Active Virtual Reality Gaming: A Content Analysis and Case Study

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Master of Science

In

Kinesiology

by

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Certification of Approval

I certify that I have read Active Virtual Reality Gaming: A Content Analysis and Case Study by Mathias S Sorensen, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Science in Kinesiology at San Francisco State University.

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Abstract

This paper is a two-part thesis. The first part is a content analysis on Virtual Reality (VR) gaming for children, with an emphasis on games offering additional health benefits such as exercise, cognitive improvement, and socialization skills. The second part is a pilot case study of a child playing VR to explore how children respond and react to VR games. The content analysis of virtual reality games focused on middle childhood (ages 6-12) due to the widespread usage of video games in this age group. Existing research predominantly explores specific clinical populations, including children with disabilities or health conditions. Topics covered by previous research encompass unintended side effects of VR gaming, such as cybersickness, as well as children's enjoyment and engagement with VR. The content analysis specifically examined games on Oculus's Quest 2 platform, considering those rated "E for Everyone" or "E for Everyone 10+" by the Entertainment Software Rating Board (ESRB). Out of 230 VR experiences identified, the majority were categorized as entertainment-focused games, with fewer classified as educational, health and fitness-oriented, or promoting social interactions and behavioral change. This content analysis reveals gaps VR development, prompting the need for new game development addressing explicit health benefits for children in the VR space. Further research is necessary to assess the efficacy of these games, but their potential to positively impact children's physical activity is supported by related research. The pilot case study examined the potential effects of active virtual reality games (AVRG) on an 11-year-old child, focusing on their physiological responses, including heart rate, movement analysis, and perceived exertion. The study utilized a single-subject design, featuring three 10–15-minute gaming sessions to compare differences across games with varying goals and movement needed. Data collection involved capturing and analyzing both the child's gameplay point of view (POV) and video recordings of the child playing, allowing for the identification of game features that may contribute to enhanced physical exertion and enjoyment. Results showed an overall positive experience with VR games and highlight the potential use of active VR games (e.g., *Fruit Ninja™*) as an opportunity to increase physical activity.
Acknowledgements

Thank you to my committee for your everlasting patience and for sharing your world of knowledge with me. To my family, thank you for your continued support and curiosity about my studies. And lastly, I am eternally grateful to my wife’s commitment to pushing me to achieve results beyond my imagination. I would not be here if it were not for you.
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Introduction

The present thesis document contains two separate research studies presented as Chapter 1 and Chapter 2. The first chapter, Virtual Reality Games for Children: A Content Analysis on Potential Health Games, contains research on all available games for children on the Oculus Quest 2 platform as a way to understand what VR games children may play. This research describes games that are played solely for entertainment purposes and games that can offer secondary benefits, such as socialization, and health. With VR gaming gaining traction within research and academia, a thorough content analysis is necessary to identify how unique game characteristics, such as game type, genre, level of user interaction, playstyle, and comfort ratings as these variables may affect both suitability as well as enjoyment for children’s usage. Following the content analysis is the second chapter, Physiological Responses to Active VR Gaming in Children: A Pilot Case Study. To further understand children’s VR usage, a pilot study was conducted to analyze how children physiologically respond to a variety of VR games. Currently, there is limited research on VR games used as an exercise intervention for sedentary behavior for children. However, this research aims to explore how certain VR games prompt various interactions with the user to promote increased bodily movements in opposition to traditional sedentary gaming behaviors. Identifying how children act, react, and respond to various game characteristics is critical to establishing a repeatable study protocol for a larger population and a broader variety of VR games.
Chapter 1

Virtual Reality Games for Children: A Content Analysis on Potential Health Games

Introduction

Virtual Reality (VR) systems are the new forefront of both gaming and education technology industries (Hirsh-Pasek et al., 2022). Through VR, a user can explore the planet, swim with sharks, enter fantastical worlds, and exercise with a trainer without leaving their living room. The once cumbersome and expensive VR technology that required professionals to operate has been developed into a more affordable and accessible tool that provides an immersive world where you can escape from reality in your home or school (Aubrey et al., 2019). As of a 2019 national survey, there are already more than 10 million VR sets in circulation in the US alone (roughly 1 in 5 households) and the prevalence of VR is constantly growing as the technology develops (Aubrey et al., 2019). A 2022 large-scale survey found that VR usage by children increased during the COVID-19 pandemic from a median of 20 minutes a day to a median of 30 minutes a day (Mado et al., 2022). Of children and youth who play VR, 76% report they use it to play games, 33% use VR to explore environments, and 22% use VR for learning (Aubrey et al., 2019). Perhaps a more telling story of VR’s potential applications for children and adolescents comes from a 2017 study that reported 70% of children in the US aged 8-15 were interested in experiencing VR (Yamada-Rice et al., 2017). Although the prevalence of VR systems is continuing to grow, parents have their reservations. According to a Common Sense Media report, 60% of parents surveyed were concerned about VR’s impact on their children's health, and only 43% of parents believed VR was appropriate for children under 13.
Despite these reservations, 62% of parents also believe that VR has educational potential for children (Aubrey et al., 2019). Mado et al. (2022) surveyed and interviewed caregivers on children’s VR use during the COVID-19 pandemic finding that parents reported VR was an innovative tool that increased children’s learning, including social-emotional learning by “enhancing school materials and sparking conversations about current affairs”. For example, parents said that they had engaging and meaningful conversations with their children after experiencing *Traveling While Black™*, an experience that according to its Meta (formerly Oculus) webpage “immerses the viewer in the long history of restriction of movement for black Americans and the creation of safe spaces in our communities” (Mado et al., 2022).

While VR is not yet as popular as traditional gaming systems (e.g., PlayStation®, Xbox®, Nintendo Switch®), the prevalence of children’s and adolescents’ use will only grow as the systems become more affordable and more age-appropriate games are developed. The goals of the current paper are to provide an overview of the research on VR with children and to conduct a content analysis of currently available VR games for children specifically looking at games for health. We focused our review and content analysis on middle childhood, defined as age 6 to 12 years old, because children in this age range are beginning to adopt technology and spend an increased time using video games (Blumberg et al., 2020; Flynn et al., 2021; Yamada-Rice et al., 2017). Indeed, De Araujo et al. (2018) found a correlation between increased screen time during early childhood and a subsequent decline in leisure-time physical activity. Moreover, their follow-up data revealed that this trend worsened as children got older, leading to a
cumulative effect of reduced physical activity behaviors, including decreased sports participation and leisure time physical activity, for those exposed to higher levels of sedentary screen time.

**Research on VR and Children**

We focused our review of research on manuscripts that had been published since 2016, the year that the first commercially available VR Head Mounted Displays (HMD) became available (i.e., HTC Vive® and Oculus Rift®). Bailey and Bailenson (2017) provided a comprehensive overview and history of VR technology and how it might impact children’s development in various domains. Very little empirical research with children had been conducted at this time. Bailey and Bailenson (2017) identified four areas of research using immersive VR with children. The authors reviewed research on using VR as an assessment tool, specifically measuring attention patterns; for pain distraction (e.g., burns, cancer, and dental), for learning; and to see if VR caused health issues (e.g., visual system, accurate memories). Three years later, Kennedy (2020) conducted a literature review of digital games, including VR. These authors also report very few studies examining outcomes for elementary-age children using VR beyond the topics reviewed by Bailey and Bailenson (2017).

Recent research has begun to examine children’s enjoyment and engagement with VR. One usability study by Yamada-Rice (2017) observed 20 children 8 to 12-years-old playing commercial VR games on three different VR systems, finding that children were excited and engaged in the experience. Rossi et al. (2018) developed a VR roller coaster experience to be played on the Oculus Rift® HMD as a treatment for sensory processing disorders. Occupational therapists used the game as part of their treatment plan with patients 4-15 years old and reported a positive experience that stimulated the five senses (Rossi et al., 2018). Newbut et al. (2020)
found the use of commercial VR games with an HMD in classrooms was effective and safe for
31 children on the autism spectrum. Using a simple VR headset with smartphone videos, Badke
et al. (2022) found that children aged 3 to 17 years old in a Pediatric Intensive Care Unit enjoyed
and were calmed by the experience. While these studies show promise based on engagement and
enjoyment, they did not examine changes in developmental outcomes.

The bulk of the research examining VR’s impact on children continues to be for clinical
populations including children with developmental disabilities or with health challenges, and
typically use researcher- or engineer-designed VR experiences. In a systematic review of 20
studies, Bashiri et al. (2017) found that VR was an effective tool for assessing, managing, and
improving symptoms for children diagnosed with Attention Deficit Hyperactivity Disorder
(ADHD). Mesa-Gresa et al. (2018) conducted a systematic review of 31 studies using VR as an
intervention for children on the autism spectrum finding moderate effectiveness. According to a
recent systematic review of 10 studies, VR helped reduce anxiety during pediatric (children ages
4 to 12 years) treatments (Ghaddaripouri et al., 2021). Halldorsson et al. (2021) found
inconclusive results in their review of three research studies on digital games as an intervention
for children, defined as under 18-years-old, mental health. In terms of physical health, Chen et al.
(2018) conducted a meta-analysis of 19 random-control trials (RCTs) to examine if VR
improved motor function for children with Cerebral Palsy (CP). They found that VR
interventions had larger effects than traditional interventions for improving arm function,
postural control, and ambulation (Chen et al., 2018).

The most comprehensive recent review was conducted by Kaimara et al. (2021) to
examine the effects of VR (both immersive and non-immersive) on children’s development
specifically looking at physical, cognitive, and psychosocial domains. They reviewed 85 research and review articles from 2010 to 2020 examining ethical issues and concerns of parents, educators, doctors, and researchers. Kaimara et al. (2021) concluded that the effects of VR can be both positive and negative depending on the domain and age of the children. These review articles show evidence that VR can be used as a positive intervention for multiple outcomes, however, less is known about the impact of commercially available games that children play in their homes for fun. Overall, the research on VR with children shows that it is an enjoyable and engaging experience and may have positive benefits on some developmental outcomes. However, there is still a need for more research examining VR’s impact on children’s developmental outcomes, especially for typically developing children or while using commercially available games.

**VR’s Potential as Fitness Intervention**

One of the primary purposes of our content analysis was to identify VR games that were age-appropriate for children while also offering potential health benefits through increased physical activity. In a 2016 Report Card on Physical Activity, children and youth in the United States have poorer cardiopulmonary fitness compared to normative standards (Katzmarzyk et al., 2016). Furthermore, an analysis of global fitness trends found that 81% of youth (11-17 years old) did not meet physical activity standards of 60 minutes of moderate-to-vigorous activity each day (Guthold et al., 2020). Physical inactivity and sedentary lifestyles increase serious health risks, as cardiovascular disease, obesity, and type II diabetes are more prevalent in populations not meeting physical activity standards (Katzmarzyk et al., 2019). Technology is sometimes blamed for children’s sedentary lifestyles because people assume it displaces more active
activities, however research paints a more complicated picture where reducing screen-time does not necessarily increase physical activity (see Gottschalk, 2019 for a review).

Children enjoy using technology, therefore it has been used to deliver a range of interventions aimed at improving health (Staiano & Flynn, 2014). Research on traditional active video games (AVGs) has found they offer physical fitness benefits (see reviews by Oliveira et al., 2020; Ramirez-Granizo et al., 2020) for children and can also improve cognition (Flynn & Richert, 2018; Staiano et al., 2012). Thus far, research with children has used traditional AVG platforms, such as Nintendo Wii Fit®, Wii Active®, Dance Dance Revolution™ and Microsoft Kinect® (Gao et al., 2015). There are now AVGs for VR platforms [termed Active Virtual Reality games (AVRGs)] which might have the potential to increase both exercise and cognition for children beyond traditional AVGs based on the immersive nature of the technology.

