'.

Carne y Arena was created by ILM x Labs, in tandem with Alejandro Iñárritu. It is a gripping VR installation at the prestigious LACMA, which puts the viewer in the place of those crossing the Mexican-American border, as they are captured by border patrol.

Project Syria, created by Emblematic Group, is a socially conscious VR experience which places users in the middle of a war-torn town as they experience the chaos of living in a hot war zone.

Clouds over Sidra was a short-film produced by Gabo Arora for UNICEF. It had a significant impact on donations, contributing to a raise that was twice as high as UNICEF expected.

From healthcare and training, to generating empathy and understanding of social issues, VR is already demonstrating that it can be a force for good.

In spite of the enormous potential of VR to effect social change, the high cost and technical expertise required for content creation remains a barrier for many people. However, key industry figures have recognised this, and are actively working on solutions to this problem. VR company REWIND is attempting to make VR creation more accessible and collaborative through a product they call VRTogether. This is a networking tool that brings together creators and artists with charities, non-profits and individuals who are looking to utilise immersive technologies. Any charity can upload an idea, and creatives can then see what skills are needed to complete the idea. They can get in touch if they feel that they're able to donate their time and resources to getting the project completed. Often the most powerful and socially-conscious pieces of content are not commercially viable, and therefore lack resources. REWIND is one company among many that fill this void, as they connect people who otherwise would have no means to execute on their mission to raise awareness about an issue.

On another level, VR offers some, perhaps unexpected, benefits for people who may have difficulties accessing traditional interactive content. For instance, users can play a number of games just by looking around, or moving their head, and more technology is being developed around gaze tracking. VR, in this sense, certainly has a chance to bring gaming back into lives of people who have lost, or never had, the ability to use traditional game controllers.

Last, but by no means least, is the use of VR for healthcare purposes. Although this is not a new field, the rapid proliferation of consumer-level technology has led to a dramatic rise in the number of health and rehabilitation applications. Evidence is growing that VR has potential for pain management, physical and cognitive rehabilitation, and treatment of a variety of mental health conditions, as well as being used in medical training and patient education. Of particular interest is the overlap between content created for artistic or entertainment purposes, and the use of VR for emotional well-being. For example, there is a program at Bristol Hospital to bring VR experiences of the natural world to very ill or long term patients who are not able to leave their beds. AppliedVR is working on a platform that offers games, virtual travel, music visualization, and nature mediations, in order to reduce preoperative anxiety, and nDreams have recently released their "Perfect" VR relaxation app which takes users on a gentle journey into mountains or beaches. BioFlight VR is company whose main applications is the creation of VR experiences which take users on a virtual tour of organs in the body. This helps patients understand their specific illness or health issues. This kind of experience stimulates a lasting, positive change. For instance, the company created an experience designed for cigarette smokers trying to quit, taking users through the mouth, lungs, heart and other organs to see first-hand the damage done by smoking.

2.1.4 TRAJECTORY FOR COMMUNAL/SOCIAL VR

Both AR and VR (and, ultimately, mixed reality) will fundamentally change the way in which we connect with each other. While AR and MR are moving towards a "Star Trek Holodeck" type experience that will allow people to visualize their friends and family with them wherever they are, VR is likely to provide a type of experience derived from what we know today as MMORPGs or massively multiplayer online role playing games, except on a much grander scale and with many more different activities to partake in.

Although certain social spaces in VR will end up being more popular than others, eventually all virtual worlds will be seamlessly navigable, in a framework connecting all such virtual space together which is known as the "metaverse".

There are several companies working on social VR experiences. Facebook has developed Spaces whereby Oculus Rift users enter a virtual space that they can share with other Rift wearers, as well as with friends via Facebook. In this shared space, 360 videos and movies can be experienced together, users can create virtual objects in the space, and they can emote by choosing facial expressions for their avatar to perform. The avatars can even take virtual selfies together.

Similarily, AltspaceVR's aim is for anyone to be able to build and drop in 3D assets or entire interactive experiences using A-frame. Altspace has focused on hosting live events to bolster engagement and explore such a possible avenue for monetization. Their next goal is to build an engaging, monetisable, and scalable social ecosystem.

Coming at social VR from a different angle is PlutoVR which allows users to communicate directly with one another alongside other VR apps that are already available, instead of attempting to create a social virtual world that users can only interact within.

Ultimately, social VR is the next logical evolution of online social networks. Therefore, it should come as no surprise that the largest social network is also making arguably the strongest push to fully realize social VR.

2.2 MANAGEMENT OF CURRENT ISSUES AND LIMITATIONS OF VR

2.2.1 ACCESSIBILITY CONCERNS DUE TO SOCIO-ECONOMIC CONDITIONS

There are distinct limitations inherent in VR at the present time that may tend to preclude certain populations. These populations are generally less well-educated, and unable to afford luxuries on a regular basis. Unfortunately, due to the price-points of high-end VR systems, and the technical skillsets they require, this population will not be able to enjoy VR as frequently as others. The remedy for this will unfold as the industry matures; proliferation of both curated location-based VR installations where technical know-how is not required, and quality smartphone VR will prove most relevant and practical in this regard. These solutions, although expanding accessibility, are not without drawbacks: smartphone VR quality is less than that of a high-end system, and location-based VR cannot handle a high throughput of users as it is so time consuming and dependent on manpower.

VR is also well-positioned to reach a spectrum of society wider than traditional video games, having an audience composition more akin to films and television. The video game industry has marketed primarily to 18-34 educated, upper-class males whereas film and television appeals to audiences from all socio-economic background. Immersive media will also provide ample opportunities for women and other underrepresented groups to get involved, tell their stories, and allow others to experience their challenges and triumphs in a very unique, immersive, and interactive way. Recommended steps to be taken would be creating content that a broader audience can relate to; supporting programs that equip women and minorities in particular with creative and technical skills; and proactively recruit women and minorities into studios.

2.2.2 ACCESSIBILITY CONCERNS DUE TO LIMITED PHYSICAL ABILITY

We're seeing VR be incredibly useful for, and enjoyed by, users with a variety of disabilities. Traditional game controls are often inoperable to a person who has limited ability to control their extremities. With VR, users can control their interaction with their gaze and head movements. Nonetheless, it can still be difficult to access the fullness of room scale VR for those with physical disabilities that limit their ability to move freely around the tracked space. Locomotion in room scale VR presents challenges such as the need to simultaneously push a wheelchair to navigate, avoid wires, and hold the controllers. It is challenging to turn the body, and a wheelchair's turn radius can make it easy to bump into walls, even with a chaperone nearby. Seated gamers also have trouble reaching out to grab virtual objects on the floor or above them. In-game lines of sight are also generally created for people of average height, therefore confusion and difficulties can arise from the perspective of a seated gamer. Suggestions would be to create and/or offer games and experiences according to Game Accessibility Guidelines, and to have adjustable UI and text size, alternatives to motion controls, and a "tourism" modes with no blockers or fail states.

