CVR

Children and Virtual Reality:
Emerging Possibilities and Challenges

Contents

Photography by Jules Lister

1. Background to the Study

1.1 Introduction

Virtual Reality is fast becoming a reality, with estimates that over 200m headsets will have been sold by 2020, and the market value for VR hardware and software reaching well over $20bn by then. Key players in the market currently include PlayStation with PSVR, Facebook with Oculus Rift, Google Cardboard and Daydream, Mattel with Viewmaster, and many other brands investing in content production for various audiences. One of those audiences is young people and children.

"Children and Virtual Reality" is a collaboration between Dubit, Turner, WEARVR and the COST (European Cooperation in Science and Technology) Action DigiLitEY.

Dubit, Turner and WEARVR are companies that specialise in digital, TV and VR content, with an interest in developing best practices around VR and children.

DigiLitEY is a five year (2013-2017) academic network that focuses on existing and emerging communicative technologies for young children. This includes wearable technologies, 3D printers, robots, augmented reality, toys and games and relevant aspects of the Internet of Things.

This report brings together industry research into the effects of VR on 8 to 12 year olds, and ideas that arose from a COST funded Think Tank to explore what the research findings might mean for the use of VR by under 8s.

1.2 Aims, objectives and research questions

The aims of the project were inspired by growth in VR content, the uptake of hardware globally, and yet the lack of research around the effects of VR on young people. VR is appealing to children but there are concerns around potential health and safety issues, as well as questions concerning the appropriateness of current content for young people. For example, hardware manufacturers often advise that VR use is limited to children over 13 years old, but there appears to be no rationale behind the choice of 13 as a lower limit.

This study investigated if there are any potential harmful effects of experiencing VR under 13 years old, and what best practices should be followed in developing appropriate VR content for children. The project has also led to the development of guidelines and recommendations for this user group.

The decision was taken to work with 8-12 year olds because under 8s seemed less likely to be an early adopter market and also because there was less suitable available content to test with. Additionally at the start of the study some of the bigger devices were still quite heavy for younger children's necks and heads.

The objectives of the study were:

- To understand awareness and appeal of VR to children, and usability of VR in relation to different headsets and platforms for 8-12 year-olds.
- To understand engagement of children with different types of VR gaming content.
- To gain preliminary evidence on how short-term use of VR might affect the vision and balance of children aged 8-12 years.
- To develop guidelines to help parents and children understand VR and its use.
- To begin evolving "best practices" in design and production of VR, supporting children's safe, comfortable, engaging and beneficial uses.

1.3 Methodology

Quantitative data regarding VR and children was taken from Dubit's Global Tracker - this collects information on children's digital practices every six months across eight countries. In addition, the industry partners (Dubit, Turner, WEARVR) undertook a small-scale qualitative research study looking at children's use of VR, focussing on 8-12 year olds.

The research project comprised of four separate phases specifically designed to address the aims and objectives.

1.3.1 Phase 1: Online survey on awareness and appeal of VR

The project used data from Dubit Trends - a regular online survey of children aged 2-15 years and their parents across 8 countries around the world, to represent different regions and cultures. The data used in this project came from the total of 1917 children aged 2-15 in the USA, and 1119 in the UK who completed the study. Over the last two years, this Dubit Trends survey has asked questions relating to emerging technology, making it possible to track awareness and appeal of technologies over time. In addition to this, the latest survey included 4 additional questions relating specifically to VR. The aim was to understand their interest in experiencing VR and the types of experiences they think they would enjoy. The final question was a set of agreement statements for parents to answer.

1.3.2 Phase 2: Observations on children's engagement with VR

This phase investigated how children engage and interact with a range of VR content on different headsets, from Google Cardboard to the HTC Vive. Dubit observed 20 children between the ages of 8 and 12 years (10 boys and 10 girls) playing with VR, in the presence of their parent. Each play session was video recorded and an informal interview took place before and after play to establish children's previous use of and knowledge of VR, as well as what they liked or didn't like about the different types of content they used in the session. We restricted the sample of children to 20 as a precaution: we were unsure of the effects of VR and saw this study as preliminary, with a view to expanding once results were known.

1.3.3 Phase 3: Vision and Balance tests

This phase explored the extent of the visual and postural after-effects experienced by the 20 children aged 8-12 years following 20 minutes of VR play. Objective visual and postural stability measures were led by vision and cognitive scientists at the University of Leeds and carried out by a paediatric physiotherapist.

1.3.4 Phase 4: DigiLitEY Think Tank

After completion of the first three stages of the research study, Dubit collaborated with the academic DigiLitEY network to produce a one-day Think Tank. This was used to disseminate some of the research findings, and to explore how these findings might be related to younger children under 8 years old. This day also explored ideas around future research in the areas of creating VR content and its educational potential.

The Think Tank included participants from a range of sectors interested in the development of VR for children. These included the digital games industry, health and safety specialists, academics specialising in children and digital technologies, lawyers, and those from other parts of the creative economies such as designers, artists and theatre directors.

1.4 Approaches to data analysis

The survey data from phase 1 was processed and analysed using SPSS 22 (BM SPSS Inc., Chicago IL) statistical package. Descriptive statistics summarising the demographic features of the dataset are provided.

The observational and interview data from phase 2 was transcribed using a multimodal framework that considered body movement and aural modes of communication in relation to images of the VR content the child participants were watching. These were then analysed using thematic analysis (Braun and Clark, 2006). Data were coded both deductively (engagement, interaction, balance and vision) and inductively.

The phase 3 visual and postural measures were analysed using R Statistics (R Core Team, 2017) and illustrated using Prism 6.0 (GraphPad Software, La Jolla, CA, USA).

1.5 Ethics

Ethical issues were addressed throughout the study, in line with the BERA Ethical Guidelines (2011), as well as the Market Research Society (MRS) ethical guidelines. Parents were asked to sign a consent form giving permission for their child to take part in the study. In addition, verbal consent was sought from the child participants. The researcher also observed for non-verbal signs of discontent (of which there were none). The project and their role within it was explained to each parent and child in language appropriate to their

age. They were given the chance to ask questions and also told how they could opt out of the study at any point (this included closing their eyes and removing the headset). Parents were present with their children throughout the research session and each parent was offered the chance to try the VR content ahead of their child so that they could make an informed decision.

Report structure

The remainder of this report is structured as follows :

Each section provides insight from specialists working in these areas, including those present at the think tank, as well as from the research findings.

Photography by Jules Lister

2. Current Access and Appeal

2.1 Introduction

The latest wave of the Dubit Trends survey (Spring 2017) contained data relating to VR access and appeal across 2-15 year olds. Questions were asked of both children and parents (see section 1.3.1). Findings from the USA and UK have been chosen from the wider study because the qualitative research study took place in the UK and therefore can be used as a point of comparison, and, because the USA is traditionally an early adopter of new technology, it therefore serves as a useful indicator of what might happen later in other countries.

2.2 Children's awareness of VR

Children are becoming increasingly aware of VR, with the number in the USA having never heard of it dropping by to half from Autumn 2016 (40%) to Spring 2017 (19%)(Figure 1).

Figure 1: Levels of familiarity with VR
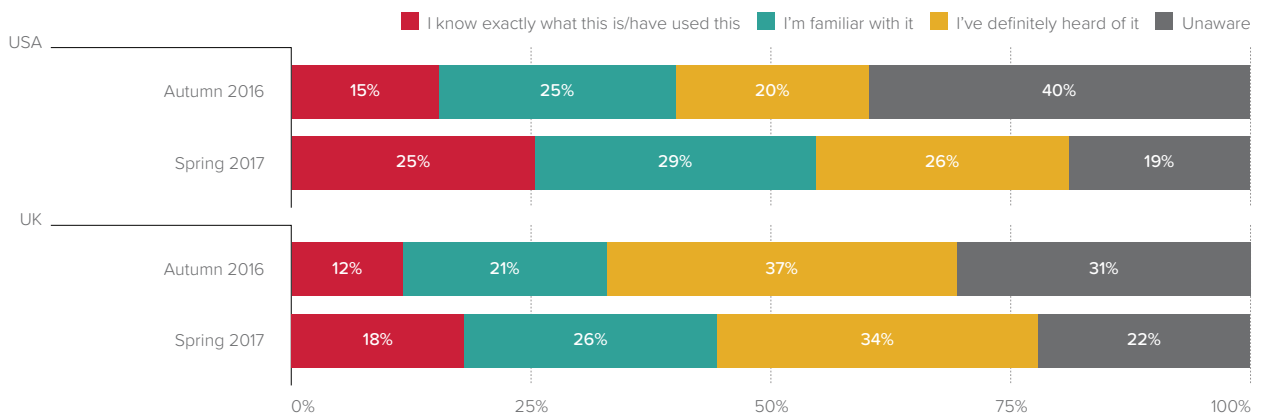
Source: Dubit Trends. BQ16.5. How familiar are you with the following terms [is your child with the following terms]?
(Base: Wave 6 US 1109 UK 582/Wave 5 US 1139 UK 507)

In the USA, the number of children who have heard of VR is more than 50% for both age groups (8-10 years and 11-15 years). However, this is far lower in the UK with only 24% of 8-10s and 29% of 11-15 year-olds stating they are familiar with the technology (Figure 2).