Immersion refers to the capacity of the VR to produce an environment that is realistic and all encompassing (Cao et al., 2020; Mashal et al., 2020; Slater, 2018). Aubrey et al. (2019) stated that immersive VR produces the greatest sense of presence, defined as the feeling in a virtual environment that you are really in the place, when compared to other media platforms such as books, phones, tablets, and traditional video game consoles. The added level of immersion adds both concern for safety as well as potential for greater improvements in cognition and fitness (Kaimara et al., 2021).

There is evidence that VR can improve cognitive and fitness outcomes for adults. For example, a meta-analysis found that VR improved cognition (Rosa et al., 2016) and several studies have demonstrated it can be used as a fitness intervention (Costa et al., 2019; Dębska et al., 2019; Gomez et al., 2018). Kaimara et al. (2021) reviewed research examining physical
outcomes (i.e., cybersickness, obesity, radiation, sleep disorders, and visual symptoms), however no study examined if playing exercise-based VR games could improve fitness for children. Cadet & Chennai (2021) and Cadet et al. (2022) present promising findings that children ages 10 to 14 years old had a higher sense of presence and emotional arousal during VR when compared to adults. It is possible that these elements may enhance game enjoyability, prolong usage, and curb sensations of fatigue during AVRGs (Stewart et al., 2022). In addition, research has shown that AVG’s can create social engagement between peers when played in a multiplayer mode (Marker & Staiano, 2015), this is also a feature of VR games that warrants future research.

While VR has potential as a fitness intervention for youth, no studies to date have examined exercise-based VR games for children. While future research is needed on this topic, one of the first questions is if there are age-appropriate fitness VR games available on the commercial market for children. We conducted a content analysis on currently available VR games for children to provide researchers and developers with a comprehensive list of VR games, highlighting gaps that may provide directions for new research or development. Part of this analysis specifically explored health and fitness-related VR games.

**VR Technology**

Currently there are only a few VR systems available to purchase for recreational use: Meta Quest® (formerly Oculus), Sony PlayStation VR®, Valve Index VR®, HTC Vive®, and HP Reverb® (Greenwald, 2022), and Apple Vision Pro. Varieties in VR headsets are similar to varieties in traditional gaming consoles as each platform offers unique features, games, or computing specifications. Many VR headsets develop games within their own platform (e.g., Meta’s Oculus Rift & Quest series, Sony’s VR system), but some can also be used as a 3rd party
feature alongside a gaming PC or console (Greenwald, 2022). The current study examined games from Meta’s Quest 2 platform because of its competitive price point ($399 at date of publication), user-friendly interface, and variety of games suitable for children. The Quest 2 is a fully immersive VR device (see Figure 1) that uses an HMD to remove the user’s outside environment by replacing the user’s real world with visual and auditory stimuli that feels real enough for the user to forget they are not in the environment portrayed on the HMD (i.e., sense of ‘presence’) (Cao et al., 2020).

**Figure 1. Meta Quest 2 Headset in Use**

![Figure 1: Images from Meta Quest 2 showing the headset and controller in use. From https://www.meta.com/quest/products/quest-2/?utm_source=www.google.com&utm_medium=oculusredirect](https://www.meta.com/quest/products/quest-2/?utm_source=www.google.com&utm_medium=oculusredirect)
Content Analysis Methods

We reviewed all available VR experiences rated “E for Everyone” (E) and “E for Everyone 10+” (E10+) on the Meta’s Quest webpage (n.d.) (https://www.oculus.com) as these are the games/apps that, in theory, are age-appropriate for children and adolescents. We first reviewed the content in 2022 and then updated our findings in 2023 as new games were added to their library. The Entertainment Software Rating Board (ESRB) (n.d.) provides ratings and information about games (https://www.esrb.org/ratings-guide/). The ESRB defines E as a rating that may contain minimum cartoon, fantasy or mild violence and/or mild language while the E10+ rating “may contain more cartoon, fantasy, or mild violence, mild language and/or minimally suggestive themes”. The research team organized the games/apps in alphabetical order onto a spreadsheet and used Quests’ Game Details webpages (n.d) to obtain information on the Developer, Price, Rating, Genre, Game Mode(s), Player Mode(s), and Comfort Rating.

Procedure

Three categories of VR experiences were identified from the Oculus Quest 2 library: Games, Apps, and Entertainment. Oculus’s internal distinction between the three categories may be a sorting mechanism constructed by Oculus but did not provide any context to the details or characteristics that clearly distinguish a game from one from category or another.

After organizing the VR experiences in alphabetical order, the research team began listing the Genre(s) for each game according to the Game Details page found when opening the hyperlink as listed by Oculus (e.g., Puzzle, Interactive Story, Arcade, Casual, Shooting, etc.). Unfortunately, Oculus does not provide an expert or description about each genre to explain the criteria necessary for labeling the various games within one or more of the genres. Similar to the
categories, our analyses are limited by hypotheses generated when comparing various games within the same genre.

In addition to Categories and Genres, the research team copied other details about the game, including the Player Mode(s) (e.g., Sitting, Standing, and/or Roomscale), Game Mode(s) (e.g., Single User, Multiplayer, and/or Co-op), and Comfort Rating (e.g., Comfortable, Moderate, or Intense). Once all games were entered, the research team used pivot tables to identify the frequency each of the Categories, Genre(s), Player and Game Modes, and Comfort Ratings appeared.

To assess which VR experiences may be classified as improving health and fitness, the researchers initially play tested the games to understand how physically active the games were. Unfortunately, the abundance of games and limited time constraint made it impractical to demo all 230 VR experiences. Fortunately, we were able to sort games that Oculus had identified as health-purposeful and generated the genre, “Health and Fitness” which we would use in our analysis and discuss further in the results. In addition, we were able to utilize metabolic ratings previously collected from the Exercise Physiology lab at San Francisco State University with collaboration from the VR Institute of Health and Exercise (https://vrhealth.institute/). These ratings provided a metabolic equivalents (METs) score comparative to other recreational activities, such as tennis, jogging, or cycling. Refer to Table 4 for an overview of these games.

Reliability

The first round of data entry was purely organizational and did not serve analytical purposes. To ensure information was accurately transcribed from the Oculus website onto the spreadsheet, we tested for reliability once all entries were finalized. Two researchers
independently transcribed the data (e.g., Genre, Plyer Type, Genre, etc.) from the Oculus website onto separate spreadsheets. A third sheet was used to compare any differences or discrepancies between the datasets and recorded as either accurate (0) or inaccurate (1) and then calculated against the total entries to measure reliability. The two raters were found to be reliable, see Table 1 for an overview of the reliability by each data type.

Table 1. Reliability Testing

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Accuracy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genre</td>
<td>87.4%</td>
</tr>
<tr>
<td>Comfort Rating</td>
<td>99.6%</td>
</tr>
<tr>
<td>Game Modes</td>
<td>100.0%</td>
</tr>
<tr>
<td>Player Modes</td>
<td>99.1%</td>
</tr>
<tr>
<td>ESRB Rating</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

*Table 1 shows the breakdown of reliability scores (represented as an accuracy percentage) between researchers during data entry.*

In the first review in 2022, *Categories* were not included in Oculus’s Game Details and were updated in 2023 and were then included in our revision in 2023, and as such reliability testing was omitted for *Categories*. Additionally, many of the games received new genre designations by either adding, removing, or changing one or more of the previously listed genres at this time. As such, the accuracy percentage for this dataset was reflected with an error rating of 12.6% discrepancy between researcher one and two. All other datasets remained unchanged and accuracy percentages reflect the overall reliability of researcher transcription.
Results: Content Analysis Findings

Overview

A total of 230 VR experiences were found that were rated E (154) or E 10+ (76) (see Table 2 for an overview and Supplemental Material for the dataset). Oculus lists their VR experiences into three distinct categories: Games (165), Entertainment (30), and Apps (35). While Oculus does not denote reasons why some experiences were categorized as either a Game, App, or Entertainment, we interpreted that an element of interaction between the user and the game defined which category they belonged to. For example, experiences in the Apps and Entertainment category have little interaction between the player and the virtual experience. This Receptive Interactivity requires encoding and processing of information, but little to no interaction from the player (Flynn et al., 2019).

For example, in Ocean Rift™ (an ‘Entertainment’ game), the player floats through a virtual ocean while observing different sea creatures where facts and information boxes appear as they approach their vicinity. However, there are little to no interactions between the animals and the user experience as they are pre-determined regardless of the user’s input. Similarly, in Guided Meditation™ (1 of the 12 experiences in the Health & Fitness genre, categorized as an App) the user can select different virtual environments to practice meditation but is limited by the possibilities of user interaction within the game itself. These two experiences are unlike Games where the user may need to control various tasks, elements, or inputs to the game to make progress through a level.

Other VR experiences that were categorized as ‘Apps’ include titles like Guided Meditation VR™, Guided Tai Chi™, and Liminal™ as these selections were structured around
health and wellness as opposed to gaming purely for entertainment. Similarly, language learning or creativity games (e.g., *Let's Create Pottery* VR™ and *Mondly: Practice Language in VR*™) as well as traveling and virtual share-space hosting (e.g., *Metaverse*™, *OtherSight*™, *BRINK: Traveler*™, and *Villa: Metaverse Creation & NFT Collaboration Platform*™) were also found in the *Apps* category as these were generally tools and resources designed for VR usage but not intended as gaming for entertainment.
Table 2: VR Experiences Overview

<table>
<thead>
<tr>
<th>Overview</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Experiences</td>
<td>230</td>
</tr>
<tr>
<td>MSRB Ratings</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>154</td>
</tr>
<tr>
<td>E 10+</td>
<td>76</td>
</tr>
<tr>
<td>Game Modes</td>
<td></td>
</tr>
<tr>
<td>Single Player</td>
<td>229</td>
</tr>
<tr>
<td>Multiplayer</td>
<td>73</td>
</tr>
<tr>
<td>Co-op</td>
<td>31</td>
</tr>
<tr>
<td>Multiplayer or Co-op Only</td>
<td>11</td>
</tr>
<tr>
<td>Player Modes</td>
<td></td>
</tr>
<tr>
<td>Sitting Only</td>
<td>22</td>
</tr>
<tr>
<td>Standing Only</td>
<td>4</td>
</tr>
<tr>
<td>Roomscale Only</td>
<td>7</td>
</tr>
<tr>
<td>Roomscale or Sitting</td>
<td>4</td>
</tr>
<tr>
<td>Roomscale or Standing</td>
<td>32</td>
</tr>
<tr>
<td>Sitting or Standing</td>
<td>53</td>
</tr>
<tr>
<td>Roomscale, Sitting, or Standing</td>
<td>107</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td>Comfort Ratings</td>
<td></td>
</tr>
<tr>
<td>Comfortable</td>
<td>183</td>
</tr>
<tr>
<td>Moderate</td>
<td>39</td>
</tr>
<tr>
<td>Intense</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2 provides a visual overview of all 230 games and their MSRB/ESRB ratings, Game Modes, Player Modes, and Comfort Ratings.