VR IN ENTERTAINMENT

3.1 THE ROLE OF VR IN ENTERTAINMENT

The role of VR within the media industry can be separated into three discrete classes:

1. Distinct 'VR as artistic form' experiences that reflect the fundamental interactivity and technological facets of VR

2. Using VR as an additional route to market for various media outputs that could also be released on alternative platforms

3. VR as a supplementary experience attached to a different form of media. Within the various branches of media, games, short films and television are prominent examples of where VR has a more established relationship with media.

More extended content is certainly on the horizon and will likely become reality provided some of the key user experience issues with VR hardware can be resolved. It is also noted, that as a supplementary experience, VR is largely limited to marketing but there is an expectation that this will change in the relatively short term, depending predominantly on whether the uptake of VR hardware is great enough. The more positive prediction for VR in relation to the media is that the platform will replace flat screens, though this eventuality is largely acknowledged to being emerging and 'to be determined'. Again, it is the facet of presence that underpins the role of VR within media. Its capacity to centre the narrative, world and action around the user distinguishes it as a unique means of consuming media. It is therefore this facet of VR that content producers should seek to exploit to establish the long-term value of VR.

3.2 PRODUCTION INSIGHTS

3.2.1 KEY ROLES IN VR PRODUCTION

At present, roles in VR production largely mirror those of either a video game or film production studio, depending on the type of content produced. A VR firm that produces games and/or interactive computer generated content closely resembles a video game studio, commonly requiring artists (conceptual, 2D and 3D), programmers, designers, voice-over artists, sound designers/composers and quality assurance/user experience testers alongside producers, marketing and management roles. Additional roles in this context can include network developers, writers, effects specialists, rendering engineers. Many VR games firms also acknowledge some of the unique characteristics of VR, with roles that prioritise these characteristics such as User Interface Engineer and Interaction Developer. Similarly to video games,

film-focussed VR production reveals comparable roles to a traditional film studio, including actors, scriptwriters and directors, but will also include more VR-specific roles such as VR Technologist and VR interaction designer.

With new applications and challenges being raised almost daily there is currently a skills shortage and a great need for the right people. In the UK, career opportunities in VR can vary dramatically depending on the industry and the job. Graduate/starter roles in VR typically offer £20-24,000 whilst more experienced developers can expect up to £70,000. Many of the roles in VR are combined, in which VR expertise is required alongside a designated, more traditional, skill set such as animation, software engineering and 3D modelling.

3.2.2 BEST PRACTICES IN VR PRODUCTION

The most fundamental tenet of best practice in VR is arguably to create an experience that could not possibly be comparably recreated without VR. This grand concept filters down into two key aspects: (1) considered utilisation of VR hardware and; (2) evoking powerful user-presence and intimacy to connect the user to the virtual place, narrative and characters. Bespoke 'built for VR' designs are heavily favoured over ported/adapted content as the integration of narrative, character design, action and interaction are essential to an outstanding VR experience. The mere fact that something is presented in VR is not an automatic route to success, and designers should be conscious that any poor-quality elements within the content (from the visual design to the story) will not be overlooked by the user simply because it is in VR. Best practice in VR should be careful to not draw too heavily upon traditional game design. Numerous elements, from user interface and player-movement to directing attention, all work very differently in VR and ignoring VR design specificities will likely lead to poor quality experiences. It should also be observed that, as an emerging medium, best practice in VR should itself be creative and flexible. Individual projects are likely to require rigorous testing and significant nuancing for an outstanding quality experience to be achieved.

3.3 VR FOR NARRATIVE AND STORYTELLING

With regards to storytelling, VR's current position arguably raises several descriptors that reflect VR in general, namely 'emerging', 'at the dawn of its potential' and 'the next logical platform'. The flexibility of VR experiences facilitates a wide range of storytelling experiences but it is immersion and presence that primarily distinguishes VR as a narrative platform that can both surround the user in the story and directly involve them in its action and outcomes.

In effect, virtual reality completely dismantles the traditional notion of narrative. The filmmaker, or the TV producer has enjoyed tyranny of authorship for years. They force the audiences' gaze by limiting their view to a flat frame and employing camera movements and techniques. In VR, an audience has much more autonomy over where they focus their gaze. Creators must innovate new ways to cue their viewers' attention. A Venn diagram has made itself apparent, which has film and television creators in the

one circle, and game designers in the other circle. The sweet spot for VR is where the overlap is. The gaming and TV/film industries have never been closer than they are today, and the studios that hybridise their content in this regard will be most successful.

3.3.1 BEST PRACTICES ON WRITING FOR VR

Comparisons can be drawn between best practice in VR narrative and VR production in terms of creating an overall experience that is exclusively VR in nature. For narrative, this equates to effective incorporation of VR's technological facets (immersion and interactivity) and its primary user experience features (presence and empathy). Amongst VR developers, this narrative form is colloquially referred to as 'storyliving', the chief goal of which is to present the user with a narrative that incorporates them into the story through meaningful interactions that evoke feeling of agency.

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For storyliving to be effective requires the VR experience to both exemplify best production practice in utilising the technology and engaging the necessary user experience elements, but also best practice in traditional storytelling. Characters need to be engaging and relatable, whilst plots need to evoke the imagination and emotional investment in the outcomes. At present, the great challenge comes in the third step, bringing together the best practices of VR production and traditional storytelling to seamlessly incorporate the user and craft a storyliving experience. Here 'seamlessly' is the crucial qualitative term. The antithesis, a narrative or interactive component that feels 'tacked on', may have attempted to bring together two quality components, but done so in a manner that exposes them as separate and breaks the illusion.

It is generally acknowledged that, to date, there has yet to be a significant breakthrough in realising the storyliving ambition of VR narrative, but to do so would arguably be of huge significance to the future of VR as it would demonstrate the power of the technology to facilitate the crafting of experiences that are truly unique and a significant step forward in human experience. That said, there are several contemporary best practice approaches that may not guarantee the realisation of storyliving, but nevertheless have strong potential for ensuring a higher quality of experience. A good example of this includes the direction of user-attention. As noted previously, the content-creator's 'tyranny of authorship' is rejected by VR, requiring the narrative to unfold around the user with the significant risk that they may miss crucial narrative elements as the story unfolds. There is however, an established toolset for influencing attention through various techniques. These include visual cues that utilise motion to draw the user's gaze towards an event just before it happens. Audio cues that exploit positional/3D processing can also be used to draw the user's vision towards the source before an event occurs. A well-designed system can also exploit the user's position and orientation within the virtual world as a means of triggering key narrative events (e.g. a character will only begin to speak when the system detects that the user is looking at them). Further notable best practice narrative techniques include: creating rich environments with multiple strands of narrative content that allow the user the freedom to focus on content that

they are most drawn to whilst also facilitating repeat viewings, diegetic consistency (establishing the role of the user within the narrative and maintaining that role throughout), and AI that demonstrates an awareness of the user's presence (for example, via head/eye tracking to establish eye contact between the virtual character and the user).