Figure 2: Levels of familiarity with VR by age

NET: Have used it/know exactly what it is/am familiar with it
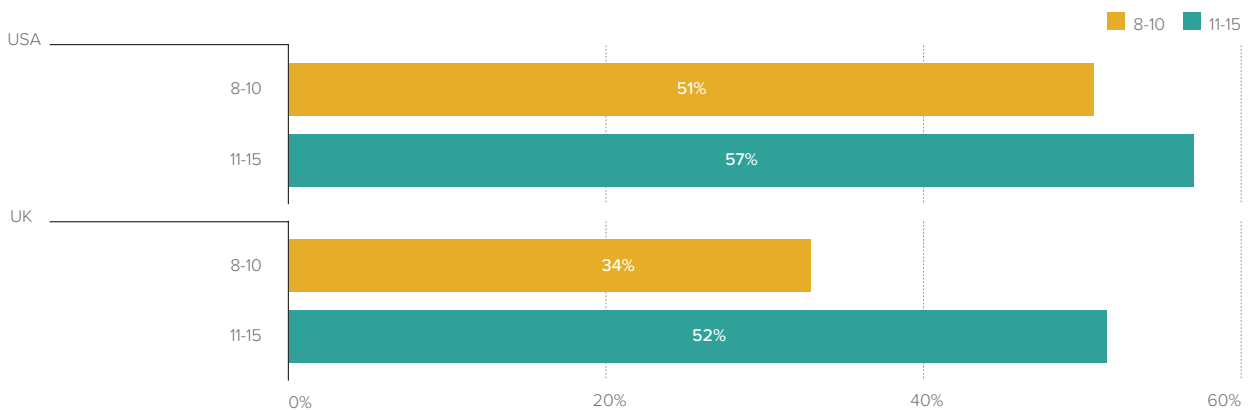
Source: Dubit Trends. BQ16.5. How familiar are you with the following terms [is your child with the following terms]?
(Base: Wave 6 US 407 (5-7). 415 (8-10), 694 (11-15) Weighted, UK 269 (5-7). 246 (8-10), 336 (11-15) Weighted)

Audiences in the US are typically described as the earliest of early adopters of new technology. This is reflected in the data; the US has more than double the number of children expressing an extreme interest in VR, compared to UK children (Figure 3).

Figure 3: Levels of interest in VR
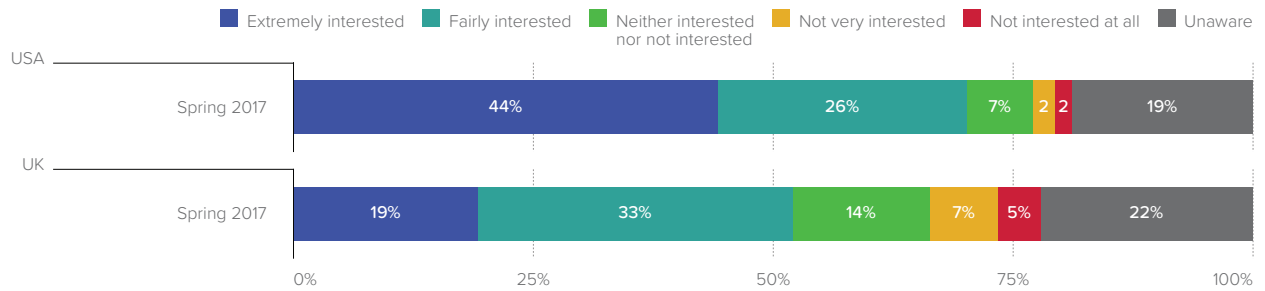
Legend: Extremely interested | Fairly interested | Neither interested nor not interested | Not very interested | Not interested at all | Unaware

USA — Spring 2017: 44% Extremely interested | 26% Fairly interested | 7% Neither | 2% Not very | 2% Not at all | 19% Unaware

UK — Spring 2017: 19% Extremely interested | 33% Fairly interested | 14% Neither | 7% Not very | 5% Not at all | 22% Unaware

Scale: 0% — 25% — 50% — 75% — 100%

Source: Dubit Trends. BQ16.6. How interested are you in [is you child interested in] experiencing Virtual Reality?
(Base: Wave 6 US 1109. UK 582)

Of those that are interested in VR, the numbers are similar across the two age groups. (Figure 4). These are high numbers for any emerging technology.
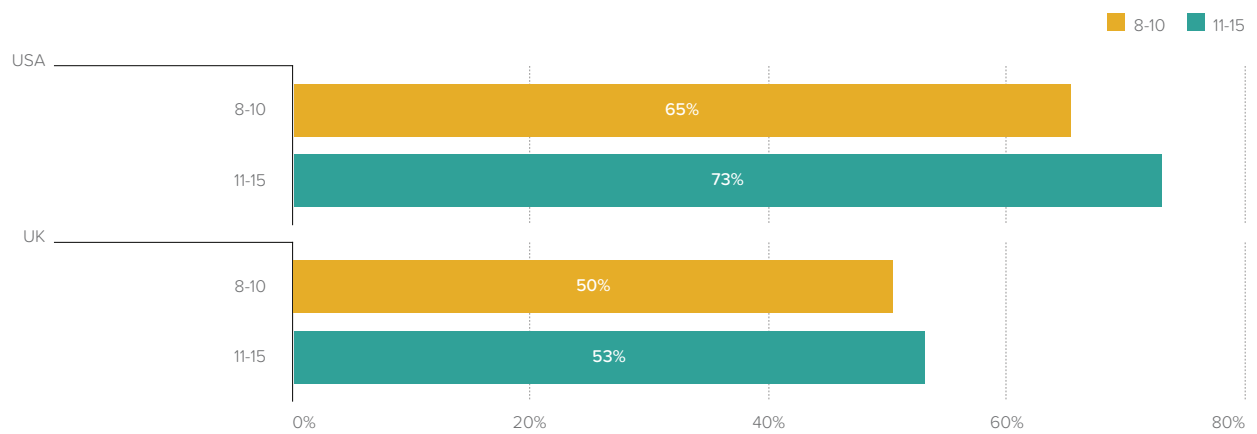
Figure 4: Levels of interest in VR by age

NET: extremely/fairly interested

Legend: 8-10 | 11-15

USA — 8-10: 65%
USA — 11-15: 73%
UK — 8-10: 50%
UK — 11-15: 53%

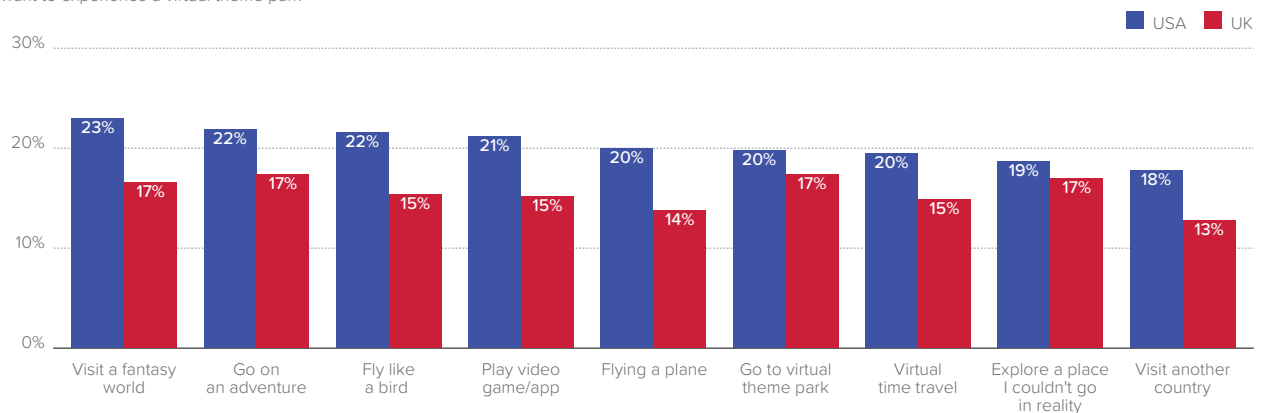Scale: 0% — 20% — 40% — 60% — 80%

Source: Dubit Trends. BQ16.6. How interested are you in [is you child interested in] experiencing Virtual Reality?
(Base: Wave 6 US 407 (5-7). 415 (8-10), 694 (11-15) Weighted, UK 269 (5-7). 246 (8-10), 336 (11-15) Weighted)

2.3 The kinds of VR experiences children want

Children were asked about the kinds of VR experiences they would want from a list of possibilities (see section 1.3.1). Whilst the US children preferred fantasy worlds, children in the UK wished to explore a theme park (Figure 5).

Figure 5: Preferred experiences in VR

Visiting a fantasy world tops the list of VR experiences for kids in the US, but by a small margin kids in the UK want to experience a virtual theme park

Legend: USA | UK

| Experience	USA	UK
Visit a fantasy world	23%	17%
Go on an adventure	22%	17%
Fly like a bird	22%	15%
Play video game/app	21%	15%
Flying a plane	20%	14%
Go to virtual theme park	20%	17%
Virtual time travel	20%	15%
Explore a place I couldn't go in reality	19%	17%
Visit another country	18%	13%

Source: Dubit Trends. BQ16.7. What sorts of experiences would you like to have in virtual reality?
(Base: Wave 6 US 2338. UK 1119)

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There were some differences in preferences by age (Figures 6 and 7).