In contrast, the VR experiences categorized as ‘Games’ have some element of interactivity between the user and the game. Games typically have either manipulative (i.e., using game controls to manipulate avatars or objects) or embodied (i.e., using hands, arms, or the
entire body to control the experience) interactivity (Flynn et al., 2019). In some games, these interactions can be contingent as the experiences vary based on a player’s choices. For example, in *Angry Birds VR: Isle of Pigs™*, players can select from a variety of birds to launch into the barricade of pigs, with each bird providing a unique feature or effect needed to advance the level. In other games (e.g., *The Curious Tale of the Stolen Pets™*) players may have different experiences based on their exploration of objects or environments, but all players will finish the game by advancing through the same levels or progression to finish the game (non-contingent).

Unfortunately, the lack of descriptions from Oculus defining why a VR experience is categorized as either a Game, Entertainment, or an App limits the ability to analyze which elements of the VR selections constitute them to serve as a form of entertainment or simply an application to be used in VR. Thus, our conclusions are made from interpreting which games in VR are most suitable for gaming and entertainment purposes versus games that are designed as a VR resource for education or simply an animated, virtual experience.

**VR Genres**

A total of 32 unique genres were identified across all 230 VR experiences according to Oculus. Refer to Table 3 for an overview for all the genres and how many games were listed within each genre. Many VR games were placed in more than one genre (e.g., *Moss™* was listed with the following genres: Adventure, Puzzle, and Action; *Fruit Ninja™* was listed with the following genres: Casual and Arcade) resulting in a total genre count (493) greater than the total number of VR experiences available (230). A brief analytical synopsis of each genre is included further below.
Table 3. VR Genres for Oculus Quest 2

<table>
<thead>
<tr>
<th>Frequency of Genres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action</td>
</tr>
<tr>
<td>Adventure</td>
</tr>
<tr>
<td>Animation</td>
</tr>
<tr>
<td>Arcade</td>
</tr>
<tr>
<td>Business</td>
</tr>
<tr>
<td>Casual</td>
</tr>
<tr>
<td>Creativity &amp; Design</td>
</tr>
<tr>
<td>Documentary</td>
</tr>
</tbody>
</table>

Table 3 provides an overview of the different genres that were identified across the 230 games as well as how many games were included in each genre.

Some genres were exclusive to a particular category. For example, the Health & Fitness (n = 12) genre and Creativity & Design (n = 16) were exclusive to VR experiences categorized as ‘Apps’, while the Documentary (n = 4) and Animation (n = 9) genres were exclusive to VR experiences categorized as ‘Entertainment’. It is unclear why this distinction was made by Oculus, as some of the Apps and Entertainment selections still maintained an element of user interactivity and could otherwise be considered a game. For example, *Color Space™* (categorized as an App) could be described as a virtual coloring game where the user is immersed in a blank, black-and-white coloring book and is tasked to paint various objects however they like, drawing from artistic creativity. This produces the possibility of endless unique and original end results as different users can select their favorite coloring palettes and apply them however they please. The following paragraphs (sorted alphabetically) provides a
brief description of each of the 32 genres that were identified and includes examples of the
games that are available for children to play.

**Action (45)**

There was a total of 45 Action VR Games at the time of the analysis. This was tied with
the Arcade genre as the most frequently occurring genre. One of the most common themes
observed within Action games was a sense of time-sensitive tasks to be completed to advance the
character, story, or level. This fast-paced nature challenges both the user's hand-eye coordination
(i.e., aiming in shooting games) and their reflexes (e.g., evading obstacles, timing cues,
manipulating their avatar, etc.) throughout the game (Abhishek, 2022; Latham et al., 2013). For
example, in *Warplanes: Battles over Pacific™*, the user controls an ancient warplane and
navigates their squadron through war as they fly through a battlefield while dodging incoming
fire, evading other fighter jets, and shooting down opponent warplanes.

The following games were listed as Action games according to *Oculus: Apex

*Construct™*, *Blaston™*, *BlazeRush: Star Track™*, *Captain ToonHead vs The Punks from Outer
Space™*, *Carly and the Reaperman™*, *Coaster Combat™*, *Doctor Who The Edge of Time™*,
*Falcon Age™*, *Fruit Ninja 2™*, *Ghost Signal: A Stellars Game™*, *Gorilla Tag™*, *Iron
Gaurd™*, *Ironlights™*, *Journey of the Gods™*, *Jupiter & Mars™*, *Jurassic World™*,
*Kartoff™*, *Lucky’s Tail™*, *Mixture™*, *Moss™*, *Moss Book II™*, *MOTHERGUNSHIP™*,
*FORGE™*, *Nock: Bow + Arrow Soccer™*, *Papaye Bang Bang VR™*, *Racket Furry: Table
Tennis VR™*, *RuinsMagus™*, *Sam and Max: This Time It’s Virtual™*, *Shooty Skies
Overdrive™*, *Space Channel 5 VR: Kinda Funky News Flash™*, *Star Shaman™*, *Tentacular™*,
*The Climb™*, *Ultimechs™*, *Ultrawings™*, *Ven VR Adventure™*, *VR Karts Sprint™*, *Wands™*,
Wands Alliances™; Warplanes: Battles over Pacific™; Windlands 2™; Wings 1941™; World of Mechs™; World War Toons: Tank Arena VR™; YUKI™; Yupitergrad™.

Adventure (38)

The Adventure genre made up a total of 38 games. This genre typically provides the user with either a character or an avatar to follow a story or narrative-driven adventure (Abhishek, 2022) where they must accomplish tasks, puzzles, mini-games, quests, or other strategic in-game activities. For example, The Curious Tale of the Stolen Pets™ follows a story narrated by a grandpa and has the user solve puzzles to find missing pets necessary to advance through different levels and continue the adventure.

The following games were listed as Adventure games according to Oculus: A Knight in the Attic™; A Rouge Escape™; Apex Construct™; Captain ToonHead vs The Punks from Outer Space™; Colossal Cave™; Cosmonious High™; Demeo™; Doctor Who The Edge of Time™; Down the Rabbit Hole™; Eolia™; Falcon Age™; Floor Plan 2™; Fuji™; Garden of the Sea™; Ghost Giant™; Ghost Signal: A Stellars Game™; Ionia™; Jupiter & Mars™; Kartoff!™; Lucky’s Tail™; Mare™; Maskmaker™; Mixture™; Morels: Homestead™; Moss™; Moss Book II™; MYST™; Sam and Max: This Time It’s Virtual!™; Silhouette™; Table of Tales: The Crooked Crown™; Tentacular™; The Curious Tale of Stolen Pets™; The Last Clockwinder™; The Room VR: A Dark Matter™; UNBINARY™; Ven VR Adventure™; Windlands™; Windlands 2™.

Animation (9)

The VR experiences listed with their genre as Animation were all also categorized as ‘Entertainment’ by Oculus. A possible theory for this distinction is that these VR experiences were originally intended as experiencing film, videos, movies, or other animated sequences in
VR as opposed to interacting with in-game events. Over time, however, the distinction between a strict VR film and an interactive VR game may have blurred, thus highlighting the fact that these VR experiences may require some, but substantially less interaction, than the VR games categorized as ‘Games’ according to Oculus. For example, *The Line™* is a short love story chronicling the romance of two wooden dolls while the user can observe the story from various perspectives.

Animation VR experiences may provide opportunities to interact with the film or video such as selecting cues to continue the story after exploring the scene(s) and/or object(s) within the VR space. The following ‘Entertainment’ games were listed as Animation by Oculus: *Bonfire™; Gloomy Eyes™; Henry™; INVASION! Anniversary Edition™; Myth: A Frozen Tale™; Paper Birds: Part I & II™; The Key™; The Line™; Wolves in the Walls™.*

**Arcade (45)**

Tied with Action for the most prevalent genre, Arcade had a total of 45 games as well. Similar to Action games, Arcade games are fast-paced and also require an element of quick reflexes and reaction time. Additionally, Arcade games are often played as independent levels, modes, rounds, or games and provide the user with a score at the end. For example, *Fruit Ninja™* is an Arcade game where the user can play a variety of game modes (e.g., Classic, Zen, or Arcade) and receive a score for how much fruit they successfully sliced, combos they achieved, and bombs they avoided. Despite both Action and Arcade games being fast-paced and filled with in-game activity, Arcade games are usually more static (e.g., same visual/virtual background) while Action games are more dynamic (e.g., the environment or visual/virtual
background moves) as the game evolves as you play, such as driving on a highway, skiing down a mountain, or flying through the sky.

The following games were listed as Arcade games according to Oculus: 2MD: VR
Football Unleashed ALL-STAR™; Acron: Attack of the Squirrels™; Anshar 2: Hyperdrive™; Audio Trip™; BlazeRush: Star Track™; Carve Snowboarding™; Coaster Combat™; Disc Ninja™; Fail Factory™; Fruit Ninja™; Fruit Ninja 2™; Gods of Gravity™; Half + Half™; Loco Dojo Unleashed™; Lucky’s Tail™; Mini Motor Racing X; MOTHERGUNSHIP™; FORGE™; MYST™; Pinball FX2 VR; Puzzle Bobble VR; Vacation Odyssey™; Racket: Nx™; Radial-G: Proteus™; Rainbow Reactor: Fusion™; Rec Room™; Shooty Fruity™; Shooty Skies Overdrive™; Skyworld: Kingdom Brawl™; Spaceteam VR™; Sports Scramble™; Star Shaman™; Star Wars Pinball VR™; Swarm™; Tennis League VR™; Tetris Effect: Connected™; The Climb 2™; Thumper™; Traffic Jams™; Ven VR Adventure™; Void Racer: Extreme™; VR Karts Sprint™; VR Ping Pong Pro™; Warplanes: WW1 Fighters™; Wings 1941™; World of Mechs™; YUKI™.

Business (1)
The only VR experience (categorized as App) listed in Oculus’s library was Villa: Metaverse Creation & NFT Collaboration Platform™. While unclear, it can be assumed that this genre is unique to a handful of VR experiences that may indicate some form of business or ownership transactions, such as a Non-Fungible Token (NFT) collection. In this experience, the user can experience various collections of NFTs hosted in a curated library-like museum within the Metaverse™.
Casual (41)

Oculus’s Casual games tend to be intuitive and typically do not require complex tasks or demanding reflexes (Boyes, 2008). These games are fun, enjoyable, remove competitiveness, and do not require extensive time investments necessary to succeed (Winter, 2011). For example, in *Angry Birds VR: Isle of Pigs™* players use a virtual slingshot to fling birds at various structures with the goal of knocking them down. After one or two attempts, the concept of the game reveals itself and the user can casually make progress without needing a specific skill set to practice. As the name implies, games in the Casual genre are perfect for casual gamers who are looking for a simple yet entertaining experience.

The following games were listed as Casual games according to Oculus: *Angry Birds VR: Isle of Pigs™; Arcade Legend™; Bait™; Ballista™; Beat Saber™; Car Mechanic Simulator™; Chess Club™; Clash of Chefs VR™; CookOut™; Deisim™; Epic Rollercoaster™; Fruit Ninja™; Fruit Ninja 2™; Garden of the Sea™; Gorilla Tag™; Hatsume Miku VR™; HouseFlipper VR™; iB Cricket™; Iona™; Job Simulator™; Kizuna TI - Touch the Beat!™; Limelight™; Loco Dojo Unleashed™; Luna™; Neverboard™; Oculus First Contact™; Pathcraft™; Puzzle Bobble VR: Vacation Odyssey™; Racoon Lagoon™; Rainbow Reactor: Fusion™; Shave and Stuff™; Silhouette™; Spacefolk City™; Tennis League VR™; Tentacular™; The Curious Tale of the Stolen Pets™; Townscaper VR™; Traffic Jams™; Tsuro - The Game of the Path™; WHAT THE BAT?™; ZOOKEEPER: Blast Queen™."