3.3.2 WHAT TO AVOID WHEN STORYTELLING IN VR

As described in the previous section, storyliving fundamentally requires the user to feel that they have agency and purpose within the virtual world. User interactions may be technically extensive (e.g. the user can pick up and manipulate most objects within the world), but with poor narrative integration (i.e. their actions have no tangible impact upon the story as a whole) will appear superficial and ultimately pointless. Such interactions are commonplace in many VR experiences that are relying upon the 'wow' factor of VR to gloss over a lack of any real depth.

Of course, VR content that is, at present, more linear and less interactive (such as 360° film) is more hamstrung in its potential to evoke storyliving, but this does not mean that it cannot be of high narrative quality, nor does it mean that it cannot provide an experience beyond that of other narrative forms. Even without direct user-interactivity, high quality cinematic content still engages its audience in a more cognitive form of interaction – as they attempt to make sense of an unfolding plot, predict an outcome, or consider how they would feel in a comparable situation. Therefore, a key mistake to avoid when storytelling in VR is to neglect the established best practices of traditional narrative design.

3.4 LOCATION-BASED VR

3.4.1 THE ROLE OF LOCATION-BASED VR

The role of location based VR is multifaceted and cannot be overstated. Foremost, it is to drive adoption and enthusiasm for VR while also giving many people their first taste of premium VR, because it is the sensible alternative to owning a costly rig. It has the ability to entertain, engage, educate and unravel some of the perceived mysteries that surround VR.

Location-based VR will be especially beneficial to the industry while the installed base of in-home premium VR systems still remains small because it provides access to a wide variety of high-end content, running on best-in-class hardware. Such VR installations are a great way to monetize content in the current early adoption phase of VR's rollout toward mass market adoption, while familiarizing people with these new media experiences.

Location-based VR is also a way to create VR experiences not possible in-home, such as VR rollercoasters, large simulation machines, and/or advanced mixed reality experiences. VR Advisory Group members substantiate these notions, explaining

The role of location based VR is multifaceted and cannot be overstated. Foremost, it is to drive adoption and enthusiasm for VR while also giving many people their first taste of premium VR, because it is the sensible alternative to owning a costly rig.

that location-based VR is most akin to a traditional movie theatre, whereby users leave the house for a destination entertainment experience. This is often the best way to introduce people to new entertainment experiences, and create a comfort zone for the customer base that will eventually be using VR in their homes and mobile worlds. It is also a way to prove out what content can be successful and migrate to a wide audience.

It is also becoming evident that VR theme parks are indeed gaining popularity. One of the most prominent of them is The Void, a VR theme park based in Lindon, Utah with additional locations in New York and Dubai. Essentially a high-tech maze in a warehouse kitted with movement and pressure sensors, participants put on a wireless backpack with a tethered headset and plastic gun, and explore the virtual experience with friends. Utilizing a layering of real-time interactive environments, and blending the real world with the digital—participants are placed into "Hyper-Reality" experiences. The first major experience developed for The Void is the Ghostbusters Dimension: VR Experience, which launched at The Void's NY location in Madame Tussauds Wax Museum. The feedback from those who've tried it has been overwhelmingly positive. Their current revenue model is based around a $20 charge to upgrade a Wax Museum ticket for the additional 15-minute VR experience. The Void plans to open an additional 20 locations in 2017. China's Shanda Group has invested $350 million into The Void to bring VR theme parks to China, which should help accelerate The Void's goal of opening 230 locations by 2020.

Zero Latency is another high-profile VR theme park based in Melbourne, Australia, with locations in Orlando, Florida and Tokyo, Japan. The main consumer experience revolves around a four-person shooter in which players defend a battleground from zombies. The company's plan is to provide a "business in a box" revenue share with any international partners to set up and operate a location. They consider this franchise model to be most efficient, rather than building and operating its own centres. Zero Latency helps with the design and installation of the attraction, supplying both ongoing support and content. They also offer online tools like system diagnostics and a booking engine, providing a complete turnkey package. The Melbourne space is 400 square meters of space, perceived to be much bigger because of a technique employed by the game designers known as "redirected walking." Tickets cost $88 per person, which yields an approximate 45 minutes of gameplay with 6 players at a time.

In addition, VR arcades are gaining popularity. IMAX VR has opened their first experiential VR centre in Los Angeles, charging $10 for 10-15 minute play-throughs of popular SteamVR games on the HTC Vive and StarVR headsets. IMAX has recently announced a partnership with Warner Bros. to create VR experiences for their superhero movie IPs and bring them to the VR centre.

HTC is also looking for alternate forms of consumer adoption rather than solely via retail, and has partnered with one of China's largest internet cafe software providers, ShunWang Technology. This is smart considering that the relatively short length of current VR content lends itself well to the massively successful business model of charging for play time by the minute in China, as well as the fact that ShunWang claims to reach over 100 million people in more than 100,000 cafes, currently controlling a market share of around 70%. For ten minutes, users pay anywhere from $2-$5.

In October 2016, HTC announced a partnership with InterContinental Hotels Group (IHG) to bring the HTC Vive to sites in Chinese cities like Beijing, Shanghai, and Sanya. Guests can head to a 'Vive Zone' or be in their rooms to sample the headset with a selection of games and experiences through SteamVR and Viveport. That same month, HTC opened its third "Vive VR Café" in Shenzhen, China and have confirmed hundreds more to come in 2017 worldwide. They have also suggested franchising opportunities for these cafes.

HTC also created Viveport Arcade, their proprietary content management and distribution platform for location-based entertainment. It serves both operators and developers by identifying, securing, and safely distributing content, as well as managing payments through a centralized system. The operator gets a library of VR content they can use, while HTC tracks usage and playtime directly, and shares that data with the arcade operator. Commercial arcade operators can download the software to their venues, allowing them access to a library of legally acquired content, which they can configure across all their Vive stations via a centralized host client tool. Operators and developers then split the revenue. The software is built to serve as a turnkey method for developers to easily distribute and monetize their content to physical locations like arcades, Internet cafes, theatres, and shopping malls around the world, while giving operators an end-to-end system to discover and deliver great VR content to their customers.