Figure 6: Preferred experiences in VR by age in the US

Fantasy worlds, adventures and playing video/app games appeal most to 8-10 year olds.
These experiences appeal to young teens; they would also like to fly a plane, travel through time and visit places you can't in reality
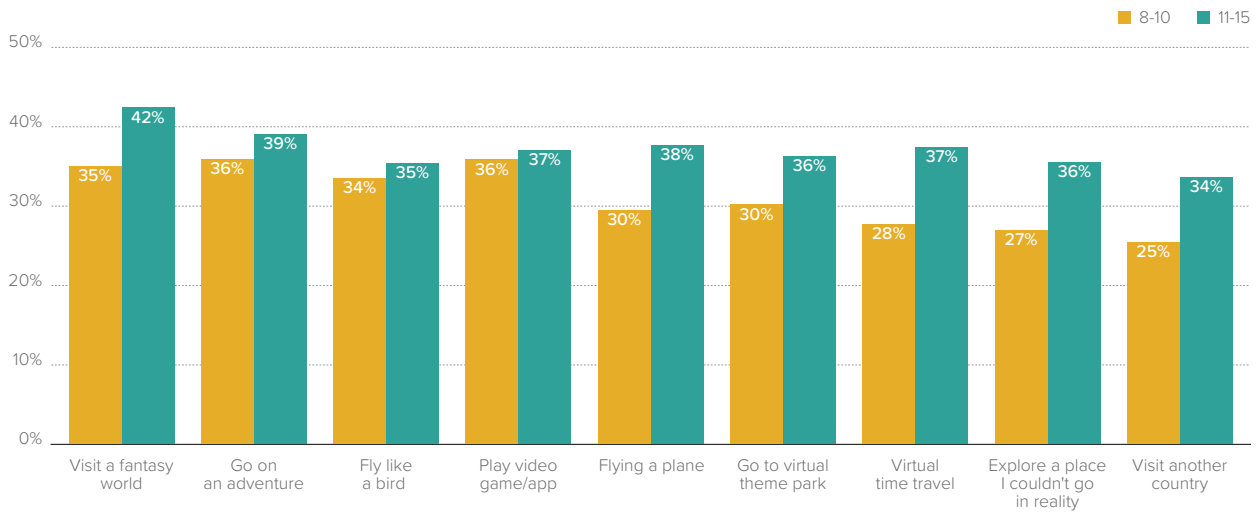
Source: Dubit Trends. BQ16.7. What sorts of experiences would you like to have in virtual reality?
(Base: Wave 6 US 2338. UK 1119)

Figure 7: Preferred experiences in VR by age in the UK

Going on adventures, flying like a bird and exploring places you can go in reality appeal most to 8-10 year olds. Young teens
would most likely to visit virtual theme parks, adventures as well as visiting places you can't go in reality
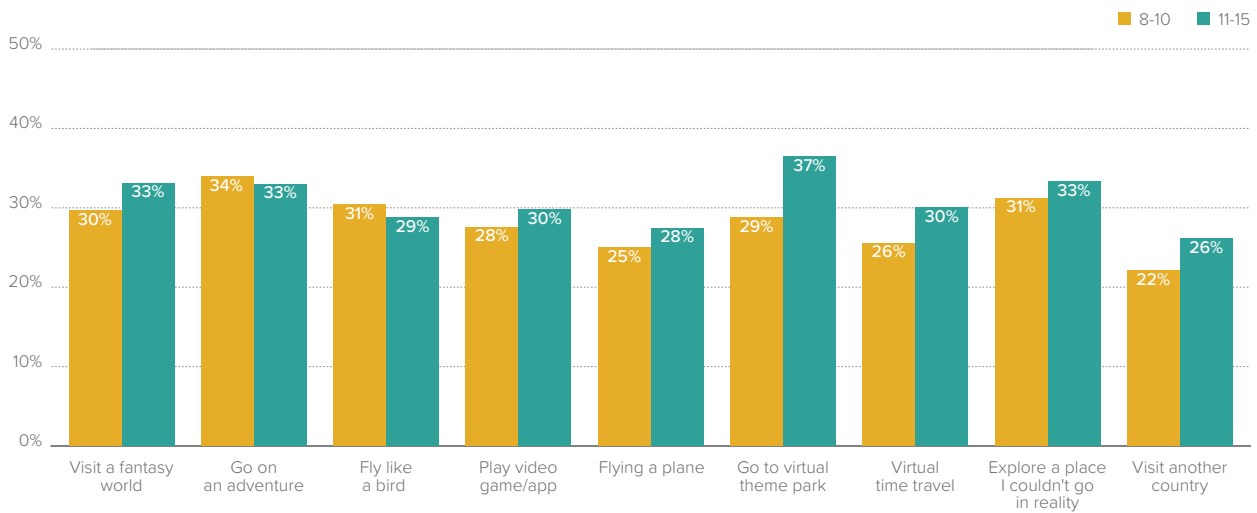
Source: Dubit Trends. BQ16.7. What sorts of experiences would you like to have in virtual reality?
(Base: Wave 6 UK 246 (8-10), 336 (11-15) Weighted)

2.4 Parental attitudes to VR

Parents in the US appear more open to VR; parents in the UK appear to be more reticent (Figure 8).

Figure 8: Attitudes of parents towards VR

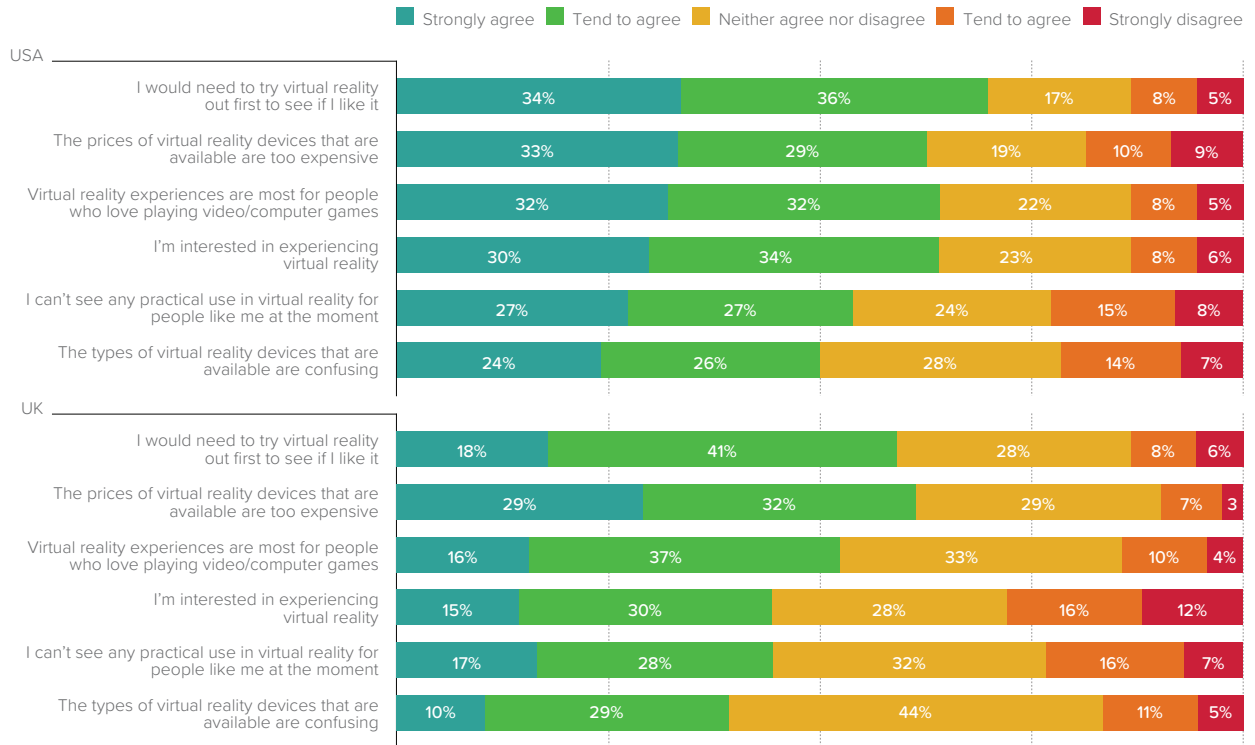Parents in the US appear more open to VR; parents in the UK appear to need more convincing

Legend: Strongly agree | Tend to agree | Neither agree nor disagree | Tend to agree | Strongly disagree

USA

Statement	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to agree	Strongly disagree
I would need to try virtual reality out first to see if I like it	34%	36%	17%	8%	5%
The prices of virtual reality devices that are available are too expensive	33%	29%	19%	10%	9%
Virtual reality experiences are most for people who love playing video/computer games	32%	32%	22%	8%	5%
I'm interested in experiencing virtual reality	30%	34%	23%	8%	6%
I can't see any practical use in virtual reality for people like me at the moment	27%	27%	24%	15%	8%
The types of virtual reality devices that are available are confusing	24%	26%	28%	14%	7%

UK

Statement	Strongly agree	Tend to agree	Neither agree nor disagree	Tend to agree	Strongly disagree
I would need to try virtual reality out first to see if I like it	18%	41%	28%	8%	6%
The prices of virtual reality devices that are available are too expensive	29%	32%	29%	7%	3
Virtual reality experiences are most for people who love playing video/computer games	16%	37%	33%	10%	4%
I'm interested in experiencing virtual reality	15%	30%	28%	16%	12%
I can't see any practical use in virtual reality for people like me at the moment	17%	28%	32%	16%	7%
The types of virtual reality devices that are available are confusing	10%	29%	44%	11%	5%

*Source: Dubit Trends. DQ11. We are going to show you a series of statements about Virtual Reality.
For each one we'd like you to tell us how much you disagree or agree.
(Base: Wave 6 US 2023. UK 1119)*

Dubit's qualitative VR study (phase 2 and 3) also found initial resistance from parents to trying out VR. During the study, all parents were offered the chance to try the VR content ahead of their child, but only a small number did so. We believe that such reluctance from parents - if representative - could impact their own trialling of VR, and consequent permission for their children to try out experiences.