Creativity & Design (15)

Even though many of these are similar to a VR game, Oculus categorized all experiences with the Genre Creativity & Design as ‘Apps’. Despite being categorized as ‘Apps’, many of them have a primary outcome of promoting artistic expression through game-like features. For
example, *Color Space™*, *MultiBrush™*, and *Painting VR™* feature large virtual canvases for the user to paint while *Let’s Create! Pottery VR™* lets the user throw clay on a virtual pottery wheel. The virtual environment in these experiences may influence the user’s sense of presence and immersion as they watch their creations come to life in VR. The following titles were listed as Creativity & Design games (Apps) according to Oculus: *Ariko™*, *Color Space™*, *Electronauts™*, *Gravity Sketch™*, *Kingspray Graffiti™*, *Let’s Create: Pottery VR™*, *MultiBrush™*, *Painting VR™*, *SculptVR™*, *Spatial™*, *Tilt Brush™*, *TribeXR DJ School™*, *Vermillion™*, *Villa: Metaverse Creation & NFT Collaboration Platform™*, *Virtuoso™*.

**Documentary (4)**

There were only four VR experiences in the Documentary Genre, and all four of them were categorized as ‘Entertainment’ by Oculus: *Notes on Blindness™*, *Space Explorers™*, *Spheres™*, and *We Live Here™*. Similar to regular film-based documentaries, this VR version presents non-fictional narratives that aim to inform, educate, and explore real-world subjects, events, or people, often employing a factual and objective approach to present a compelling and informative story using the immersive technology of virtual reality. For example, *We Live Here™* is an interactive VR experience that allows players to explore and connect with the personal belongings of Rockey, a homeless individual, unraveling her memories and experiences through animated poems, photographs, music boxes, and nostalgic objects, painting a poignant picture of her past and desires.

**Education (8)**

VR experiences in the Genre Education were categorized as either Games or Entertainment according to Oculus. Since Oculus’s categorization process did not provide a clear framework for distinguishing between them, our hypothesis suggests that all these selections,
regardless of their classification, incorporate elements of gamified learning. Additionally, many of these VR experiences promote a unique learning opportunity made possible by the immersive experience VR presents. For example, non-fiction experiences like *Adam Savage’s Tested VR™* and *Anne Frank House VR™* (categorized as Entertainment) provide the user with first-person and hands-on experiences in the virtual environment where they can interact with features, such as helping Adam with his experiments or interacting with ancient artifacts from Anne Frank’s home.

Furthermore, experiences like *Mission:ISS™* and *Star Chart™* share a theme of space exploration, presenting an opportunity to learn about the universe through the immersive technology made possible by VR. These experiences transport the user into outer space with complete fidelity and complete removal from their physical location. This heightened sense of presence in the virtual world may enhance the learning experience more so than reading a textbook or watching a regular movie. The following VR titles were listed as Education by Oculus: *Adam Savage’s Tested VR™; Anne Frank House VR™; Cubism™; Homestar VR: Special Edition™; Mission: ISS™; Notes on Blindness™; Star Chart™; Titans of Space PLUS™*. Of these eight, *Cubism™* was the only one categorized as Games.

**Events (1)**

The only VR experience in the genre of Events was *VARK™* and was also categorized as an App by Oculus. This VR experience is simply an immersive concert or festival-like experience where users can attend events in VR and see other friends and family within the virtual world. The interactions within this VR experience are dependent on which events are currently occurring and thus can differ from one to another. For example, there may be a
classical music festival with \textit{VARK}™ one week, and the next week it is an art exhibition. These differences in events makes it difficult to analyze themes and characteristics.

\textbf{Family (9)}

Like the Animation genre, Family VR experiences on Oculus were consistently classified as Entertainment. However, despite this categorization, many of these experiences can still be regarded as a game due to the substantial user interaction they offer. For instance, \textit{Bogo}™ is a VR experience where users adopt a fantasy pet, engage in activities such as brushing its pelt and providing it food, and cultivate a compassionate and affectionate bond. The Family genre shares similarities with movies that are good for families, implying that they are friendly, wholesome, and offer elements of love, romance, and/or compassion for something or someone else. These experiences have an underlying message implying the importance of family. The following VR titles were listed as Family by Oculus: \textit{Bogo}™; \textit{Bonfire}™; \textit{Gloomy Eyes}™; \textit{Henry}™; \textit{INVASION! Anniversary Edition}™; \textit{Myth: A Frozen Tale}™; \textit{Paper Birds: Part I & II}™; \textit{The Line}™; \textit{Wolves in the Walls}™.

\textbf{Fighting (2)}

There was a total of two VR Games in the Fighting genre listed by Oculus: \textit{Ironlights}™ and \textit{The Thrill of the Fight}™. Both games contain an element of combat, whether its fantasy (e.g., \textit{Ironlights}™) or realistic (e.g., \textit{The Thrill of the Fight}™). We hypothesized there would not be many VR Games in the Fighting genre due to the violent nature of most fighting games, and this analysis is exploring games suitable for children (i.e., rated E for Everyone or E for Everyone 10+ by the ESRB).
Flying (8)

A total of eight VR Games were in the Flying genre. Flight becomes possible in VR as the user can observe a first-person perspective of flying through the sky while being removed from their current environment (Abhishek, 2022). Flying games involved some sort of flying, soaring, or racing, either in cars, airplanes, spaceships, or even on broomsticks. For example, *Anshar 2: Hyperdrive™* is a flying game where the user controls fighter jets navigating through outer space to destroy enemy combatants and rogue asteroids while using evasive maneuvers to avoid crashing. The following games were listed as Flying by Oculus: *Anshar 2: Hyperdrive™; Interkosmos 2000™; Little Witch Academia: VR Broom Racing™; RUSH™; Shuttle Commander™; Ultrawings™; Warplanes: Battles over Pacific™; Warplanes: WW1 Fighters™*.

Health & Fitness (12)

Our primary focus was to identify which VR experiences could provide health and fitness benefits beyond just entertainment. Out of a total 230 VR experiences, just 12 were listed in the Health & Fitness genre. Interestingly, all 12 of these VR experiences were categorized by Oculus as Apps despite many of them using some form of gamification or interactivity elements to keep the user engaged (e.g., *FitXR - Box. HIIT. Dance. Sculpt. Combat™; REAKT Performance Trainer™*). These gamification elements include rewards, bonuses, accolades, and/or prizes that are accumulated when the user succeeds at various goals. Other titles (e.g., *Liminal™; TRIPP™*) utilize the possibilities of fully immersive VR to enhance the health and fitness experience.

During our content analysis, we observed that many Health and Fitness VR experiences lack typical game features such as story-driven narratives, personalized avatars, arcade-like stimuli, or challenging puzzles to sustain user engagement beyond the primary health
improvement goal. Unlike experiences in other genres that offer quests, character progression, and action-packed elements, most experiences defined by Oculus as Health and Fitness simply provide a single one-time workout experience in VR. While the immersive nature of VR enhances engagement compared to traditional workout settings, these experiences prioritize health benefits over entertainment. In the discussion, we highlight other games, not confined to the Health and Fitness genre, that have been found to induce moderate-to-vigorous physical activity as a secondary outcome of gameplay (Gomez et al., 2018).

The following VR titles were listed as Health & Fitness by Oculus: *FitXR* - *Box. HIIT. Dance. Sculpt. Combat™; Guided Meditation VR™; Guided Tai Chi™; Hoame™; Holofit by Holodia™; Les Mills Bodycombat™; Liminal™; Maloka™; REAKT: Performance Trainer™; Rezzil Player™; TRIPP™; VZfit™.

**History (3)**

Three total VR experiences were included in the History genre: *Anne Frank House VR™; Apollo 11™; and Spheres™*. All three of these experiences were categorized as Entertainment, likely due to their reduced user interactivity compared to other experiences that were categorized as Games. Nonetheless, these VR experiences provide the user an opportunity to learn or experience historical non-fiction elements in virtual reality, an experience that might heighten their engagement and enjoyment compared to a textbook, video, or classroom setting.

**Interactive Story (10)**

Games within the Interactive Story genre were often adventurous or exploratory in nature, providing the user with an engaging and interactive setting to explore the game behind a story-telling narration. For example, *A Fisherman’s Tale™* is a game set on a remote island where the user plays the role of a lonely fisherman who must solve puzzles and navigate life
living by the sea. From start to finish, the game progresses through storytelling while occasionally requiring some form user interaction, such as solving puzzles or playing minigames. A total of 10 Games were listed by Oculus as an Interactive Story: *A Fisherman’s Tale™; Arcsmith™; Flow Weaver™; Ghost Giant™; Sam and Max: This Time It’s Virtual!™; Shadow Point™; Table of Tales: The Crooked Crown™; Vacation Simulator™; Windlands™; ZOOKEEPER: Blast Queen™.

Music & Rhythm (8)  
A total of eight VR experiences were listed in the Music & Rhythm genre and were centered around music. Games like *Audio Trip™, Beat Saber™, and Hatsume Miku VR™ required the user to synchronize dance moves, choreography, or other tasks (shooting, slashing, dodging, etc.) to the beat of the music. In addition to the eight titles categorized as Games, there were other experiences such as *Electronauts™, TribeXR DJ School™, and Virtuoso™ that incorporated music and rhythmic elements along with creative features enabling users to compose their own music. However, despite these similarities, these games were classified as Apps or Entertainment and were in the Creativity & Design, rather than being included in Music & Rhythm genre. It is not clear why this distinction separates the Games from the Apps or Entertainment nor why they were excluded from the Music & Rhythm genre. Nonetheless, the following Games were listed by Oculus as Music & Rhythm: *Audio Trip™, Beat Arena™; Beat Saber™; Hatsume Miku VR™; Kizuna AI - Touch the Beat!™; Rez Infinite™; Space Channel 5 VR: Kinda Funky News Flash!™; Thumper™.

Nature (7)  
All seven of the VR experiences in the Nature genre were also categorized by Oculus as Entertainment. These seven VR experiences were all centered around being immersed in nature,
either for educational or exploratory purposes. For example, *National Geographic Explore VR™* and *Nature Treks VR™* had a focal point of being in a peaceful and/or scenic location from Earth, such as walking around Machu Picchu or The Great Wall of China. Other experiences, like *Blueplanet VR Explore™* and *Ocean Rift™*, immersed the user deep into the ocean to provide an interactive experience with nature underwater. The following titles were listed as Nature experiences by Oculus: *Blueplanet VR Explore™; Ecosphere™; Jurassic World™; National Geographic Explore VR™; Nature Treks VR™; Ocean Rift™; Wander™.*

**Productivity (4)**

The four experiences listed in the Productivity genre by Oculus (*Arkio™; Mondly: Practice Language in VR™; Painting VR™; Vermillion™*) varied amongst each other. For example, *Arkio™* is a VR application (categorized as Apps by Oculus) used to design interiors, buildings, or virtual spaces used to meet and collaborate with others on projects. *Mondly: Practice Language in VR™* is an educational tool used to practice a new language in an immersive virtual reality platform to simulate real situations, such as a conversation on a bus or train ride, ordering food at a restaurant, or asking for directions in a touristy area. *Painting VR™* and *Vermillion™* are both artistic Apps where the user can create works of art. However, none of these VR titles had any gaming elements commonly seen in some of the other genres.