A general best practice is to house the VR installation in a "destination" location. The ripest areas for placement are where they can leverage an existing audience primed for entertainment. This would be in or nearby theme parks, movie theatre lobbies, shopping malls, and locations where there is a customer base, with time and leisure capital, who wants to be engaged, and is ready to spend a little bit of money on it. Contributors ultimately agree that VR installations will do well wherever there is already a focus around guest experience, and managing those guests throughout a day of entertainment.

04 THE ROLE OF VR IN THE MISSION OF BAFTA

4.1 IDENTIFYING EXCELLENCE IN VR

The creation of a standout VR experience arguably denotes a complex and evolving set of requirements. However, four elements of good practice stand out as particularly powerful means of elevating the standard of a VR project: bespoke for VR, strong storytelling, genuine presence and consistently high quality across all elements of the work.

Bespoke for VR asserts that an outstanding VR experience should be built from a foundation of creatively exploring and exploiting the uniqueness of VR, both as a technology and as a concept. Run-of-the-mill is typified by a project that 'just adds a headset', presenting content that could otherwise be delivered on a flat screen with no significant loss to the experience or its meaning. It is also observed that VR content should demonstrate the unique qualities of VR with consistency throughout the experience. A film that briefly utilises VR interactivity and presence-evoking techniques at the beginning, then quickly abandons this and the content becomes transferable to a flat screen, is not presenting a distinguished experience to its audience.

Contemporary VR at its current stage of development is heavily prioritising spectacle and short-term impact, a brief 'wow' that quickly fades. From the opinions of many experts currently working in VR, the maturity of VR is dependent upon a shift towards a more sustaining experience and it is widely asserted that the primary means of achieving this is by way of strong storytelling – specifically, story leading spectacle. As a result, a present-day project can distinguish itself by prioritising story and endeavouring to engage the user on deeper emotional levels through more complex and developing narratives.

Genuine presence refers to the capacity of a VR project to both immerse and engage the emotions of the user, to the extent that they naturally suspend disbelief and feel present within the virtual world that surrounds them. Such a quality requires a comfortable 'disconnect from reality', enabling the user to 'teleport' form the physical space to the virtual space. An attractive multisensory virtual world can provide a space in which the user wishes to be present, whilst relatable characters and involving narrative can convince the user that the virtual world has meaning, and in-depth interactivity and feedback evoke a sense of agency, enabling the user to feel that they themselves have meaning within the world.

Lastly, it is important to observe that just as a high-quality game or film cannot presume distinction as a VR experience by simply adding a headset. A project that exploits VR technology and concepts well cannot negate the effect of poor quality content. Poor acting/voice acting, superficial narrative and a contrived musical score are just a couple of examples of how an otherwise high quality VR experience could potentially be derailed.

4.1.1 CRITERIA THAT COULD BE USED TO OBJECTIVELY EVALUATE EXCELLENCE

Bringing together the numerous issues discussed throughout this paper, the following are preliminary assessment criteria for identifying excellence in a VR project:

1. Visual Design: The technical and aesthetic quality of the graphics and animations. An excellent VR project would demonstrate fluency and originality in the craft of its visual design. It will also demonstrate cutting edge features as appropriate within the context of the project. In line with the integration criterion (below), excellence would also dictate that the visuals possess deep functionality and purpose within the broader experience. As with several other criteria, excellent visuals will demonstrate a unique-to-VR quality.

2. Audio/Music Design: largely similar specifics to visuals in terms of quality, cutting-edge, originality, functionality, unique-to-VR and integration.

3. Narrative: The extent to which the project has achieved the ambitions of 'storyliving' narrative. Does the work utilise the unique technological and user experience facets of VR to position the user not just within the world, but also within the story? To what extent is the involvement of the user within the narrative meaningful, consistent and seamless? The underlying principle is that VR has a fundamental advantage over traditional storytelling formats in its technology and, by proxy, its capacity to evoke presence and empathy. An excellent project should therefore present an experience that is 'beyond' that of a traditional narrative format.

4. Interactions: The quality of the means and methods by which the user acts within the virtual world. Comparable to the narrative criterion (above) but focussing specifically upon the more technical aspects such as: the extent to which the control hardware is utilised creatively, comfortably and effectively; the usability and user experience of the user interface and/or heads-up displays; the natural/organic quality of the interactions and the extent to which the user's actions support presence.

5. Integration: The extent to which the above elements of the VR project work together to create a complete experience. An excellent work will demonstrate deep, multi-layered and consistent interrelations between the visuals, audio, narrative and interactions. Integration could also extend to ways in which the project integrates VR with other technologies (for example, multiplayer/social networking, Internet of Things, biometric wearables and others.)

6. Vision: The extent to which the project realises a clear and precise vision/intention. This relates to the integration criterion but specifically examines not only that the various facets of the experience are deeply interconnected and consistent, but that they come together to clearly express a particular ambition (be it to raise awareness/empathy, bring people together, or to facilitate great fun).

7. Overcoming Limitations: The extent to which the project has circumvented the numerous comfort/side-effect issues of VR use and, rather than simply attenuating its limitations, has creatively utilised them as means of creating a positive experience (e.g. delivering work as episodic content with compact and compelling narratives to keep the user coming back whilst negating the side effects associated with prolonged use).

8. Impact: The extent to which the project is deemed to have impact on society in some form. This can include demonstration of a new design technique or approach that is judged likely to significantly influence future VR projects, but can also include a way in which the project's application is judged to have substantial impact on a particular aspect of society. Ultimately, this criterion would assess whether a VR project has 'pushed things forward' in some regard, either in terms of VR itself, or by way of progress in another aspect of society.

4.1.2 CURRENT EXAMPLES OF EXCELLENCE IN VR

Relating the above excellence criteria to existing VR content, the following are a selection of the titles that have been identified by the VR Advisory Group to have distinguished themselves as outstanding experiences in relation to one or more of the criteria:

1. Tilt Brush (impact): As a means of creating 3D art within VR itself, Tilt Brush stands as a good example of impact with regards to the progression of VR. Crucially, the artistic processes of creating work within the program and the qualities of the artworks make Tilt Brush significantly different to other, non-VR artistic platforms.

2. Superhot VR (interactions): Superhot VR utilises a unique 'time moves when you move' mechanic that requires the user to carefully consider their physical movements within the world. This creates a highly unique interactive experience that expertly utilises the tracking features of VR.

3. Carne y Arena (impact, narrative): An immersive VR film that places the user in the world as an immigrant journeying across the Mexican/USA border before being violently apprehended by authorities. Carne y Arena stands as a great example of both narrative (by utilising presence to evoke intense emotional reactions to the events as they transpire) and impact (by way of powerfully evoking empathy to raise virtual-first hand awareness of an important societal issue).

4. Rez Infinite (audio): As an audio-centric VR game, Rez Infinite demonstrates excellent integration of audio into both the visual design and interactions of the experience.