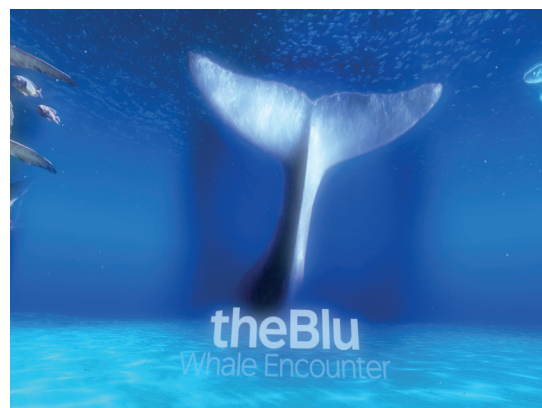# 3. VR Content for Children

3.1 Introduction

The industry research investigated how children engage and interact with a range of VR content on different headsets, through a small scale qualitative research phase. The purpose was to assess the appeal and issues around VR content generally, but did not address relative appeal or issues between different headsets.

Dubit observed 20 children between the ages of 8 and 12 years (10 boys and 10 girls) using VR, in the presence of their parent. Each session was video recorded and an informal interview took place before and after play to establish children's previous use of and knowledge of VR, as well as what they liked or didn't like about the different types of content they used in the session. This introduced the children to a range of VR content played across these specific devices in the research sessions:
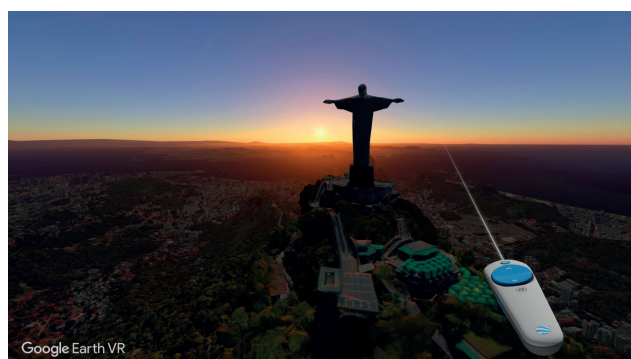
- Google Cardboard;

- Oculus Rift;

- HTC Vive.

1. HTC Vive: Job Simulator: The 2050 archives (Owlchemy Labs)
https://www.wearvr.com/apps/job-simulator

2. HTC Vive: The Blu (Wevr)
https://www.wearvr.com/apps/theblu

3. HTC Vive: Google Earth VR (Google)
https://www.wearvr.com/apps/google-earth-vr

4. HTC Vive: Fairy Garden (Dubit)
https://www.wearvr.com/apps/fairy-garden

5. Oculus Rift and Gear VR: Adventure Time Magic Man (Turner)
https://www.wearvr.com/apps/adventure-time-magic-mans-head-games

6. Google Cardboard: Adventure Time We See Ooo (Turner)
https://www.wearvr.com/apps/adventure-time-i-see-ooo

The aim of this phase of research was to help shape the design of future VR content and devices for younger children by understanding which visual aesthetics appeal to them and how easy or difficult they find it when interacting with objects in a virtual space. These apps were chosen to reflect the different graphical styles across the range of VR content - from real, to realistic, to cartoon.

High appeal and enjoyment of VR

Overall, every child who took part in the study loved the VR experience.

When testing new technology we often experience moments of disengagement and confusion - but not in this case. In our test, we found all children and parents to be excited at the prospect of trying VR. Most had heard of the new technology; some of them had already spent time searching for VR content on YouTube; others had previously tried VR and wanted to experience new content. Despite this there was high engagement throughout and after the testing. Below are some of the metrics we measure when testing content and technology which indicate a positive and engaging experience:

- All parents and children expressed an excitement and interest in the prospect of using VR

- All listened to the instructions and waited patiently to be setup on the device. This is a telling observation as often children are less patient when setting up tests

- Most children were amazed with their first steps into VR, even when the on-boarding wasn't perfectly suited

- All children narrated their VR experience, commentating what was happening, expressing their delight at their preferred moments. The desire and ability to express their experience is a key metric when measuring engagement. It tells us that not only are they enjoying the experience, but they comprehend what is being asked of them as the user

- Children were disappointed when the testing ending, citing that they wanted to continue using VR

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- Children were positive about their VR experience and were able to clearly explain their favourite moments within VR. This demonstrates a high level of enjoyment and comprehension
- Children expressed an interest in using VR at home
- When asked if they would recommend it to friends they all said "Yes".

The next sub-sections share some details of how this excitement at engaging VR manifested and gives suggestions for how parents can enhance their child's experience. Recommendations for how designers can make the best experiences for children are also offered.

Observation of the children in these VR apps highlighted three important areas related to producing appropriate VR content for children and delivery of the best experience:

- On-boarding
- Usability
- Engagement

3.2 On-boarding

One of the key areas for focus is how the children understand the context and content, and how to act within a virtual environment.

3.2.1 Research findings

"Wow strange!"

- Eight out of ten children who tried VR for the first time described the initial experience of entering VR content as "strange", a neutral term they used to express an entirely unfamiliar experience. However, they were engaged by the wow factor of the experience and they were not uncomfortable.

"I felt shocked at first. Like I was on the TV."

- Children understood the specific intentions of VR content best when they had previously engaged with it on YouTube. In our small sample, many recognised the Job Simulator design and gameplay from YouTube. The fact that children had previously been looking for VR content on YouTube is also an indicator of their interest in the medium.

- Children were more confident to explore VR content when it was in a familiar context, e.g. children really enjoyed playing in the kitchen context of Job simulator. They were also excited to go to Hollywood in Google Earth as this was a place they had heard a lot about and wanted to visit. Some asked their parent to take a photograph to capture the moment. When VR contexts were less familiar to them (such as being underwater in 'The Blu'), children needed more on-boarding, in terms of what to expect and how to use the content. Once they had become familiar with the environment they wanted to stay in the VR content for longer.

3.2.2 VR design tips for on-boarding

Controls	Field of View	Preview on Youtube	Comfort Zone
A good introduction to the controls is to have the player use them in the early on-boarding, e.g. in 'Space Rustlers' the player has to hover over a stationary spaceship for a few seconds to launch the main play - this same input is how players fire at spaceships in the game.	In common with normal game design, help children adjust their eyes to the VR experience by not beginning with an uncomfortable view, (i.e. do not place objects close to them or restrict their field of view). It is important that children can look around and have a context to the experience, and their place in it.	Record the experience and publish on YouTube. Content owners might consider placing videos of their VR experiences on YouTube to allow children to familiarise themselves with what the content will look like and what is expected ahead of playing it for the first time. This encourages sharing, discussion and demand.	Try to think of children's comfort zone relating to spheres of familiarity spiraling out from themselves to their family and home, then to local environments and places they have experienced in the physical environment. Further spheres may relate to unfamiliar places that they will not have visited but may have heard about or seen in pictures and videos. For example, when children played Google Earth they wanted to stand on a platform when looking down at Earth. In Fairy Garden children went up into the air by standing on a giant bean stalk leaf which made them feel more comfortable.

3.2.3 On-boarding tips for parents

- Where possible, play the game first in the presence of your child. This allows the child to feel more comfortable and be able to ask questions, and you can give guidance about what to expect, and be aware of potential issues around movement.

- Make sure that if VR content is shared by family members, that it is re-calibrated between players to avoid an uncomfortable and 'strained' experience.

- Make sure children have a chance to learn how the controllers work before they put on the headset. Some controls can be complex, so learn how they work before giving them to a child.

**"So I am just going to hand your hands (VR controllers).
How do they look? Are they the right way around?"**

- Remind children that if they see content that scares them they can look the other way, close their eyes or take off the headset.

- If a child is upset during a VR experience, engage them in a conversation about their feelings to understand what has affected them.

3.3 Usability

3.3.1 Research findings

- Most children would benefit from having a transitional object to link the physical to the virtual world, i.e children liked the controllers that looked like hands in the game Job Simulator. This helped link their physical body to the virtual world.

- Users naturally expect to be able to see their feet in VR, and not having this can be disorientating for a child if they are encouraged to walk around in the game.