**Puzzle (42)**

The Puzzle genre featured 42 Games, making it one of the most frequently occurring genres in our analysis. Puzzle games are unique for requiring the user to solve puzzles or develop a specific strategy necessary to advance their character through levels, stages, or chapters of a game. This popular feature can be simultaneously exciting and challenging for the user and provide a deep sense of satisfaction upon successfully completing each puzzle. Of the 42 Puzzle
games, only 3 (Gravity Lab™, Puzzling Places™, and Wonderglade™) were exclusively listed in the Puzzle genre while the other 39 games had a secondary (or even tertiary) genre listed as well. Most of these secondary or tertiary genres included Adventure (18), Action (5), Arcade (5), Casual (12), and/or Interactive Story (5). This shows that puzzles are a popular addition game developers and designers like to use within their games, likely to add a layer of difficulty and prolonged engagement.

The following games were listed in the Puzzle genre by Oculus: A Fisherman’s Tale™; A Knight in the Attic™; A Rogue Escape™; Angry Birds VR: Isle of Pigs™; Arcsmith™; Ballista™; Carly and the Reaperman™; Colossal Cave™; Cubism™; Down the Rabbit Hole™; Eolia™; Fail Factory™; Floor Plan 2™; Flow Weaver™; Gadgeteer™; Gravity Lab™; I Expect You to Die™; Ionia™; Kartoffl™; Keep Talking and Nobody Explodes™; Linelight™; Luna™; Mare™; Maskmaker™; Moss™; Moss Book II™; MYST™; Pathcraft™; Puzzle Bobble VR: Vacation Odyssey™; Puzzling Places™; Rainbow Reactor: Fusion™; Shadow Point™; Silhouette™; Tetris Effect: Connected™; The Curious Tale of the Stolen Pets™; The Last Clockwinder™; The Room VR: A Dark Matter™; Tsuro - The Game of The Path™; UNBINARY™; Wonderglade™; Yupitergrad™; ZOOKEEPER: Blast Queen™.

Racing (10)

The primary task of a racing game is to compete with friends (or the game’s artificial intelligence) to be the first person across the finish line using their avatar’s vehicle (Abhishek, 2022). Racing VR games, one of the smaller genres, usually provide the user with a first-person (or cockpit) perspective of the race. For example, VR Karts: Sprint™ is a cartoon racing game where users speed around circuits and can collect items to boost themselves in front of others.
The following games were listed as Racing according to Oculus: *BlazeRush: Star Track™; Epic Rollercoaster™; Grid Legends™; Little Witch Academia: VR Broom Racing™; MarineVerse Cup™; Mini Motor Racing X™; Radial-G: Proteus™; RUSH™; Void Racer: Extreme™; VR Karts Sprint™.*

**Role Playing Games (RPGs) (6)**

Virtual reality *Role Playing Games (RPGs)* transport players into immersive virtual worlds, allowing them to assume the role of a character and engage in interactive storytelling, quests, and character development within the virtual realm. For example, in *Journey of the Gods™*, the user plays an adventure through a fantasy world as the hero who must solve ancient mysteries while combating enemies. Many of the Games that were included in the RPG genre were also included in either the Adventure (3) or Interactive Story (2) genres as they had similar gaming mechanisms (e.g., story-driven narrative, a hero’s adventure, journey, or quest, and strategic puzzle-solving opportunities). The following Games were listed as RPGs in Oculus’s library: *Demeo™; HouseFlipper VR™; Journey of the Gods™; RuinsMagus™; Table of Tales: The Crooked Crown™; Windlands™.*

**Romance (3)**

There were three VR experiences listed in the Romance genre: *Gloomy Eyes™, Spice & Wolf™*, and *The Line™*. All three of these VR experiences were also categorized as Entertainment, as they were all some type of animated film or interactive fantasy story. They all shared an underlying element of love and romance, whether it was between two fictional dolls (*The Line™*) or an awakened zombie and his lover (*Gloomy Eyes™*).
A total of three VR experiences were listed in the Science Fiction genre: *Bonfire™, INVASION! Anniversary Edition*, and *Jurassic World™*. Each of these experiences was categorized as Entertainment, with the elements of a VR viewing experience taking precedence over a VR gaming experience. Like books, Science Fiction games often dive into the intersection of science, technology, humanity, or fantasy, offering thought-provoking narratives that contemplate the potential impact of advancements on individuals and the broader universe. With VR, these generated worlds can come to life as the user is fully immersed in a new reality and can offer an exciting opportunity to explore new adventures.

Shooting games in VR heighten the sense of presence and immersion because you are typically playing in a first-person perspective (Krompiec & Park, 2019). While Shooting games are often rated T or M by ESRB due to blood, gore, and violence, the 21 games in our analysis were rated E and E 10+ and did not provoke elements of violence. Instead, these games feature fantasy, historical, or make-believe weapons that mimic shooting tasks without blood or excessive violence. For example, *YUKI™* is a cartoon fantasy game where the user shoots lasers through moving targets to conquer enemies. Other games, like *Anshar 2: Hyperdrive™* and *Star Shaman™* require the user to shoot enemies while navigating a spaceship through outer space.

The following Games were included in the Shooting genre by Oculus: *Anshar 2: Hyperdrive™*, *Apex Construct™*, *Blaston™*, *Captain ToonHead vs The Punks from Outer Space™*, *Epic Rollercoaster™*, *Ghost Signal: A Stellars Game™*, *Iron Gaurd™*, *MOTHERGUNSHIP: FORGE™*, *Nock: Bow + Arrow Soccer™*, *Papaye Bang Bang VR™*, *Rez Infinite™*, *Shooty Fruity™*, *Shooty Skies Overdrive™*, *Star Trek: Bridge Crew™*, *Swarm™*,
With VR, it becomes possible to simulate almost any environment or experience. This can range from operating an ancient warship to snowboarding down the Alps to surviving a zombie apocalypse, or even playing on a professional football team. The fully immersive nature of VR can quickly blend what is perceived as real or not, offering an opportunity to simulate a wide variety of games and experiences without any unwanted consequences of an otherwise dangerous environment. Some games (e.g., *Car Mechanic Simulator™, Cooking Simulator™, Disc Ninja™, HouseFlipper VR™, and Job Simulator™*) offer the user an opportunity to experience a simulation of different professions without the necessary background to work in those environments. Other games (e.g., *2MD: VR Football Unleashed ALL-STAR™, GOLF +™, iB Cricket™, MarineVerse Cup™, and Premium Bowling™*) attempt at simulating real sports in a virtual environment. These games allow the user to feel present in the fast-paced action of a football game or fleet racing without the added dangers associated with their real-life counterparts. Additionally, VR games offer the user a first-person perspective of what the sport would be like and may simulate some of the excitement of a real game, despite it being just a virtual version.

The following Games were all listed in the Simulation genre according to Oculus: *2MD: VR Football Unleashed ALL-STAR™, A Rogue Escape™, Arcade Legend™, Car Mechanic Simulator™, Carve Snowboarding™, Cities: VR™, Clash of Chefs VR™, Cooking Simulator VR™, Deisim™, Disc Ninja™, Eleven Table Tennis™, Eternal Starlight™, First Person*
Social (28)

Social experiences usually incorporate other VR players into the game either as a teammate, an opponent, or a co-op member. Additionally, Social games provide an extended opportunity for the user to interact with other players to cultivate teamwork depending on the specific task(s) or game outcome(s) (e.g., *Keep Talking and Nobody Explodes™*). Many Games in the Social genre also appeared in other genres (e.g., Arcade (7); Casual (5); Sports (5)) as the social environment can potentially enhance the game experience. For example, *CookOut™* is a simulation of a restaurant kitchen where multiple players must cooperate and complete their specific tasks (measure ingredients, cut vegetables, etc) in order to successfully prepare a perfect dish.

Of the 28 Social VR experiences listed by Oculus, six of them were categorized as Apps (*ALCOVE™; First Steps for Quest 2™; MultiBrush™; Multiverse™; Spatial™; Villa: Metaverse Creation & NFT Collaboration Platform™*) while the rest were categorized as Games. One hypothesis for the mixed categories is that VR allows users to interact with other users’ avatars in remote, virtual locations. And since Oculus is owned by Meta, it is not unusual...
to observe a handful of titles, such as Multiverse™ or Villa: Metaverse Creation™ to be featured on their list of VR titles where users can casually socialize with each other in a near-realistic virtual environment. As such, these six Apps featured little to no gaming elements unlike the other 22 Games listed in the Social genre: *Acron: Attack of the Squirrels™; Arcade Legend™; Beat Arena™; Carly and the Reaperman™; Catan VR™; CookOut™; Eleven Table Tennis™; Gods of Gravity™; GOLF+™; Golf 5 eClub™; Gorilla Tag™; Half + Half™; Keep Talking and Nobody Dies™; Loco Dojo Unleashed™; Neverboard™; Real VR Fishing™; Rec Room™; Spaceteam VR™; Star Trek: Bridge Crew™; Swarm™; Totally Baseball™; Windlands 2™.

**Space & Universe (7)**

The Space & Universe genre had 7 titles, all categorized as Entertainment by Oculus. These experiences typically featured one of two outcomes: exploring space in VR or learning about the universe in an educational setting. In fact, most of the Space & Universe experiences were also featured in the History, Education, and/or Documentary genres (e.g., *Apollo 11™; Mission: ISS™, and Space Explorers™*). The primary outcome of these experiences is to provide users with an interactive and immersive platform to better learn about the vastness of our solar system as well as the history of human civilization’s first journey into space.

Oddly enough, there were other experiences in Oculus’s library that had elements of both space and universe (e.g., *Captain Toonhead vs The Punks from Outer Space™, Spacefolk City™; Spaceteam VR™, Star Trek: Bridge Crew™*) without being included in the Space & Universe genre. It is likely, however, that Oculus made the distinction that the Space & Universe genre was reserved for educational, animated, or documentary style Entertainment selections, while Games could have elements of space and universe without being specifically designated in
that genre. The following VR titles were included in Oculus’s *Space & Universe* genre: *Apollo 11™; Homestar VR: Special Edition™; Mission:ISS™; Space Explorers™; Spheres™; Star Chart™; Titans of Space PLUS™.*

**Sports (31)**

The Sports genre included experiences that simulate traditional sports in the VR world for users to experience what it may feel like to compete in that sport. Many of these games (e.g., *2MD: VR Football Unleashed ALL-STAR™* and *MVP Football - The Patrick Mahomes Experience™*) place the user in the perspective of the athlete in an attempt to recreate real-world elements, requiring the user to be attentive to their surroundings as they test their reflexes against opponents. Other Sports games (e.g., *First Person Tennis - The Real Tennis Simulator™, Walkabout Mini Golf™, Eleven Table Tennis™, and Carve Snowboarding™*) deliberately aim to simulate the real–world physics of the sport to provide the user with the most realistic experience possible.

Of the 31 Sports experiences available on Oculus, only two were categorized as ‘Apps’: *Rezzil Player™* and *VZfit™*, as these also shared the genre of Health & Fitness. *Rezzil Player™* is a melting pot for a variety of sports-like activities, such as testing reaction time, dribbling, passing, and throwing skills, as well as competing with others to see who can get the highest score. *VZfit™* is an immersive exercise platform where the user performs a series of cardiovascular movements (e.g., jumping rope, aerobics, and stationary cycling) to progress their avatar through scenic geographical locations.