5. Land's End (overcoming limitations): As a mobile VR games, Land's End is an excellent example of overcoming limitations, specifically those relating to interaction within the virtual world and the relatively low computing power of mobile phones. Land's End presented one of the first and best designed gaze-tracking interfaces whilst also utilising low-poly models and simple shaders creatively to present highly aesthetic graphics that ran optimally on low computing specifications and avoided overheating phones.

6. Job Simulator (integration): A good example of an all-round high quality VR experience, Job Simulator combines stylised visuals and audio, satirical and self-aware narrative, and fun yet contextualised interaction/gameplay in which the whole is undoubtedly greater than the sum of its parts.

7. Dear Angelica (visual design): A VR film with its visual content created entirely in VR, Dear Angelica is an outstanding example of how VR visuals can be entirely unique-to-VR.

4.2 SHARING INSIGHTS INTO THE CREATIVE CRAFT OF VR

4.2.1 WHAT WORKS BEST AND WHAT ADVICE CAN WE SHARE WITH PRODUCERS, DIRECTORS, ACTORS AND WRITERS?

The best advice in today's world of crafting impactful and important VR is to become a student of the medium. Spend a lot of time experiencing what has been created in the various sectors and genres of VR. Like any art, once you have spent enough time studying others, you can then begin to hone your own craft. You can draw upon things that inspired you, and work towards solving things that frustrated you. The point is to evolve what you've experienced from other artists working in the same medium. Don't delve into creating your project after having just experienced a few VR games and narratives. Treat this medium with the same importance as you may have with film or TV, where you've logged countless hours to grasp the various ways in which the greats tell stories. Then, build upon that legacy to define your own creative voice.

4.2.2 INSTITUTIONS WHERE VR EDUCATION IS TAKING PLACE

VR education can be broadly categorised into "education using VR", and "education about VR", although there can be significant overlap between the two. "Education using VR" is being embraced in a number of areas, including training and simulation in hospitals, industry and the military, and also in delivering classroom content, with a notable success in this area being Google's "Expeditions" educational initiative. In relation to meeting the needs of the BAFTA community, there is a growing number of educational institutions offering VR-specific courses or training including (but not limited to):

USA:

Carnegie Mellon University
CalArts
Chapman University
Columbia University
Emerson College
Expressions College
Full Sail
Georgia Tech
Loyola Marymount
MIT
New York University
Ringling School of Art and Design
San Francisco Art Institute
Savannah School of Art and Design
Stanford University
Texas A&M
University of North Carolina
University of Texas
UCLA
USC

CANADA:

Centre NAD UQAT
Raindance Toronto
Simon Fraser University
Toronto Film School
The University of British Columbia
Vancouver Film School

UNITED KINGDOM:

Escape Studios
National Film and Television School
Plymouth College of Art
Staffordshire University
Teeside University
The Glasgow School of Art
University of Hertfordshire
University of Portsmouth
University of York

4.2.3 EXISITING TOOLS AND EXAMPLES FOR INTRODUCING PEOPLE TO VR

The first experience people have with VR will often fix their opinion of VR - for better or worse. It's therefore important to minimise the chance of a poor first experience, and to create opportunities for great first-time exposure. With the ever-growing range of VR content available, how do we decide on that first experience?

Key things to consider are the viewers' genre preferences; how much interactive/gaming experience they have had; and what are their favourite video games or other media favourites. This can help frame up how comfortable they will be with navigation in VR, and with using their hands to interact with the experience. Learning whether they prefer action movies and TV shows over dramas, romance over horror, and so on, and what level of interest they have for various genres can help frame up the choices, as well as how much time they spend on YouTube, and on mobile games. This also gives us a sense of the time they have available to commit. If they are in the mood to really 'go in', or if they have an upcoming meeting, will determine the optimum length of their best experience.

> The best advice in today's world of crafting impactful and important VR is to become a student of the medium. The point is to evolve what you've experienced from other artists working in the same medium.

The following are the titles most frequently cited by VR Advisory Group members as ideal for early viewing:

Game/Application

Arizona Sunshine
Batman VR
Batman: ARKHam VR
Budget Cuts
Bullet Train
Eagle Flight
Edge of Nowhere
EVE: Valkyrie
Everest VR
Face your Fears
Gnomes and Goblins
Google Earth VR
Job Simulator
Land's End
London Heist
Raw Data
Robo Recall
Serious Sam
Star Trek Bridge Crew
Star Wars - Trial on Tatooine
Superhot VR
The Climb
The Lab
TiltBrush
Touch First Contact

Film/Visualization

360° Video

BBC: Home A Spacewalk
Carne y Arena
Catatonic
Clouds over Sidra
Gone

Computer Generated

Abe VR
Allumette
Evolution of Verse
Firebird: La Peri
Henry
Invasion
Lost
Notes on Blindness
Old Friend
Pearl
Robot Repair
Showdown
The Blu
The Walk
Tree VR

4.3 BAFTA'S APPROACH TO VR

4.3.1 HOW OTHER AWARDS BODIES ARE CURRENTLY APPROACHING VR

Well-constructed awards have propelled the careers of numerous novelist, painters and poets for centuries. Nonetheless, awards bodies and art can be uneasy bedfellows. In practice, today's awards organizations live on a continuum, from conscientious, peer-reviewed definitions of excellence, to gaudy, sponsor-driven popularity contests.

Several VR-specific awards ceremonies now exist, within which the average number of individual awards is roughly 10. Recurrent categories include: overall game/experience, best technical, best artistic and best narrative. Various awards relating to user-experience also pop up, albeit typically in slightly different forms (e.g. most 'transportive', most immersive). A common distinction is made between filmic (360 video, non-interactive CGI) and game VR types. Wider non-recreational applications also feature repeatedly as separate categories.

Non-VR-specific awards (including those that specifically encompass games, film, television and/or technology) typically do not, at present, include VR categories, though VR entries are typically acceptable across numerous other award types. There are a small number of exceptions however.

Video games awards are the most common type to include a VR or VR/AR category. Typically, this is limited to a single 'best VR' award. The Lumiere and Raindance awards standout as embracing VR more significantly, including a range of VR-specific award types that largely reflect those found in VR-specific awards. These VR awards do present some overlap with others at Lumiere and Raindance, suggesting that these bodies are content to distinguish artistic, narrative and technical achievements within VR as separate from their equivalents in non-VR media.

The most relevant analogue for BAFTA may be The Television Academy. Headquartered in Los Angeles, The Television Academy is composed of 30 Peer Groups in specific craft areas: Animation, Directors, Documentary Programming, Interactive Media, Motion & Title Design, Music, Performers, Producers, Reality Programming, Sound Editors, Special Visual Effects, Television Executives and Writers.