- Children like the perspectives and scale of the virtual content to match their real life experiences (unless it is obvious why they don't). As children become more familiar with VR content, these issues should diminish.

- Many VR experiences are created by adults for adults and most environments have the incorrect dimensions for children's use and enjoyment.   This can cause overstretching and children walking on

tiptoe, and potentially stumbling or falling.

- Some children will walk or run around with the headset on, and bump into furniture or even fall over.

3.3.2 VR designer tips:

Reference Point

VR allows gamers to look or move in any direction, but some children find this overwhelming. Consider a visual 'resting point' directly in front of the user as a reference point they can come back to.

Action Area

Guidelines for the action area of less 'mobile' VR games (such as for Google Cardboard) is 70 degrees to the left and right and 45 degrees up and down from the resting point. This action area gives the biggest playable area against the physical limits of a person. Anything past these points will normally start to strain muscles in the neck, or create dizziness.

Objects in VR

Care should be taken when placing VR objects so that they don't make children need to overstretch or stoop to reach them, for periods of time. It's obvious, but apps directed at children should be created with a child's dimensions in mind.

Child's Orientation

Children find it difficult to understand their position in the environment as they do not have a reference point such as being able to see their feet. Creating a shadow, or virtual feet (or some other "anchor") can improve a child's orientation , as they regularly look down to check their position.

Sound Guide

In reality people navigate with signposts and sounds. The same can be implemented and encouraged in VR - for example binaural sound can direct a user to turn around, or a "guide" can be followed to navigate the journey and gameplay.

- 15⁰ Home
- 30⁰ Comfortable
- 60⁰ Occasional
- 90⁰ Typical Bounds

Guidelines for the action area

3.3.3 Tips for parents:

- To introduce the child to the game or experience, have the child seated and comfortable, to give them a physical point of reference.
- Supervise your child. Remove any obstacles around the room, and monitor your child's movements during the VR experience. This is especially true for headsets that encourage moving around, such as the HTC Vive.

3.4 Engagement

All of the children enjoyed playing in virtual reality, and revealed some preferences for style, opportunities for expanding play, and general comfort.

3.4.1 Research findings

- All children in this study were very engaged with the VR experience and all asked to play for longer. Many of the children immediately asked their parents to buy the VR equipment. Parents watching their children play also mentioned how engaged their children were. Children used VR in very social ways, i.e. simultaneously talking with a friend "outside" the experience, and "overreacting" to situations to describe or involve others in the VR experience.
- Children used VR in very social ways, i.e. simultaneously talking with a friend "outside" the experience, and "overreacting" to situations to describe or involve others in the VR experience.
- Children seemed to prefer low poly or cartoon graphics, such as in Job Simulator. This was because it allowed them to bring their own narratives into the content and thus brought about greater engagement. For example, a low realistic image of a robot in Job Simulator allowed children to create a multitude of personalities and emotions for the robot.
- Graphics that are animated at low rates, eg. 30 Frames Per Second (FPS) were found to be disorientating.
- Children's engagement was multi-sensory (taste, touch, verbal etc). They engaged with VR content by using all of their body.
- Children enjoyed breaking rules and doing things they could not do in the real world, for example, going on a roller-coaster (they are usually too short to go on the real thing), and setting things on fire.

1. Aaron (10): "What's on the menu? Burgers. Wash it."
(He washes the menu)

2. Aaron (10): "Right! Let's fry this."
(Frying the menu)

3. Aaron (10): "There you go"
(The menu is on fire)

An example of children's play, breaking rules in VR

3.4.2 VR design tips

SDKs

Problems can occur where experiences are not correctly ported for a specific device. There is plenty of advice for this available from Google, Unity, and Unreal to get the best user engagement, but there are many new headsets coming onto the market which may require specific versions to be created, using custom Software Development Kits (SDKs).

Multi-player

When in a VR experience, children enjoy talking and being social with people in the same room: great opportunity for multi-player experiences (where spectators can help the person in the VR experience).

Sound Effects

VR requires good binaural sound to reflect the 3D environment and guide the child. Poor, audio quality or an absence of sound breaks the experience. At the very least, the VR environment should be rich with sound effects that are correctly placed in the user's stereo sound field.

Frame Rate

If the graphics allow, try to create experiences at at least 60 FPS, for a slicker and less disorientating user experience.
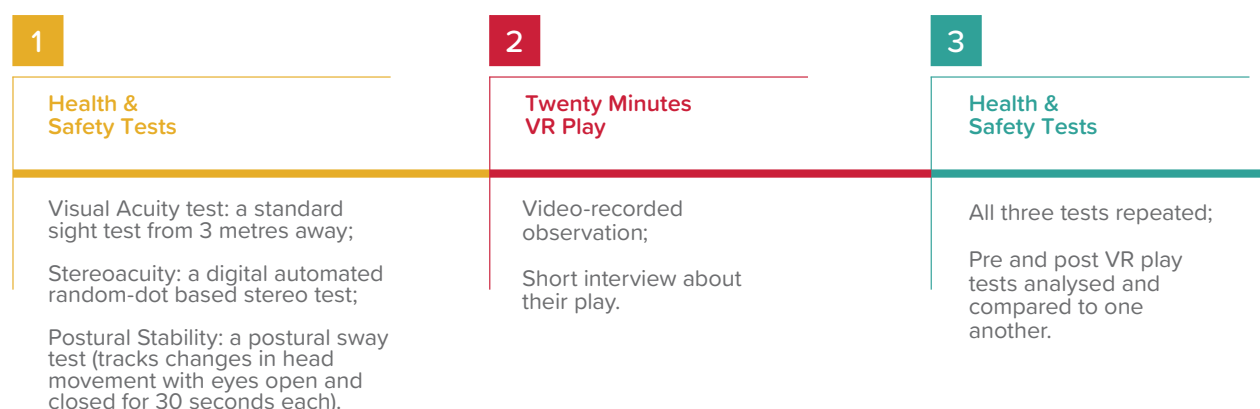
4. Health and Safety

4.1 Introduction

To gain insight into the effects of VR on the vision and balance of 8 to 12 year olds, Dubit, WEARVR and Turner collaborated with specialists in vision and balance from the University of Leeds (Holt, Mon Williams, and Mushtaq). This preliminary investigation was carried out to address concerns across industry about the possible negative effects of exposing younger children to close screen viewing, as well as issues related to the devices that have been designed primarily with adult users in mind.

4.2 Methodology

To provide a platform for future investigations of the impact of VR use on children's health and safety, we focussed on objectively examining two commonly reported adverse phenomena; eye strain and dizziness.

Twenty children aged between 8 and 12 years old undertook the following three tests before and immediately after 20 minutes of VR use:

- A standard eye examination from 3 metres away to examine eyesight

- A digital automated random-dot, stereo test to study stereoacuity

- A measure of head movement as a child stands still to index postural stability/ balance.

1	2	3
Health & Safety Tests	**Twenty Minutes VR Play**	**Health & Safety Tests**
Visual Acuity test: a standard sight test from 3 metres away;	Video-recorded observation;	All three tests repeated;
Stereoacuity: a digital automated random-dot based stereo test;	Short interview about their play.	Pre and post VR play tests analysed and compared to one another.
Postural Stability: a postural sway test (tracks changes in head movement with eyes open and closed for 30 seconds each).		

Flowchart illustrating the process for examining the impact of VR use on vision and balance

The data was collected in two waves. In wave 1, 10 children watched a variety of VR content using a commercially available head mounted display (HMD) system with a 110 degree field of view and positional head tracking. In Wave 2, the same tests were conducted pre and post viewing, with six children watching the content using another fully immersive HMD system whilst another four children used a low cost, mobile phone based device. The second wave presented the opportunity to examine differences between the different types of headsets; however, given the small sample size and the fact that results across both waves showed the same pattern of results, we grouped the data for analysis, unless stated otherwise.

4.3 Results

4.3.1 Eyesight

On the standard vision resolution test (equivalent to the clinical measures of eyesight taken by optometrists / ophthalmologists), there was no difference between pre and post scores across both waves of data collection for any child in our sample. There were also no differences observed between the effects on the eyesight of low-cost mobile VR system and the high-end fully immersive HMD unit.

4.3.2 Stereoacuity

Good stereoacuity relies on good eyesight in both eyes and good binocular coordination between the two eyes (something that previous research has shown can be disrupted by VR headsets; Mon-Williams et al.,

1993). To examine whether stereoacuity might be affected by VR use, we measured global stereopsis (in seconds of arc) of children pre and post VR play using a digital automated stereo test (StereoTAB v3.0.4).

The test involved asking children to determine which direction a pac-man shaped character was facing whilst viewing a pair of stereo images comprised of random dots. These images were designed so that, when viewed using 3D (red and cyan anaglyph) glasses, the silhouette of the pac-man character would leap-out in front of the display (as a result of binocular disparities). Following each correct response, the task increased in difficulty (it became harder to detect the character as the disparities became smaller) and the point at which a child could no longer make out the character's orientation provided an index of their stereoacuity (with lower scores indicating better performance). This test has previously been shown to have discriminative power and strongly correlates with the gold-standard TNO stereo test.