The other 29 titles in the Sports genre were listed as Games by Oculus: *2MD: VR Football Unleashed ALL-STAR™; Bait™; Blaston™; Carve Snowboarding™; Disc Ninja™;*
Strategy (13)
Strategy experiences in VR provide players with a dynamic and immersive experience where they can strategize, plan, and make decisions to control and manage resources, build structures, and lead armies or civilizations, challenging their tactical skills and problem-solving abilities within the virtual environment. Virtual reality technology breathes life into classic board games such as Chess and Catan™ by immersing the user in a dynamic environment, where they can assume a first-person perspective and actively manipulate their pieces, offering a truly engaging and interactive experience. The following Games were listed in the Strategy genre according to Oculus: Catan VR™; Chess Club™; Colossal Cave™; Deisim™; Demeo™; Eternal Starlight™; Gods of Gravity™; Iron Gaurd™; Little Cities™; Per Aspera™; Skyworld: Kingdom Brawl™; Spacefolk City™; Tsuro - The Game of The Path™.

Travel & Exploration (14)
Similar to the Animation, Education, and Documentary genres, the Travel & Exploration experiences were categorized as either Apps (7) or Entertainment (7) by Oculus. The absence of distinct descriptions within each category, differentiating whether the titles belong in the App or Entertainment category, poses a challenge in analyzing their characteristics consistently with other titles, hindering a comprehensive understanding of their sorting. However, we noticed that
many of the Apps in the Travel & Exploration genre also included titles in the Health & Fitness genre, such as *Guided Meditation™, TRIPP™*, and *VZFit™*. Another crossover we noticed was between Travel & Exploration games and Nature games, such as *National Geographic Explore VR™, Nature Treks VR™, Ocean Rift™*, and *Wander™*. The following titles were included in the Travel & Exploration genre: *Blueplanet VR Explore™, BRINK Traveler™, Ecosphere™, Guided Meditation™, Lost Recipes™, Mission: ISS™, Multiverse™, National Geographic Explore VR™, Nature Treks VR™, Ocean Rift™, Othersight™, TRIPP™, VZFit™, Wanderer™*.

**Utilities (2)**

With only two experiences listed in the Utilities genre, this was the second fewest genre we analyzed. Both experiences (*Ariko™* and *Spatial™*) were categorized as ‘Apps’ and were both also listed in the Creativity & Design genre. These two experiences both involve virtual communities where users can collaborate with others to create features of art, design, attend concerts, and even play minigames. However, the focal points of the experiences focused on using VR as a tool to collaborate in virtual spaces as opposed to gaming for entertainment purposes.

**Player Modes: Sitting, Standing, and Roomscale**

Player modes signify whether the experiences can be done while Sitting, Standing, and/or in Roomscale. Stereoscopic displays, field of view, frame and refresh rate, and VR Head Tracking provides the technology necessary for HMDs to create the feeling of presence in Roomscale (Cao et al., 2020). Roomscale VR experiences give users the ability to walk through a real-world space (the physical room) and have these movements translated (scaled) into the
virtual world (Porges, 2016). For example, stepping forwards or backwards will move their in-game character forwards or backwards, mimicking the direction the user is moving. Further, this enables the user to interact with different in-game elements, such as obstacles or objects, that need to be evaded by jumping or leaping in different directions. Ultimately, this allows VR users to experience a fully immersive world without relying on joysticks and controllers to advance their character or avatar as commonly seen in traditional video games.

A total of 150 experiences could be played in Roomscale player mode. Only four of the 230 experiences could exclusively only be played in Roomscale, while a majority (107) could be played either Sitting, Standing, or in Roomscale. See Table 2 for a breakdown of the different Player Modes. If an experience offered the possibility of either Sitting, Standing, or Roomscale, the user often had to designate how they wanted to play the game in the settings or menu tab of the game. Otherwise, suddenly moving could disrupt the virtual environment as the software may not be expecting the user to move.

It is noteworthy that the Roomscale feature is not a requirement for a VR experience to feel immersive. Non-Roomscale (Sitting and/or Standing) VR games may still create a fully immersive 360-degree panoramic view where the user can turn their head and constantly observe the virtual environment, but they lack ability for the user to physically traverse through it. For example, *Coaster Combat™* is a Sitting or Standing VR game where the user rides roller coasters, mine carts, or high-speed rails while trying to hit targets or capture enemies as they zip past giant ravines or underwater seascapes. Despite not offering a Roomscale player mode, the game is still fully immersive and offers a great sense of presence inside the virtual world. There were 70 experiences across multiple genres considered non-Roomscale (i.e., Sitting and/or
Standing only). Only one experience, *Linelight™* was uncategorized in any of the Player Modes. According to Oculus’s Game Details page, *Limelight™* should be played lying supine on the ground or a similarly comfortable position. Refer to Table 2 for an overview.

**Game Modes: Single Player, Multiplayer, or Co-op**

Game Mode explains if the game is for a single player, multiplayer, or cooperative (Co-Op). Multiplayer games can be played with other players as teammates, opponents, or interactive players within the virtual world. Co-op games are a type of multiplayer game where tasks are shared amongst other players in order to solve puzzles, quests, or complete obstacles. Of the 230 total experiences, only 11 games required some format of multiple players (either Multiplayer or Co-op). Additionally, 73 games allowed for Multiplayer as an option, while 31 games allowed for Co-op Game Modes as an option. Most games offered multiple combinations of Game Modes, thus bringing the total possibilities higher than the total number of games. See Table 2 for an overview.

**Comfort Rating**

Some of the risks Kaimara et al. (2021) outlined while using an HMD-VR system included cybersickness and nausea. As a result, Oculus provides a Comfort Rating for each game, ranging from Comfortable (183 games) to Moderate (39 games) to Intense (8 games) depending on the level of motion sickness users may experience throughout their session. In our analysis, we found that experiences that feature mild head tracking, such as gentle story and adventure games were typically rated comfortable. Similarly, experiences with low amounts of video and graphics in your visual field (i.e., visual motion), such as simulation games, artistic games, music & rhythm games, and puzzle games were also usually rated comfortable.
Experiences with a greater amount of visual motion, such as sports, traveling, and action games were more likely to be rated moderate. Lastly, an intense rating was given to experiences that feature extreme amounts of visual motion or head tracking, such as flying, riding, racing, or rollercoaster games. Most experiences rated E were comfortable, while moderate and intense experiences were generally reserved for the rating E10+.

**Level of Physical Activity**

Unfortunately, Oculus does not report any data regarding the level of physical activity the average user experiences while playing their games. Additionally, not all of Oculus’s experiences in the Health & Fitness genre were designed specifically to increase the user’s physical activity, as half (6) of the experiences focused on meditation or meditative-like activities such as Tai Chi. While stress-reducing games like Hoame™ and Guided Meditation VR™ have benefits, we were more interested in exploring which VR experiences had the possibility of improving health by reducing sedentary behaviors and increasing physical activity.

We collaborated with The Virtual Reality Health Institute (VRHI: https://vrhealth.institute/vr-ratings/) and were able to quantify how much metabolic activity different VR games elicited. These metabolic ratings were analyzed using a breath-by-breath metabolic cart to measure exercise intensity (in METs) during VR gameplay. METs are a useful, convenient, and standardized way to describe the absolute intensity of a variety of physical activities (Hargens et al., 2022). SFSU and VRHI found VR games at all intensity levels (Light intensity = 2.0–2.9 METs; Moderate intensity = 3.0–5.9 METs, and Vigorous = 6.0+ METs). As a result, these VR games may be physically demanding enough to meet the ACSM guidelines for
exercise (150 minutes of moderate intensity per week) to oppose health risks linked to sedentary lifestyles (Hargens et al., 2022).

The following 13 Oculus games had been previously rated by the VRHI: *Audio Trip™; Beat Saber™; Electronauts™; Eleven Table Tennis™; FitXR– Box. HIIT. Dance. Sculpt. Combat™; Fruit Ninja™; Job Simulator™; Loco Dojo Unleashed™; Racket Fury: Table Tennis VR™; Racket:Nx™; The Thrill of the Fight™; Tilt Brush™. See Table 4 for more details on these games and the associated physical activity ratings. It is important to note that only 1 of these were categorized in the Health and Fitness genre by Oculus, despite the MET levels associated with the other VR experiences from other genres.
Table 4: Physical Activity Ratings by VRHI

<table>
<thead>
<tr>
<th>Game</th>
<th>Genre(s)</th>
<th>METs</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Thrill of the Fight</td>
<td>Sports; Fighting</td>
<td>9.28</td>
</tr>
<tr>
<td>FitXR – Box. HIIT. Dance. Sculpt. Combat</td>
<td>Health &amp; Fitness</td>
<td>7.94</td>
</tr>
<tr>
<td>Audio Trip</td>
<td>Music &amp; Rhythm; Arcade</td>
<td>6.94</td>
</tr>
<tr>
<td>Beat Saber</td>
<td>Music &amp; Rhythm; Casual</td>
<td>6.24</td>
</tr>
<tr>
<td>Fruit Ninja</td>
<td>Arcade; Casual</td>
<td>4.75</td>
</tr>
<tr>
<td>Racket Fury: Table Tennis VR</td>
<td>Sports; Action; Simulation</td>
<td>4.17</td>
</tr>
<tr>
<td>Racket: Nx</td>
<td>Sports; Arcade</td>
<td>4.03</td>
</tr>
<tr>
<td>Rec Room</td>
<td>Sports; Arcade; Social</td>
<td>3.75</td>
</tr>
<tr>
<td>Eleven Table Tennis</td>
<td>Sports, Simulation; Social</td>
<td>3.71</td>
</tr>
<tr>
<td>Loco Dojo Unleashed</td>
<td>Arcade/Action, Casual, Social</td>
<td>3.53</td>
</tr>
<tr>
<td>Tilt Brush</td>
<td>Creativity &amp; Design</td>
<td>2.97</td>
</tr>
<tr>
<td>Electronauts</td>
<td>Creativity &amp; Design</td>
<td>2.31</td>
</tr>
<tr>
<td>Job Simulator</td>
<td>Casual; Simulation</td>
<td>2.19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Average METs</th>
<th>Standard DEV METs</th>
<th>Median METs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.75</td>
<td>2.19</td>
<td>4.03</td>
</tr>
</tbody>
</table>

Table 4 shows the various games rated E for Everyone and E for Everyone 10+ that have been given a MET (metabolic equivalent) rating from the Virtual Reality Health Institute (VRHI). MET ratings represent values that typical adults (18-35 years old) might achieve during gameplay. More detailed overview is available at https://vrhealth.institute/vr-ratings/.
**Discussion**

Children and adolescents will likely play more VR games as they continue to rise in the consumer marketplace. While VR play could be purely for entertainment, it would be ideal if it also provided opportunities for children and adolescents to have educational or creative experiences, increase their physical activity, or have social experiences (Hirsch-Pasek et al., 2022). The purpose of this content analysis was to understand which VR games are currently commercially available for children to discern if there were games that might have potential developmental benefits for children, particularly in terms of health and fitness. A key finding from our analysis showed that a majority (165 out of 230) of the experiences available for children serve primarily for entertainment/enjoyment purposes, with multiple secondary benefits such as developing creativity, socializing with new and/or existing friends, or even increasing their daily physical activity levels. However, future research is needed as there are no studies showing empirical data of these secondary benefits of commercial games.