In 2015, the Governors of the Interactive Media Peer Group moved to allow VR projects to submit in their five Emmy Award Areas of Competition. One of these entries was FOX and The Secret Locations' VR experience The Sleepy Hollow Experience, which submitted for the Emmy in User Experience and Visual Design. The project won, becoming the first VR project to win an Emmy Award.

Several VR-specific awards ceremonies now exist, within which the average number of individual awards is roughly 10. Recurrent categories include: overall game/experience, best technical, best artistic and best narrative.

In 2016, the number of VR entries increased by an order of magnitude, prompting full reviews by the Interactive Media Peer Groups' Executive Committee—who evaluated each 360 and VR experience, and disqualified those whose 360 was fully passive rather than active, meaning that it did not meet the "interactive" requirements of these Awards. That year Oculus' Henry won the Emmy in the category of Outstanding Original Interactive Program, and the Academy received numerous universal accolades from the press for moving quickly to recognize VR as an art form

In 2017, the entries increased again, with over 30 VR entries in the Interactive Media Peer Group's five Emmy Award Areas, including:

OUTSTANDING ORIGINAL INTERACTIVE PROGRAM

Dear Angelica
The People's House - Inside the White House with Barack and Michelle Obama

OUTSTANDING CREATIVE ACHIEVEMENT IN INTERACTIVE MEDIA WITHIN A SCRIPTED PROGRAM

The Mr. Robot Virtual Reality Experience
The Simpsons - Planet of The Couches
Stranger Things VR Experience
Westworld VR

INNOVATION IN INTERACTIVE PROGRAMMING

Gnomes and Goblins
Halcyon
Pearl
Wonder Buffalo
Buzz Aldrin: Cycling Pathways to Mars
Lincoln in the Bardo
Allumette
Under Neon Lights

Three of these VR projects won Emmy Awards in their respective categories: Felix and Paul's The People's House, HBO's Westworld VR, and Google Spotlight Stories' Pearl.

Ultimately, based upon these observations, the wider collective opinion of film, television and videogames award bodies is that VR is not yet ready for its own category outside of non-VR-specific awards—but that incorporation of VR entrants in existing Awards is widely perceived as "timely" and "appropriate" by the media industry, the press and the public at large

4.3.2 OPTIONS FOR INTEGRATING VR INTO BAFTA

BAFTA's long history of celebrating new and impactful art forms will be well served by a series of bounded initiatives in VR and AR. Its unique position in film, television and games presents many opportunities for incremental movement into this space. These opportunities were voiced many times by the members of VR Advisory Group, and can be modelled on successful current iterations of the offerings at universities, co-working spaces and online.

1. Shared lectures online: The creation of TED-style talks by leading VR proponents (e.g., Alejandro Iñárritu, Jon Favreau, James Cameron) for distribution to BAFTA members and the general public, extending BAFTA's thought leadership by partnering with film and television creatives who are moving into VR

2. Half-day training programs on authoring in VR, in conjunction with supplying tech providers, perhaps based on learnings from BAFTA's Young Game Designers

3. Case studies and Key Learnings documents: via BAFTA.com

4. Continuation of the BAFTA VR Advisory Groups' Showcases.

5. Creation of a curated newsletter, pointing interested parties towards VR projects and opportunities of note

6. Eventual inclusion of appropriate VR entries within select Game Awards.

7. Showcase centre

All interviewees agree that hands-on experience with VR is a must. BAFTA will find ways to showcase the very best artists and creators in the new mediums of VR/AR with specialized awards, events, social gatherings, viewings and salons and educational events.

4.4 SUMMARY AND RECOMMENDATION

There is unanimous agreement, among both the committee members and the authors, that VR is here to stay, and it is the best interests of BAFTA and its membership for the VR work to continue. Although still an emerging platform which presents a number of challenges, VR is a unique storytelling medium which warrants serious consideration.

In the words of one executive "BAFTA needs to show patience. How do we nurture and incentivise, people to become involved in this new medium? I think BAFTA should recognize VR as an up-and-coming entertainment medium. I think they should support the creation of a committee on this, and that committee should take its time to query the landscape."

While there is some debate as to how far into the committee plan BAFTA should move at this time, the opportunity cost of not continuing is something mentioned by many members. Nonny de la Peña summarises it thus:

"You know that all the major film companies — and many of the major film artists, are opening up VR projects. …. I would suggest that BAFTA would prefer that it be with them, rather than without them. And I think it's really important that we understand that this is a train that has left the station already. BAFTA should be happy that they were early in thinking about this and offering a way for their membership to see the future. VR doesn't simply supplement reality. It takes you to a whole other place. It's a new medium, but it's super exciting as a new tool to create really fabulous experiences."

Based on this and similar feedback from within and without the VR community, our recommendation is that BAFTA continue the VR Advisory Group for another twelve-month exploratory term.

GLOSSARY
(COMPILED BY ROY TAYLOR)

AUGMENTED REALITY

Simple definition:
Augmented reality is the overlaying of digital data on top of the real world, supplementing the reality of what the user sees by adding, replacing, or removing elements, and allowing them to interact with both the real world and the digital elements.

What does this mean for you?
Augmented reality technology is still a couple years behind virtual reality, but devices like the Microsoft HoloLens are beginning to become available for developers. Once this technology hits the consumer market in a few years, we will start to see a convergence of augmented reality and virtual reality in what's known as 'mixed realities'.

FIELD OF VIEW

Simple definition:
The field of view (also known as field of vision, or FOV for short) is all that you can see while looking straight. This is the extent of your natural vision. The average human field of view is approximately 200 degrees.

What does that mean for you?
When researching virtual reality headsets (also known as head-mounted displays) you will see that there is a specification for field of view. Most current VR headsets have a minimum field of view of 90-110 degrees, which is a baseline for a great VR experience. The higher the field of view, the more of the environment you will see as it will extend to the edge of your vision, and as a result, the more immersive experience you will have. Think of this like the difference between an IMAX movie theatre screen and a regular movie theatre screen. The IMAX screen is much larger and therefore takes up more of your field of view, which allows you to see more, thus creating a more immersive experience.

A wide field of view is difficult to achieve because the issues related to lens optics (chromatic aberration and barrel distortion) become more severe, and the optics themselves have to become bigger or more complex. Like a photograph taken with a fisheye lens, the images on the HMD screen are distorted to account for the optics of the HMD. Furthermore, widening the field of view "stretches" the available screen resolution, meaning that resolution must increase to keep the same pixel densities at higher FOV angles (with the potential impact lessened slightly by the use of multi-res VR shading & foveated rendering).

FOVEATED RENDERING

Simple definition:
By taking advantage of human biology, advanced VR rendering engines will be able to spend more time on the centre of the visual field, rendering less detail in the periphery.