Sixteen of the twenty children could see the character without any problems pre VR play. Fifteen had the same score post VR, and one participant's score worsened. From the remaining four participants, one child was was unable to perform the assessment on both attempts - indicative of impaired stereoacuity in that child. Two remained stable, and one had a steep drop off in their stereo sensitivity- from being able to discriminate the orientation of the object with relative small binocular disparities, to only just managing to make out the pac-man shape in the easiest conditions.

In summary, 2 in 15 children using the fully immersive HMD showed steroacuity after-effects and no changes in stereoacuity were reported in the subsample of children (n=4) using the low-cost mobile VR system (Google Cardboard).

Figure 9: Stereoacuity Test

Changes in Stereoacuity Following VR Gaming
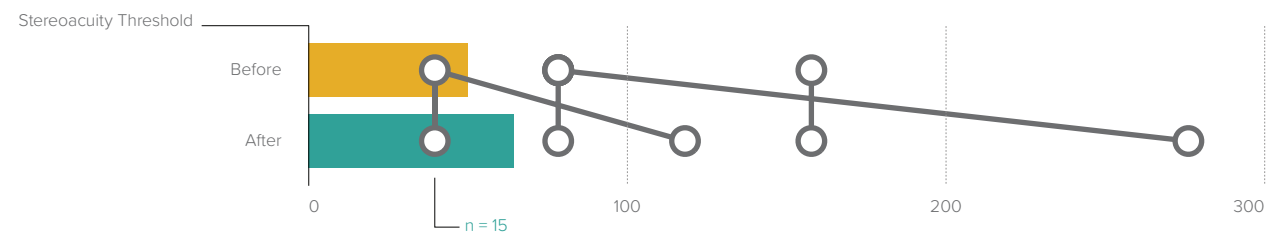
Stereoacuity thresholds pre and post 20 minute VR game play for 19 participants (one child was unable to complete the task). Fifteen of the children received the highest score possible, two children with good levels of stereoacuity showed no change and two children's scores worsened - with one child having a substantially poorer stereoacuity performance following VR use.

In the above graph the circles represent individual participant scores and the lines show the change in score from pre to post VR play for each child (n.b. there are only 5 circles on each side because 15 children had the same value at pre and post). The yellow bar represents the mean average of pre scores and the blue bar is the mean average of post VR play scores. The higher scores indicate a worsening of stereoacuity.

Whilst it is difficult to draw broad conclusions from these tests, the results suggest that for the majority of children, one 20 minute VR game play will have little impact on their stereoacuity in the short-term.

These data also indicate that, for a very small population of children, VR use may disrupt normal binocular coordination. These data make sense in the context of a relatively small number of children having less stable binocular vision, and it is this population that might be expected to be affected adversely through use of VR (at least in the short term – the long term consequences have not been established). The characteristics of children who might be most prone to disruption of binocular vision are currently unknown. We also do not know how long any disruption persists, nor the consequences of repeated exposure over a longer time frame. Further research into these potential factors is planned.

4.2.2 Balance

A small proportion of adult users report dizziness and a sense of disorientation following VR use. To explore whether children's balance might be affected by VR gameplay, we measured the children's postural stability (how well they could maintain balance) for 30 seconds with their eyes open and closed.

Across both waves of testing, the majority of the children performed relatively similarly pre and post gameplay, with differences in scores reflecting natural variability. One child showed substantial improvement post game play, reflecting greater adherence to experimenter instructions. One other child showed drastic worsening of performance following gameplay (with their eyes open and closed; the former are displayed below for brevity). Cross-referencing these data with video observations revealed that this child tripped and fell whilst playing in VR (data point highlighted in orange in the figure below).

These results point in the same direction as the stereoacuity tests, indicating that a small proportion of children may be at-risk of negative after-effects following VR use, whilst the majority are robust to this level of exposure and show no change in balance.

Figure 10: Balance Test

Changes in Balance Following VR Gaming
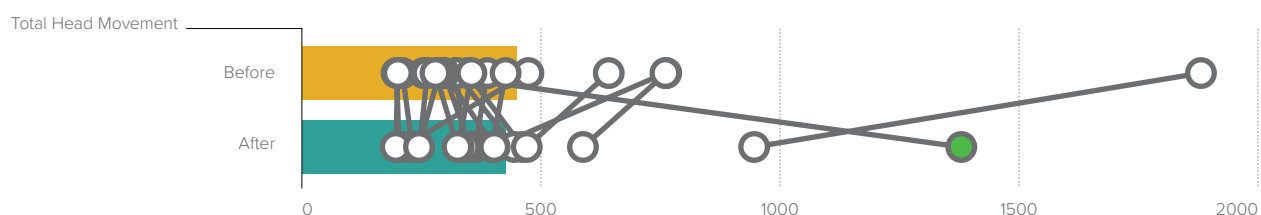
Head movement whilst children stood still with their eyes open for 30 seconds pre and post 20 minutes of VR game play (n = 20). One child showed a dramatic decrease in postural stability (higher total head movement score) following VR use.

As in the previous graph the circles represent individual participant scores. The lines connect each individual participants scores on the pre and post tests. The yellow bar represents the mean average of pre scores and the blue bar is the mean average of post VR play scores. The higher scores indicate a worsening of balance.

4.4 Summary

These findings present a starting point for investigations into health and safety issues related to VR.

For children's visual acuity, we found no effects of short-term play.

In our stereoacuity and balance tests, in the majority of cases we found little difference between pre and post VR play, but in a very small number of cases, postural stability and stereoacuity did worsen.

Thus, within this small study, there is evidence indicating that VR systems can place the binocular system under pressure and can disrupt balance in some children. The characteristics of children who might be most at-risk of being affected by these pressures are unknown and the long term consequences that may or may not arise from such short term pressures are unclear. Until this evidence base accumulates, we propose that the following suggestions might be useful in minimising any potential negative effects on children's health and safety.

4.5 Tips for health and safety

In addition to the tips from the previous section 3, we can advise some further tips that are suggested by our research into acuity and balance.

4.5.2 VR design tips for health and safety

Playtime Restriction

Apps could include a timer that locks children out of play to take a break, eg. the 'Adventure Time We See OOO' app locks the player out after every ten minutes of play. Naturally, the length of comfortable play time can be customised to the experience.

Child's Dimension

Ensure children do not have to stand on 'tiptoes'- which can be disorientating when you can not see a physical context. We advise that children should not have to stretch their necks for too long- which can be addressed by moving interactive objects within easy reach.

4.5.1 Tips for parents with regards to health and safety

- Ask children to sit down when playing with devices that do not require full body movements (eg Google Cardboard, Samsung Gear VR)

- Where devices permit free movement around a room (HTC Vive, Oculus Rift), supervise children so they do not bump into furniture or fall over.

- Ensure that the head tracking on top-end devices is adjusted to individual child height.

- Restrict use to children with no history of ophthalmological problems (e.g. hypermetropia or strabismus).

- Ensure that children take time to adjust to the real world after a period of time within VR (especially before they engage in activities such as crossing roads, navigating stairs or riding bicycles).

- After the session, check on your child's physical and emotional well-being.

5. Regulatory Perspectives

5.1 Introduction

One of the aims of this study and report was to begin the discussion around best practices for industry, and then built on and refine these through further research. This section frames the discussion in relation to two areas: legal issues; and applying the PEGI age rating system to VR content.

5.2 Legal issues

Dr Elizabeth Milovidov, Consultant and Coach, Digital Parenting

As with any new technology, there are potential legal issues that may be anticipated, that include privacy, content, and health and safety. Most device and content creators will be cognizant of these, as well as previous precedent-setting situations:

- The introduction and evolution of new technologies is a constant cycle of improved security and hackers' ability to violate it. Parents and advocates will demand concern for children's safety and privacy.

- Years ago, Disney advertised educational benefits for children based on use of Baby Einstein videos. Without research evidence, Disney later agreed to offer refunds to purchasers, rather than defend a lawsuit. Any claims about VR's educational potential require rigorous research support.

- Personal injury lawsuits against Nintendo followed when gamers were injured while playing Wii Tennis and Wii Boxing. Immersive experiences should be evaluated for health and safety risks including motion sickness, dizziness, nausea, eye-strain, headaches, falls, etc.

- In 2016, McDonald's Sweden created a Happy Meal VR headset for children. Given uncertainty around the effects of VR, the industry might consider forging a "code of conduct" in advance of potential complaints.

- As with other digital content adults supervising children's use of VR will need to be aware of what content is appropriate for their child. How VR is currently rated for children is outlined in the PEGI age ratings section that follows.

- Data privacy affects all types of communication technology, and so VR will also prompt discussions and policies on how to best protect children when data is collected on them through this new technology.

5.3 PEGI age rating

Dirk Bosmans, PEGI

PEGI has been monitoring the development of the market for VR games since 2015, to question whether its criteria are appropriate and sufficient for dealing with this new way to experience video games, while also collecting academic research related to the topic.

PEGI is an age classification system that assesses whether content in a video game is appropriate for children of a certain age. A set of content criteria is used to objectively assess what role is played by violence, language, fear, sex, drugs, gambling and discrimination in a game. The level of realism and the degree of specific content like violence or sex further refine how such content affects the age rating. This allows game content to be classified on an age spectrum that ranges from 3 (all audiences) to 18 (adults only).