**Health Benefits from VR Games**

In our analysis, very few experiences were included in the Health & Fitness genre (12 out of 230), and roughly half of these were centered around relaxation and/or meditation. As we noted earlier, there were 13 VR games categorized in various genres (e.g., Casual, Arcade, Sports) where the player exerts energy in similar ways to traditional exercise, as rated by VRHI. Therefore, simply implementing elements requiring large bodily movements (such as squatting, lunging, dodging, and dynamic arm motions) into gameplay may be stimulating enough to produce health-rewarding physical activity. In addition, there are other games that may promote additional health benefits that were not included in our analysis because they were rated T for
Teen or higher. For example, *Supernatural™ (T for Teen* due to suggestive themes, language and drug references) was rated to have high intensity (11.44 METs). Despite this high potential for physical exertion, the inappropriate content makes this game a poor choice for children. Future research should investigate which games are the most enjoyable so game developers can find ways to incorporate body movement into those games as enjoyment will lead to the most sustainable play (Staiano et al., 2016). Overall, it is important for game developers to consider producing games suitable for children that also promote health and fitness and to consider adopting a data-driven categorization approach like the exercise ratings from VRHI as this would solve some of the inconsistency in how games are categorized and listed in certain genres. It is noteworthy, however, that the ratings available from the VRHI were conducted on young adults (18 – 35 years old), whereas children may not expend the same amount of energy while playing the games. As such, more research is required to evaluate the physical demands of VR specifically on children.

**Social Interactions in VR Games**

This content analysis also revealed very few VR experiences that purposely promoted social interactions, only 28 of the 230. This is disappointing as the social aspect of videogames has been highlighted more recently within online communities, sparking friendships, camaraderie, and opportunities to socialize with others, especially during the COVID-19 Pandemic (Barr & Copeland-Stewart, 2021). VR play can also be social even if it is not the intended purpose of the game. Indeed, Yamada-Rice et al., (2017) found that children used VR in social ways even if the game was a single player game by talking to others in the room outside the VR experience about what they were doing.
The Roomsacle feature of VR games may heighten the social component of gaming because users can see other gamers’ avatars imitating real-life movements, hang out in virtual environments, and/or chat with each other. This may increase the sense of presence for the user despite not being in the other person’s physical vicinity. Social interactions, whether in the form of video games or traditional exercise, are a critical component of the basic psychological needs established in the Self Determination Theory (Deci & Ryan, 1985). These social interactions can establish a sense of relatedness within the gaming community, fostering relationships with other gamers and develop a stronger intrinsic motivation to participate in gaming. Indeed, research by Barr & Copeland-Stewart (2021) found that engaging in online video games helped promote a stronger sense of wellbeing and relatedness in teenage and young-adult gamers (16-24 years old) during COVID-19’s lockdown and shelter-in-place events. While their study examined a slightly older population, the basic psychological needs of autonomy, relatedness, and competence is not exclusive to teenagers and can similarly influence children’s motivation towards gameplay (Deci & Ryan, 1985). Future game development should consider creating games that require extensive social interaction with combined efforts of increasing physical demands during gameplay. This can enable future research to examine the impact of these social interactions and the likelihood for children to remain engaged in these socially and physically stimulating games.

**VR Games as an Education Platform**

This content analysis also revealed that there were very few VR experiences listed in the Education genre (8 of 230) for children. We recognize this subset of experiences were categorized as Apps or Entertainment due to the limited interaction between the user and the experience, and there were a few games unlisted in the Education genre that may also promote a
learning opportunity for children. However, this does not diminish the value of the experience as the immersive effect of VR platforms may heighten enjoyment and engagement with the educational and/or historical content (Mado et al., 2022). Nevertheless, the lack of VR games labeled as Education may be based on the same vague categorization that plagued the relatively low quantity of Health & Fitness games. Mado et al. (2022) explored educational VR games during the pandemic finding parents were concerned about lack of content available. This may be because fully immersive VR devices initially were not recommended for children under the age of 13. However, based on our analysis there are many games in other genres rated E and E10+ as these previous recommendations may have been adjusted.

Research has found that traditional video games can promote learning or cognition even if they are not categorized as educational. A recent review showed that several studies found commercially available games to have positive outcomes on learning and/or cognition (Hirsh-Pasek et al., 2022). Mado et al. (2022) addressed this issue by coding 169 VR games that had educational potential (https://www.stanfordvr.com/edvrapps/). For example, they categorize Angry Birds™ as Physics, National Geographic Explore VR™ as Biology, Geology, and Environmental Science, and Wander™ as Geology and History. This is a great example of how developmental science researchers can provide guidance on categorization of video games in ways that can help developers and producers. Future researchers can also use this database to select games for testing efficacy.

Limitations

This content analysis has several limitations. First, we only reviewed games from one platform (Meta Oculus Quest). Furthermore, we were reliant on Oculus’s genre categorization,
which had some inconsistencies. Additionally, we were not able to play-test most of the games, which would give an in-depth understanding of primary and secondary game outcomes as well as the elements that lead to engagement. Finally, the genre categorizations reported in this analysis may change in the future according to game updates or changes from Oculus. Future research should develop a coding scheme to identify characteristics of games to better categorize genres.

Conclusion

We reviewed 230 VR experiences available for Meta’s Oculus Quest 2 platform that are suitable for children to use. A majority of these games serve primarily entertainment and enjoyment purposes. While there were VR experiences that offered ways to learn about nature, history, or enhance creativity, these were limited. One of the biggest areas for more development is in the Health & Fitness genre as there were only 12 experiences. However, we identified many games from other genres that have previously been rated by the VRHI to produce significant levels of physical activity in adults as well. Perhaps if Oculus (or other VR game developers/ producers) had this type of physiological data observed during gameplay, they could better categorize which games could have health benefits as an addition to the entertainment focus of their games and thus be included in the Health & Fitness genre. While related research shows potential for VR games to provide enough physical activity to reverse detrimental health consequences associated with a sedentary lifestyle for children, there simply are not enough commercially available games for efficacy testing. We hope future game developers will consider increasing Health & Fitness VR games for children and implementing movement tracking into gameplay whenever possible to continue inspiring opportunities to increase daily physical activity while playing video games.
Chapter 2

Active VR Gaming in Children: A Pilot Case Study

Introduction

Engaging in regular physical activity has long been established as a means to reduce the risk of obesity, type II diabetes, and heart disease risk factors in children (Kelley et al., 2021). Despite this well-documented evidence, concerns about sedentary behavior and its adverse impact on children's health persist in the United States and globally. A 2016 report highlighted that children in the United States scored below age-related normative standards for health and fitness on a global scale (Katzmarzyk et al., 2016). Similarly, worldwide trends indicate that approximately 80% of youth aged 11-17 fail to meet the recommended daily target of 60 minutes of moderate-to-vigorous physical activity (Guthold et al., 2020). Moreover, leisure time physical activity among children after school has been declining, with increased screen time being identified as a contributing factor to sedentary behavior (Barnett et al., 2018). However, the relationship between screen time and physical activity is complex, and simply reducing screen time does not guarantee an increase in physical activity levels (Gottschalk, 2019).

One significant contributor to abundant screen time is video game usage. An earlier study conducted by Greenberg et al. (2008) revealed that children aged 9-11 spent an average of 12.7 hours per week gaming, while children aged 12-14 spent 17.2 hours per week on video games. Instead of eliminating video game usage entirely among children, it is crucial to explore alternative strategies for combating sedentary behavior associated with gaming. Active video games (AVGs) have emerged as a promising approach to address the sedentary nature of
traditional video games. Previous research has shown that AVGs can positively impact children's physical fitness, cognition, and self-esteem (Krause & Benavidez, 2014; Ramirez-Granzino et al., 2020; Staiano et al., 2013; Gao et al., 2015). However, limited research exists specifically on children's responses and interactions with virtual reality (VR) and active VR games (AVRGs), particularly in terms of enjoyment, perceived exertion, physiological changes, and the overall gaming experience. Investigating these factors and analyzing the impact of VR games can provide valuable insights into their potential to promote positive health influences among children. Therefore, the present pilot study aims to investigate and shed light on these aspects, laying a foundation for future research in the field.

Study Aims and Research Question

This pilot case study aimed to assess a child’s physiological responses (e.g., heart rate and physical movement), enjoyment, and overall experiences with VR games. A secondary purpose of this study was to shed light on VR games’ potential benefit for promoting positive health influences without sacrificing the entertainment and enjoyment video games can provide. To do so, it is critical to identify games that are both fun, appropriate, and physically demanding. Lastly, a goal of this pilot study was to lay the groundwork for future research with larger sample sizes necessary to better understand how children experience VR games differently.
Method

This single-subject case study was conducted at a university with the participation of the principal investigator (PI) and research assistants for data collection. Informed consent forms were signed by the participant and their respective parents/guardians. The participant was recruited from a convenient sample at a local YMCA after school program. All data collected was securely stored on San Francisco State University's (SFSU) password-protected and two-factor authenticated Box platform. Prior to data collection, the study received approval from an Institutional Review Board (IRB) committee.

Participant

The participant was an 11-year-old 5th grader attending a local YMCA after school program. Through an interview with a researcher, the participant reported moderate experience with traditional video games and occasional experience with virtual reality. In addition to video game usage, the participant reported watching television daily and occasionally playing games on a computer or handheld devices.

Materials

Meta (Oculus) Quest 2

The virtual reality equipment used in this project is the Oculus (formerly Meta) Quest 2 Headset and handheld controllers. The participant also used the Elite Strap accessory for added comfort while donning the headset.

Video Games

Three video games, all rated “E” for Everyone by ESRB was purchased and downloaded from the Oculus Quest 2 game catalog (https://www.oculus.com/experiences/quest/). The participant's initial game was Color Space™ by Lighthaus Inc.
This game offers a virtual coloring book experience, allowing the user to paint captivating images on a blank canvas using self-selected colors with the controllers. The participant's second game was *Fruit Ninja™* by Halfbrick Studios Pty Ltd. (~https://www.oculus.com/experiences/quest/2215140511885250/~). This VR adaptation of the well-known phone app/game enables users to wield large katanas and slice fruit as it dynamically flies across the screen. The participant's third game was *Sports Scramble™* by Armature Studio (~https://www.oculus.com/experiences/quest/705576999566582/~). This arcade-style sports simulation game offers a unique twist on traditional sports, allowing users to play games like baseball or bowling with unconventional elements. For example, players may use a tennis racket instead of a baseball bat or a soccer ball instead of a bowling ball, adding a fun and unexpected element to the gameplay.

**Video Recording**

Two videos were recorded concurrently: one capturing the participant's physical gameplay and another capturing their gaming point of view (POV) through screen-capture technology. The participant's POV was recorded using Oculus' Streamcast recording software onto a researcher’s laptop, allowing for analysis alongside heart rate data and additional video recordings. To analyze the participant’s physical movements in relation to their gaming POV, video recordings were captured using an iPad and a tripod. All video and game recordings from the participant were uploaded and securely stored on SFSU’s Box platform.

**Heart Rate Monitor & Polar App**

Heart rate data was obtained using a Polar H10 chest strap (Polar Electro, Kempele, Finland) and subsequently exported from the *Polar Flow™* exercise app for analysis. The Polar
H10 chest strap has been employed in prior studies focusing on children and VR exercise (Flynn & Colon, 2016; Flynn & Richert, 2018; Flynn, Staiano, Beyl, et al., 2019), ensuring its suitability for this research. Heart Rate data was converted from a CSV file to an Excel file to compare descriptive statistics.