What does this mean for you?
The computer can render the entire scene more quickly if it allows itself to render at a lower resolution or with simplified objects. Because human eyes perceive more detail in the centre of the visual field, there is a lot of detail in each frame that we don't even see. By rendering at low quality at the edge of the frame, the computer can either spend more time rendering detail in the centre or render a single frame quicker.

FRAMES PER SECOND

Simple definition:
Frames Per Second or FPS for short refers to the number of times an image on the screen is refreshed each second.

What does this mean for you?
The higher the frames per second, the smoother the motion appears and the more comfortable your VR experience will be. This is extremely important for virtual reality because slow or choppy motion will often cause nausea. In order for you to feel comfortable while experiencing VR, ensure you purchase a VR headset that can achieve at least 90 frames per second. Most VR headsets on the market today achieve 90 to 120 frames per second. This is also known as the screen refresh rate and is sometimes identified in Hertz (90Hz or 120Hz).

MOTION-TO-PHOTON LATENCY

Simple definition:
Motion-to-photon latency is the measure of time between when actual motion occurs in the real world and the eye receives a photon from the HMD screen that reflects this change. It is very hard to measure, but represents the total effectiveness of a VR system from a latency standpoint.

What does this mean for you?
A high frame rate will render smooth motion and avoid the appearance of "strobing," which can certainly contribute to motion sickness, but the underlying cause is discrepancy between real-world motion and visual perception. The computer might be rendering frames very quickly, but if the tracking data is on a delay, or if the frames need to be encoded and streamed, the high motion-to-photon latency will still cause motion sickness. This issue makes it difficult-to-impossible to do VR with cloud-based rendering.

LOW-PERSISTENCE DISPLAY

Simple definition:
A low-persistence display goes dark between frames to avoid motion blur while the user is looking around. Traditional displays that emit light for the duration of the frame are hard to read while moving the head.

What does this mean for you?
As part of the Daydream specification, a low-persistence mode for smartphone displays is one of the major distinguishing features between just a smartphone with some lenses and a VR HMD. The Samsung GearVR switches the display into this special mode when it is inserted into the HMD, and can be manually activated using GearVR's developer mode. In this mode, outside of the HMD, the device appears to flicker, which is why it is important that the low-persistence state is temporary.

INPUT

Simple definition:
Input refers to the method of control you will use for virtual reality. This most likely means motion tracking with controllers, but could also be a mouse and keyboard or a gamepad.

What does this mean for you?
Most VR experiences today use motion tracked controllers or a gamepad. As virtual reality matures, more input devices will become available like gloves, body suits and full body-to-finger tracking which will allow for a much more natural and realistic experience, allowing you to reach out with your hands and interact with the virtual environment as you would in real life.

MOTION TRACKING

Simple definition:
Motion Tracking is the ability to record your movement and the movement of objects in real-time.

What does this mean for you?
Motion tracking is what allows you to move around in an environment just as you would in real life. When you lean in to look at something in a virtual world, you will get closer to that object. Just like you would in real life. Motion tracking is one the biggest components required to tricking your senses into thinking you are really participating in the virtual environment.

POSITIONAL TRACKING

Simple definition:
Positional Tracking is the ability to record your movement and the movement of objects in real-time. This translates to you being able to move around and rotate in the virtual world. Movement: Forward and backward, up and down, left and right. Rotation: Pitch, yaw, and roll.

What does this mean for you?
Positional tracking is what allows you to move around and rotate in a virtual environment. The more accurate the positional tracking, the more it will feel like you are in that environment. Positional tracking is one of the biggest components required to trick your senses into thinking the virtual environment is real.

When researching VR headsets and accessories, you will see a specification for positional tracking. It will say 'yes' or 'no' and may also include the sensors it uses and the latency time. Most high-end VR headsets like the Oculus Rift and HTC Vive will have positional tracking or room-scale tracking which is the ability to track your movement and the movement of objects like input devices within a particular space. Entry level VR headsets like Google cardboard and mid-performance VR headsets like the Samsung Gear VR does not include positional tracking.

Latency refers to the speed at which the virtual world reacts to your movement. When it comes to latency, the less latency the more comfortable the experience will be. The rule of thumb is for latency to be sub 20 milliseconds. The lower the number the better. Higher than 20 milliseconds could mean you may feel nauseous when using the VR headset because your movements are not syncing with what you are seeing, much like sea sickness.

Another way of describing a system of sensors is "inside-out" vs "outside-in." The two major desktop platforms, the HTC Vive and Oculus Rift both rely on either a camera or lighthouse to be in a fixed position in the room outside of the HMD. This is what defines "outside-in" tracking. On the other hand, devices like Project Tango and Microsoft HoloLens use a technique called visual odometry to analyze images from cameras mounted on the HMD itself to track its position, which can be considered "inside-out" tracking.

IMU

Simple definition:
An IMU or Inertial Measurement Unit is an electronic device that can detect motion in some way. IMUs consist of an accelerometer, gyroscope, and/or compass to measure the absolute rotation of the device with very low latency. Combined with optical tracking systems, an IMU is used to determine the view direction of an HMD.

What does this mean for you?
The same basic technology that flips your phone from landscape to portrait or provides tilt control to mobile games is used in VR HMDs to match the virtual camera to the user's head direction. This is one of the reasons why Google Cardboard is able to support such a wide range of smartphones--much of the technology that enabled the new wave of consumer VR devices was perfected and mass produced as a result of the massive popularity of smartphones.

As with any tracking system, latency and accuracy are the key factors for an IMU. Generally these features aren't advertised and don't vary greatly between devices. It is worth noting that the Samsung GearVR includes a dedicated IMU, as opposed to Google Cardboard and Daydream which rely on the phone's inbuilt IMU.

EYE TRACKING

Simple definition:
Cameras inside the HMD can track which direction the user is looking. This can be used as a new input axis, e.g. for targeting bogies in a dogfighting game. The FOVE is an HMD that was launched on Kickstarter promising eye tracking capabilities and a foveated rendering SDK.

What does this mean for you?
While eye tracking is not a prerequisite for foveated rendering, it is a great improvement to be able to shift the high-detail region based on eye direction. Furthermore, new users tend to have difficulty overcoming the natural inclination to look around with their eyes. The problem is that the optics tend only to work when looking straight through them to the center of the screen, and instead the user is supposed to move his or her head to look around. Eye tracking is the first step toward allowing users to use their eyes naturally.

SIX DEGREES OF FREEDOM (6DOF)

Simple definition:
A system which provides six degrees of freedom tracks an object's position and rotation in three dimensions. Three positional axes plus three rotational axes adds up to six "degrees" which can be freely controlled.