In the course of 2016, after the necessary hands-on experience and debate, PEGI drafted an interim conclusion, pending a further expansion of the offering of VR games. The observation was that the PEGI criteria are currently adequate to address the different types of content in VR games: violence of a certain degree would still fit in the same age category regardless of whether it is viewed/played in a VR environment or not. When assessing the impact of violence on game characters - one of the main parameters for measuring violence in the PEGI criteria - the position of the viewer/player in the game does not play a crucial role.

There was one caveat: frightening content. PEGI imagined that a VR game could be produced with highly frightening content or atmosphere, but without explicit interactive violence (so it would not be captured by the Violence content descriptor in a higher age category). For such games, PEGI might need to create a new criterion. The PEGI administrators were given the task of monitoring upcoming VR game submissions to see

if such type of game would emerge.

Until now, there is no evidence that such a new category is required. PEGI can adequately classify all video games on the market today with its current set of criteria. This is also in line with other major rating boards like ESRB and USK. PEGI continues to keep a close eye on the developments in VR, but will continue to use the content classification criteria as they are.

PEGI is mindful of other aspects of VR that consumers, and parents in particular, may want to be informed about prior to purchasing a game. Potential health risks need to be studied and the use of VR in social applications will require a clear code of conduct. As this is already in place for other games that provide social interaction, PEGI expects this will be standard procedure for VR as well. Such elements cannot be integrated into content classification (a phenomenon like bullying should not have a minimum age recommendation), but game publishers and device manufacturers will continue to inform the public about this. Meanwhile, PEGI continues to encourage parents to play an active role when choosing games with and for their children. From that perspective, VR games are no different from other types of video games.

Photography by Jules Lister

6. VR for under 8s: Think Tank

6.1 Introduction

This section outlines ideas that emerged from a one-day exploratory Think Tank on VR for under 8s.

Dubit was approached by the COST- funded EU network DigiLitEY, which is focused on the digital literacy practices of children in the early years. The DigiLitEY network is just beginning to explore how VR technology might come into young children's lives. Dubit hosted the Think Tank and presented some of the key findings from the study on 8-12 year olds. These findings were then discussed in relation to two panels that considered:

Developing narratives and content in VR for young children

The educational potential of VR in the early years

This section highlights the ideas that emerged from the Think Tank , attended by a wide range of industry representatives and academics with specialised knowledge on under 8s that included:

- Content producers

- Distributors

- Childhood education and development experts

- Theatre producers

- Artists and storytellers

It is hoped that the ideas will be informative for researchers and industry professionals considering the role of Virtual Reality in the lives of the youngest children. Obviously health and safety issues for the early years will also need to be researched in depth before the ideas are put into practice.

6.2 VR, narrative and storytelling

This theme was considered important for exploration in the Think Tank because In every medium, young people learn, engage and connect via stories. What are the issues for narrative in VR?

6.2.1 Key points raised from the perspective of a researcher

Dr Dylan Yamada-Rice, a Senior Research Manager at Dubit, brought up the following points:

- Game designers are frequently removed from the experiences of young children (although of course some might have their own). Thus, it might be difficult for them to consider how the design will work for a child and research should be an essential part of the design process.

- In Dubit's qualitative research study, it was interesting to observe how VR experiences were very social for children. Children played in pairs, with one child in and one out of the virtual experience. Even though they were not simultaneously in the VR experience, they talked about the virtual space and guided each other through the experience and co-created their own stories around the content.

- Children need a comfortable level of vision. Therefore designers should consider placing objects in the virtual space at a 'child friendly' height, so children don't have to stand on 'tip-toe' to reach up for objects. Some VR content already has calibration in the onboarding.Therefore adults need to remember that with these games they need to ensure that the child is setting up the game with their help so that it is calibrated to the correct proportions.

- Adults are quite cautious in VR but children are not! They like to stretch, spin around, look up and down, and they like to do this at speed. This means that having multiple interactive elements simultaneously available within the 360 degree environment might contribute to making some younger children dizzy as they try to experience them all at speed.

- Designers should keep the first on-boarding experience simple. This helps children's eyes get accustomed to the virtual space.

- Children in the qualitative study (phases 2 and 3) wanted a physical object to take into the virtual world with them, so they could make an easy distinction between the physical and the virtual environments. The hand controls of the HTC VIVE relate to a physical object well (i.e the hands in 'Job Simulator').

Step 1: Set-up	Step 2: Acclimatisation	Step 3: Comfort

- Transitional objects / narrative
- Intuitive control systems
- No fail

- Limit play area
- Pace dictated by player
- Encourage exploration

- Mini-games to focus
- Easter eggs for delights
- Easy to describe actions

6.2.2 Key points raised from the perspective of theatre

Wendy Harris, Director of the children's theatre company Tutti Frutti, raised the following points based on her many years of experience of designing immersive physical experiences for children:

- There are many similarities in assigning narratives for children's theatre and VR. Tutti Frutti theatre company tell stories about anything - death, love, depression - in an age-appropriate manner. This can be done by placing the children in the centre of the story.

- There is much to be learned from how narratives have been created for theatre, such as letting the action develop around the child and embedding a range of possible storylines into the experience.

- Young imaginations respond to highly visual and physical storytelling.

6.2.3 Key points raised from the perspective of an artist

Anna Riddler is a designer and artist who has created immersive VR narratives based on research; Anna brought up the following points:

- Engagement can be created by giving people a choice of how to interact with the content for example offering two stories, and thus two different experiences.

- The way an audience receives information is important. Don't give all the details of the narrative - allow the audience to add to the content in their own way to bring about better engagement.

- When creating an interactive story, the on-boarding and instruction process is vital to the experience. Users must know how to use or interact with the experience on their own.

- Sound in VR is just as important as the visuals. At The Children's Media Conference 2017 in Sheffield, there was talk of the importance of sound in VR in terms of helping audiences engage with a VR environment and also heightening the immersive nature of the technology. As sound production and outputs improve inside VR headsets, this was something all studios expressed an interest in further developing.

6.2.4 Key points that emerged from the Think Tank participants

In response to presentations given by the above panellists, Think Tank participants raised the following points:

- Leave space in the narrative for children to fill in the gaps. They should not be positioned as passive users. Look to take children on a journey, but also give them space to explore and interact, similar to what they do in Minecraft. Designers should create opportunities for children to add to and alter VR narratives, if at all possible.

- VR offers an opportunity for children and young people to get physical, and this is important when most ICT use is sedentary.

- Familiar role-play settings (e.g. a cafe or park) allow for easy on-boarding into a VR environment.

- In order to encourage longer term engagement, designers can 'hide' content to surprise and delight

children at unexpected times.

6.3 VR and education

This theme emerged from seeking to understand how VR can be used within formal and informal educational contexts, and how might content be developed to have impact on future educational purposes.

6.3.1 Key points raised by academics

Dr Jackie Marsh, a Professor of Education at the University of Sheffield, identified the following points:

- Research into the area of VR and early years education is very limited, but there is insight regarding older children:

> **"There is some evidence that these new technologies and their applications in education can contribute to increase, among the others, motivation, engagement and critical thinking in students, and positively support knowledge transfer."**(Curcio, Dipace, Norlum, 2016:np)

Therefore, there is scope to undertake research in this area with young children.

- The recent Technology and Play study (University of Sheffield, CBeebies and Dubit) considered Augmented Reality apps and how these foster learning with younger children. This study found that more open-ended apps offered more opportunities for play and creativity. We need to consider this principle in relation to VR experiences, ensuring VR apps are not too narrowly defined in terms of intended uses and outcomes (see www.techandplay.org for more details).
- There are emerging examples of VR use in Key Stage 1 that can be used by other educators beginning to use VR with children. For example, Lee Parkinson is an IT teacher-consultant who has experimented with how VR encourages young children's creative writing, and has written about this at http://mrparkinsonict.blogspot.co.uk.

Dr Becky Parry, Assistant Professor in Education at the University of Nottingham, raised the following points:

- Content development for children must be taken seriously, as we know from research into children's interaction with other types of media that content created in VR will form part of children's future engagement with popular culture and narrative, influencing their play, identity and literacy development.
- VR is, importantly, an imaginative space and thus has the potential to enable children to empathise and imagine the world anew.
- It would be interesting to see VR being developed in close proximity with key innovation in education and pedagogy, rather than only trying to market to schools through an adherence to curriculum.
- There is a need to anticipate teaching about VR, not just using it as a tool for teaching, so as with other media forms like newspapers or films we might want to ensure that we enable students to critically engage with VR, to have wider cultural access to diverse VR content, and to be making VR content themselves.
- As a new narrative form, VR will be important to literacy learning.

6.3.2 Key points raised from the perspective of an artist

Deborah Rodrigues, an artist and digital coder who runs technology and play workshops for children (Gluck Workshops, Berlin), suggested:

- When children are encouraged to express themselves and take risks in creating art, they develop a

sense of innovation, sensitivity and creativity that will be important in their adult lives.

- Creating is also a question of understanding what others have done, working and exchanging with them: art makes children open their minds and open up to other people.

- Children can be involved in the design process of VR. For example with the children from Junior Lab in Berlin we made cardboard VR headsets so they could add their phone and watch 360 videos with it. Templates were downloaded from the Internet and then it was up to the children how they wanted to decorate and finish the masks. Lenses can be bought online and there are VR videos you can watch on YouTube.

Example of VR headset decorated by children

6.3.4 Key points that emerged from the Think Tank participants:

In response to the above panellists, Think Tank participants raised the following points:

- Further discussion is needed as to whether VR has to be focused on educational curriculum objectives to be of value in the classroom, or whether this will be too restrictive to foster creativity and play.

- VR has potential value for children with special educational needs (SEND). There is research that demonstrates this in relation to older children, and identifies the value of augmented reality apps for young children with SEND.

- VR can lead to playful learning, which is valuable for children of all ages.

Photography by Jules Lister

7. Concluding Thoughts

7.1 Review & preview of future research directions

This report has provided an introduction to issues surrounding children's use of VR, including content design, creating engaging content, health, safety and legal issues, as well as exploring narratives and the potential relationship between VR and education.

7.1.1 Emerging markets & young audiences

The rate at which VR is being developed - the excitement it generates in children, and the forecasted uptake of the hardware by households - highlights that it is likely to come into children's lives in a range of fields. Entertainment, gaming, education and training, health & wellbeing all present great opportunities for virtual reality to deliver content, and it seems probable that future VR research will be undertaken in relation to these individual fields.

The key question becomes: can industry, academia, child health and education collaborate to establish best practice self-regulating codes of conduct, in advance of regulation or negative perceptions? We hope this is the first step in that direction. All who contributed to the research, Think Tank and this report agree that further research is needed across the following fields, with the following areas being identified as important for future examination.

7.1.2 Health & safety

For children's visual acuity, we found no effects of short-term play. In our stereoacuity and balance tests, in the majority of cases we found little difference between pre and post VR play, but in a very small number of cases, postural stability and stereoacuity did worsen, but we currently cannot identify the characteristics of those children who might be at risk.

This clearly signposts some future research potential in this area, as well as a study around the longitudinal development issues concerning VR use:

- What sense do children make of VR, how do they negotiate cognitively with virtual reality environments? Can VR affect a child's neural development?

- What are the potential positive/negative impacts of sustained VR use on children's mental and physical health?

- What are the health and safety issues for under 8s?

Content and use issues:

- The value of 'open' versus 'closed' content in VR apps.

- How long should children use VR content in one sitting?

- What is the value of VR in therapy play, and can we evidence that VR is successful in reducing pain for children, e.g in distraction therapy?

7.1.2 Industry and marketing

With more and more children gaining access to VR, there are other opportunities that can be addressed in the next phase:

- What are parent's perceptions and concerns; what would make them feel more at ease with VR technology?

- How can educators effectively use VR to get the most benefit?

- What are the commercial models that are most appealing for purchasers?

In pursuing such questions, it will be important to undertake collaborations between academics and industry partners, and the Think Tank itself provided a good model for how that might work.

Photography by Jules Lister

8. Who's who

Dubit

Dubit is a company specialising in research, strategy and digital development for children's brands.

DigiLitEY

DigiLitEY is a five year (2013-2017) academic network that focuses on existing and emerging communicative technologies. This includes wearable technologies, 3D printers, robots, augmented reality, toys and games and relevant aspects of the Internet of toys (Internet of Things), and to examine social, cultural and digital literacy practices related to these.

Dirk Bosmans

PEGI

Dirk Bosmans is Director of Operations for PEGI s.a., the organisation that runs the pan-European age rating system for video games and apps. He oversees the continuous development of the PEGI system and works with national trade associations, governmental organisations and industry partners across Europe on raising awareness about media literacy in general and age ratings for games in specific.

Andrew Douthwaite

WEARVR

Andrew is the Chief Operating Officer of WEARVR - the largest independent VR App Store and discovery platform. He has tried almost every VR experience available and first tried VR on the Oculus Rift Development Kit 1. As well as managing the day to day operations of WEARVR, Andrew regularly travels to meet with developers and content creators at global events.

Wendy Harris

Tutti Frutti Theatre - Think tank presenter on immersive narratives for children

Wendy Harris has been the Artistic Director of Tutti Frutti theatre company since 2005 and has directed in partnership with York Theatre Royal, touring nationally and internationally and co-producing the Little Feet Festival of Children's Theatre and the First Words writers' development programme. Before working with Tutti Frutti she was Artistic Director of Red Ladder Theatre Company, and previous to this; Merseyside Young People's Theatre Company in Liverpool. Over the years as a freelance director work has included; Everyman Theatre Liverpool, Crucible Theatre Sheffield, Hope Street Ltd, Oxford Stage Company, Unity Theatre Liverpool, European Stage Company, Theatre Royal Stratford East, and Contact Theatre Manchester.

Dr Raymond Holt

University of Leeds - Specialist advisor to the health and safety phase of the VR study

Dr Raymond Holt is a Lecturer in Product Design at the School of Mechanical Engineering in the University of Leeds. He is a Chartered Engineer and member of the Institute of Mechanical Engineering. His research focuses on the design of assistive and rehabilitative technologies, with the goal of developing tools and devices that can assess individuals' motor skills to identify impairments or monitor improvements; and to improve the design of products and environments to allow greater accessibility. His work has a strong emphasis on user-centred design, combining both technical analysis of motor skills with user involvement to ensure that products are suitable for use in the field, not just the laboratory.

Professor Jackie Marsh

University of Sheffield - Director of the COST action DigilitEy and Think Tank presenter on VR and education

Jackie Marsh is a Professor of Education at the University of Sheffield. She has undertaken decades of research into young children's digital literacy practices in homes, communities and early years settings. She has conducted research projects that have explored children's access to new technologies and their emergent digital literacy skills, knowledge and understanding. She has examined the way in which parents/carers and other family members support this engagement.

Dr. Elizabeth Milovidov

Think Tank participant and specialist on legal issues to do with VR

Elizabeth is a lawyer and a law professor in Paris, France and an eSafety Consultant in Europe. Elizabeth is also an independent expert on Digital Parenting and Children's Rights and Internet, for the Council of Europe (CoE), as well as a member of the CoE Expert Working Group on Digital Citizenship Education. She teaches law and technology at ISCOM, Paris, and Intellectual Property and Internet law at INSEEC, Paris.

Her core work involves researching solutions for parenting in the digital age to empower parents as they embark on the Internet, technology and social media adventure with their children.

Professor Mark Mon-Williams University of Leeds

Specialist advisor to the health and safety phase of the VR study

Mark is Professor of Cognitive Psychology at the University of Leeds. He is also Professor of Psychology at the Bradford Institute of Health Research and Professor of Paediatric Vision at The Norwegian Centre for Vision. He is a psychologist and studies the use of visual information and the control of human action. His research explores hand movements (kinematics) in children with and without neurodevelopmental problems. This work has led him to promote the importance of perceptual-motor education within primary schools – the idea that teaching children fundamental perceptual-motor skills will benefit their physical and mental health as well as their ultimate educational outcome.

Dr Faisal Mushtaq University of Leeds

Researcher and specialist advisor to the health and safety phase of the VR study

Faisal Mushtaq is a cognitive neuroscientist and tenure track academic fellow in health engineering at the University of Leeds. His research is focussed on investigating the mechanisms underlying motor and cognitive learning and decision making across the developmental trajectory. Faisal's expertise lie in combining principles from cognitive science (including measurement of neural activity) with state-of-art technologies to assess and improve human performance across a variety of applied contexts..

Dr. Becky Parry

University of Nottingham - Think Tank presenter on VR and education

Becky is an Assistant Professor at the University of Nottingham, in the School of Education, and is a member of the Centre for Research in Arts, Literacy and Creativity. Becky's research focuses on children's engagements with popular culture especially film and television, as well as stories created by children and for children in different media.

Anna Ridler Artist and Designer

Think Tank presenter on VR and narrative

Anna works with large datasets to construct narratives and uses new technologies - augmented reality, virtual reality, machine learning and other experimental technologies such as quantum computing - to do so. Anna has found through her creative practises that technology is most effective when it is accompanied by an offline component.

Deborah Rodrigues

Gluck Workshops

Deborah is an artist and educator working with art and technology. She is the founder of Gluck Workshops where she brings her explorations in these fields, into workshops with children, where she invites them to participate in this process with her. These workshops explore the intersection of learning, interaction and play as a path to strengthen creativity. Before creating Glück Workshops, she worked as an illustrator for kids for more than 10 years. She has participated in projects developing characters and illustrations for Disney Club Penguin and in exhibitions around the world.

Sean Thompson

Dubit

Sean is a Senior Producer at Dubit. He has over 15 years experience working in Game Design, and was one of the first people in the UK to achieve a degree with honours in Games, Virtual Reality and Simulation from the University of Lincoln. He's worked as a developer or producer on projects for the BBC, Darrall Macqueen, Disney, and Cartoon Network, and has created several VR apps for installations and apps.

Dr Dylan Yamada-Rice

Dylan is both a Senior Research Manager at Dubit, as well as a Senior Tutor in Information Experience Design at the Royal College of Art. Her research is at the intersection of experimental design and social sciences, focusing on the design of digital storytelling, games and play on a range of platforms such as apps, augmented and virtual reality, as well as new content for television. She specialises in experimental visual and multimodal research methods.

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