What does this mean for you?
There is a big difference between what you can do with 3DOF rotational tracking and full 6DOF tracking. As an example, the original Wii controller only tracked rotation, which forced game developers to use control "metaphors" for things like throwing a ball or swinging a tennis racquet. On the other hand, the HTC Vive and Oculus Touch controllers can be precisely controlled in space, giving users a sense of where their hands are.
Presence or 'Sense of Presence'
Simple definition:
The sense of being somewhere else than your current physical location, the sense of being in and of the [virtual or simulated] world.

Extended definition:
Your sense of being somewhere else other than your current physical location has a lot to do with how much concentration and attention you put into displacing yourself from the physical world. Comfort, stimulation and interaction all play a role in allowing you to forget that technology is creating what you are experiencing and ultimately perceiving as your reality.

SCREEN RESOLUTION

Simple definition:
Screen resolution refers to the amount of pixels that are displayed on the screen. Much like a computer monitor or television, the more pixels present, the clearer and more realistic the image quality will be.

What does this mean for you?
The higher the screen resolution the clearer and more realistic the VR experience will be. Because the screen in a VR headset is only a few inches away from your eyes, a higher screen resolution is needed so you don't see each individual pixel.

While looking at a 1080p television may seem like great quality, you typically don't sit a few inches away from it. If you were to move right up to your television, then you would notice the little pixels that make up the image.

With VR headsets, the screen is split in half to show one image accurately to each eye.

When looking for a mid-level or high-end VR headset, look for a screen resolution with a minimum of 2160·1200 (1080·1200 per eye). Anything lower and you may notice what is called the 'screendoor effect', which feels like you are looking through a screen door (you can see the little black dots or lines in the screen)

SPATIAL AUDIO (ALSO KNOWN AS 3D AUDIO)

Simple definition:
Spatial audio is used to create sound that originates from a specific point in the virtual world. This is like surround-sound in a home theatre setup or at the movies.

What does this mean for you?
Sound is one of the most important components to creating an immersive VR experience. Spatial sound allows you to hear sound all around you and also tracks the sound when you move your head just like in real life.

For example, if you heard footsteps to the left of you, then you turned your head left, the footsteps would sound like they are now coming from in front of you. Sound plays a major part in producing a truly immersive experience, and is arguably one of the most important components when creating a virtual reality experience.

TRACKING

Simple definition:
Tracking is extremely important for a fully immersive VR experience. Essentially, tracking tells the computer where you are looking and what you are doing so that it can accurately draw the virtual world around you. The more precise the tracking, the more comfortable the VR experience will be.

Also see: Motion tracking, Positional tracking

VIRTUAL REALITY

Simple definition:
Different disciplines have different concepts of virtual reality and what hardware is required. We use a definition based on The Internet Encyclopaedia, in which virtual reality requires:
Computer-generated stereo visuals
Viewer-cantered perspective
Ability to interact with the real world
Interaction with user in real time (meaning response comes within a certain time interval that is specific to the application or field)

What does this mean for you?
A high level of VR immersion is achieved by engaging your two most prominent senses, vision and hearing, by using a VR headset and headphones. The VR headset wraps the virtual world or experience nearly to the edge of your natural vision field of view. When you look around, you experience the environment the same as you do when you look around in real life. Headphones amplify the experience by blocking out the noise that's around you, while allowing you to hear the sounds within the VR experience. When you move your head, the sounds within the VR environment move around you like they would in real life.

AUGMENTED VIRTUALITY

Simple definition
On the mixed reality continuum, augmented virtuality lies somewhere between AR and VR. Essentially, it refers to bringing real world objects into virtual worlds where they can be interacted with.

What does this mean for you?
A simple example of augmented virtuality is a 3D controller that has a representation in VR. Another example is using VR represented chaperones which are based on real-world obstacles such as walls and furniture. Augmented virtuality can also include dynamically inserted other people via real time digitization into virtual worlds.

VR HEADSET (ALSO KNOWN AS HEAD-MOUNTED DISPLAY OR HMD)

Simple definition:
A virtual reality headset (VR head-mounted display or HMD for short) is a goggle-like device that you wear on your head which generally contains a screen and lenses which allows you to see into the virtual world.

What does this mean for you?
The VR Headset is the foundation of modern virtual reality. Technology has come a long way over the last 50-60 years and what was once a big and heavy VR headset in the early '90s is now just a little bigger than a pair of ski/snowboard goggles. Some VR headsets even use your phone as the screen like Samsung Gear VR or Google cardboard. When researching VR Headsets (or VR head-mounted displays) look at whether the screens are built in or if it requires you to use your cell phone. If you are looking for the best immersive experience, high-end VR Headsets like the Oculus Rift or HTC Vive are what you should invest in. But remember, high-end VR Headsets will require a high-end computer to run them. If you are looking for a great quality mobile VR experience, then the Samsung Gear VR is your best bet if you own a 2015 or newer Samsung smartphone.

VROLOGY

Simple definition:
'Ology' is the study of a particular topic or a branch of learning. VRology is the study, or learning, of virtual reality. Virtual reality is the topic of study and branch of knowledge.

What does this mean for you?
Virtual reality is growing tremendously fast, and new opportunities and possibilities are opening up every day. We have built this resource with the simple mission of connecting people to their VR passion by simplifying the learning curve and making it easy to connect to educational material, products, people and immersive VR experiences.

STEREOSCOPY

Simple definition:
The reproduction of the effects of binocular vision by photographic or other graphic means. Most stereoscopic methods present two offset images separately to the left and right eye of the viewer. These two-dimensional images are then combined in the brain to give the perception of 3D depth. (www.stereoscopy.com, wikipedia.com)

What does this mean for you?
Most 360 movies are not stereoscopic because they present the same image to the left and right eye. In order to be stereoscopic, software would need to recalculate the left and right views depending on your position.

CYBER SICKNESS (AKA VIRTUAL REALITY SICKNESS, AKA SIMULATOR SICKNESS)

Simple definition:
As opposed to motion sickness which happens when people are moving but their brain thinks they are stationary (e.g. kid in the back seat of a car), simulator sickness happens when the subject is stationary, but has a compelling sense of motion induced through exposure to changing visual imagery (Arns & Cerney, 2005).

What does this mean for you?
Symptoms of simulator sickness are similar to those commonly experienced by subjects reporting motion sickness. There is not one single factor that causes motion sickness, for example elements like lag, refresh rate, and update rate of the visual display correlate with sickness. Other factors which may influence sickness are contrast, resolution, colour, field of view, viewing region, binocular viewing, scene content, flicker and camera movement.

HAPTICS (TOUCH FEEDBACK)

Simple definition:
Haptics recreate the sense of touch by applying forces, vibrations, or motions to the user, through feedback devices (think of vibrating game controllers).
(http://imm3rsive.com/)

What does this mean for you?
Using senses other than vision greatly enhances users' immersion and sense of presence.