**Measures/Data**

**Prior Media Survey**
Prior to gameplay, the participant filled out a survey on previous media exposure to understand their experience with different types of video games and VR games. This survey was previously used in studies examining media usage for children (Rideout & Robb, 2019). The survey was conducted as an interview with a researcher to ensure understanding. See Appendix C: Prior Media & Intake Form

**Video Trailers of Games**
Following the media survey, the participant reviewed a playlist of 18 game trailers, chosen from a predetermined list of potential games that were identified as suitable (i.e., “E” for Everyone) for children and could be experienced in a brief gaming session. This step aided them in making an informed decision about which game they would ultimately play. After each video the participant answered 4 questions: Did you like how that game looked (Response: Yes, No, Maybe)? Why did you like/dislike it (Response: Open-ended)? Would you want to play that game ever (Response: Yes, No, Maybe)? Would you want to play that game today (Response: Yes, No, Maybe)? See Appendix C: Prior Media & Intake Form for an overview. These trailers were accessible on Oculus’s website

com&utm_medium=oculusredirect) and organized using YouTube’s playlist feature (https://youtube.com/playlist?list=PLAWHmw68i-Es9bAGlvgUzjTEP5bXnH1M).

After the participant had watched all 18 videos of the games they ranked the games that they said they would want to play today in the order that they were most excited about playing. They were told that they would play 3-4 games and should have back-up games in case one of their top choices was too hard or they didn’t like it as much as expected.

**VR Game Feedback (Survey)**

After each gameplay session, the participant completed a survey that gauged their overall experience. The first set of two questions had the participant rank their enjoyment and how easy they felt the game was on a scale of 1 (*it was not fun at all; very difficult*) and 5 (*it was a lot of fun; very easy*). Additionally, the participant responded to 10 questions from the Post Exercise-Exercise Induced Feeling Inventory (EFI) from Gauvin & Rejeski (1993). The EFI consists of 4 distinct subscales (Positive Engagement, Revitalization, Tranquility, and Physical Exhaustion) to obtain an average value reported for each item within their respective subscales on a scale of 1 (*not at all*) to 5 (*very much so*). For example, Positive Engagement included items asking if the participant felt *enthusiastic, happy,* and *upbeat* while Physical Exhaustion included items such as *tired* and *worn out*. Three additional open-ended questions were also included to gather insightful feedback on specific game elements liked or disliked by the participant and suggestions for potential improvements. See Appendix B: Exercise Induced Feeling Inventory and Appendix D: VR Game Feedback Forms (Completed) for an overview.

**Coding and Analyzing Large Bodily Movements**

Coding and analyzing large bodily movements during gameplay were paramount to understanding how certain physiological responses, such as changes in heart rate, can be
associated with the type of game and its relevant gameplay. Refer to Appendix A: Movement Analysis Instructions & Procedure for a comprehensive overview of coding and analyzing these movements during gameplay.

Data Collection

To analyze the energy expenditure of gameplay, as well as identify unique ‘large bodily movements’ associated with each game, we employed a combination of screen capture technology and video recordings. Two videos were recorded simultaneously for each participant: one capturing their gameplay point of view (POV) and the other recording the participant’s movements during gameplay. Both videos were time-stamped for synchronization.

During gameplay sessions, detailed notes were taken to document themes, characteristics, and other elements that could explain variations in energy expenditure between different game types, for example, ‘Active VR Games’ and ‘Non-active VR Games’. Video replay was utilized to facilitate further analysis of the gaming experience, such as identifying reactions, responses, and body language associated with happiness, joy, and/or frustration. Games that involved many quick and rapid successive movements were slowed down to 0.5x speed to enhance the accuracy of movement quantification.

Interpretation of Movement(s)

Interpretation of large body movements during gameplay required the expertise of a panel of kinesiology researchers and faculty. These experts were responsible for identifying and labeling large body movements, such as standing, walking, arm swinging, jabbing/punching, body/torso movements, stepping, throwing (a virtual ball), swinging (a virtual bat), and other relevant game-specific movements. For example, *Fruit Ninja™* uses rapid arm-swinging
movements to symbolize slicing through fruit using a virtual sword. The panel of researchers underwent training to ensure consistent interpretation and labeling of movements across different games.

*Analysis of Bodily Movements*

Due to the absence of expensive motion capture systems, analysis of bodily movements during virtual reality, gameplay relied on video recordings. Gross body movements, characterized by large-scale actions such as jumping, stepping, squatting, and kicking, were the focus of the analysis. The nature and frequency of these movements varied depending on the specific game and the tasks involved. Unlike traditional video game controllers that primarily rely on thumb and finger-based movements, VR game controllers facilitate a wider range of interactions by requiring full bodily movements to interact with the virtual world.

*Reliability and Quantification of Movements*

To achieve a comprehensive understanding of the child’s responses to VR and active VR games, accurate interpretation and quantification of movements were crucial. Reliability was established by having the panel of researchers agree upon the specific movements of interest and develop a standardized system for their identification. This system was designed to ensure consistent results when taught to other individuals involved in the research project.

To assess reliability, each researcher utilized software capable of playback at 0.5x speed and video scrubbing to analyze the recorded participant’s videos. Separate Excel spreadsheets were created for each researcher to enter the frequency of specific movements on a minute-to-minute basis. A second researcher coded 20% of the videos. Comparisons were made among the spreadsheets to identify any discrepancies, and scores were assigned for correct (0) and incorrect
(1) entries. Reliability was then measured and expressed as a percentage, providing an indication of the consistency of movement identification among the researcher(s). There was high reliability between the researchers (*Color Space™*: 100% agreement; *Fruit Ninja™*: 82% agreement; *Sports Scramble*: 97% agreement).

**Game Performance (Game Scoring Sheet)**

Game performance can sometimes be subjective. However, many games offer a score, reward, trophies, accolades, or prizes to symbolize the user’s performance. Same games, such as *Fruit Ninja™* score the user on accuracy of fruit sliced, combo bonuses, and removes points for fruit that was dropped as well as bombs mistakenly sliced. Other games, like *Sports Scramble™* provide unlockable items and upgrades to the user’s equipment, such as a new golden bat or a special prize ball. Scoring the participants game performance was either reported by the game or made in agreement from previously establishing reliability with other researchers.

**Procedures**

Prior to beginning data collection, the participant’s parent/guardian signed consent forms and the participant signed an assent form detailing the study tasks and objectives. Once consent and assent were provided, the participant was fitted with a small, slightly moistened Polar H10 heartrate strap around the sternum. To ensure proper connection and heartrate confidence, the Polar Flow app was used by selecting the ‘workout’ tab to see live heart rate. Once the participant and researchers were ready the app was started.

The PI began taking in information from the child using an interview to collect information about their video game and VR game experience, as well as general background information about their hobbies and whether they participate in sports. Following the interview,
the child was presented with a series of videos displaying VR game trailers and ask to briefly describe their interest level in playing that game during their visit.

Once the top three games were identified, the participant was fitted with the VR headset and ensured their physical play space was identified prior to beginning gameplay. This was a critical step to prioritize safety, as the headset will immediately reveal the physical environment if it detects the user steps outside of this play space. This technology can help prevent people from running into objects during gameplay as a result of a fully immersive experience with the headset.

Prior to beginning the game, video recordings of both the participant’s gaming POV as well as a video camera capturing their gameplay was started. Each game was played for about 10 minutes with intermittent feedback (mostly for support and tips) from the researchers. Upon conclusion of each game, the child answered a brief survey about their experience with the game. This process was repeated for each of the three games. The child could request to stop gameplay and switch to a different game if desired. The current participant was standing for all three games. At the end of all three gaming sessions, the ‘workout’ was ended on the Polar Flow™ app, saved and exported onto Box along with the video recording files.
Results

Over the span of approximately an hour, a total of three games were played by the participant along with corresponding video recording, heart rate data, post-game feedback surveys, and a movement analysis. Table 5 contains an overview of the descriptive data collected for each of the three games, with more detail about the analysis of each game within their respective paragraphs.

Table 5: Gaming Data Overview

<table>
<thead>
<tr>
<th>Game</th>
<th>Time Played (s)</th>
<th>HR Max</th>
<th>HR Min</th>
<th>HR Avg</th>
<th>HR SD</th>
<th>Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color Space™</td>
<td>506</td>
<td>110</td>
<td>82</td>
<td>93.6</td>
<td>5.2</td>
<td>0</td>
</tr>
<tr>
<td>Fruit Ninja™</td>
<td>601</td>
<td>126</td>
<td>83</td>
<td>103.2</td>
<td>8.1</td>
<td>311</td>
</tr>
<tr>
<td>Sports Scramble™</td>
<td>832</td>
<td>114</td>
<td>78</td>
<td>95.3</td>
<td>6.9</td>
<td>97</td>
</tr>
</tbody>
</table>

Table 5 shows the total TimePlayed (in seconds); HR Max (heart rate max, bpm); HR Min (heart rate minimum, bpm); HR Avg (heart rate average, bpm); HR SD (heart rate standard deviation); Movements (frequency of major body movements).

Prior Media Survey

The participant reported that they had exposure to VR gaming before their visit and have played video games on the Oculus and PlayStation® platforms. They reported playing VR games every now and then, including games like Gorilla Tag™, Beat Saber™, Fruit Ninja™, and Walkabout Mini Golf™. While the participant mentioned they had heard of video games that are like exercise, they were unable to think of any active video games. Their interpretation of active video games included statements like, “I think people use active video games for both exercise and fun”. They also answered “Yes” to the questions asking if they believed people in general could get into better shape from playing active video games. Aside from VR games, the participant reported playing other video games A few times a week and that [they] really like playing video games when asked about how much they like gaming. The participant’s favorite
video games included titles such as *FIFA Soccer™, Apex Legends™, Fortnite™, Roblox™*, and *FIFA Mobile™*. Their favorite video game was *FIFA Soccer™*, they reported this was because of their previous experience playing soccer and their reported feeling that the video games “helps seeing different positions better and improves how to think about in-game playmaking decisions”. Refer to Appendix C: Prior Media & Intake Form.

**Trailer of Games**

When presented with the video trailers of games, the participant was relatively enthused about most of the games. When prompted with feedback questions such as, “Did you like how that game looked?”, “Would you want to play that game ever?”, and “If yes, would you want to play that game today?” the participant responded with “Yes” for 13 of the 18 game trailers with the other five receiving a “Maybe.”

After reviewing all of the trailers, a top three favorite games list was generated. *Color Space™, Fruit Ninja™*, and *Sports Scramble™* were selected as favorites. The participant had reported they liked these specific aspects about each game, respectively, “changing shades of color”, “slice fruits and can do it in real life”, and “different sports mixed with other sports”. A full overview of the participant’s responses can be found on page five in Appendix C: Prior Media & Intake Form.

**Game 1: Color Space™**

The first game the participant played was Color Space, and the entire game session lasted 10 minutes and 44 seconds, with 8 minutes and 26 seconds being actual gameplay. After the participant was fitted for with the headset, they immediately began testing the VR set inside the game menu. After a few moments to familiarize, they manage to open a new coloring book and
began painting. Throughout the eight minutes of gameplay, the participant remained upright and standing but performed very little movement aside from minimal gestures with the hand and wrists as they changed between colors. Occasionally the participant glanced from side to side, as if to look at their painting in its entirety, either twisting just the head or turning the torso. However, these movements where not very physically demanding and produced very little change in heart rate.

Heart Rate Data
Throughout gameplay, the participant’s heart rate did not change much. The participant’s maximum heart rate during Color Space was 110 beats per minute with a minimum of 82 beats per minute and an average (± standard deviation) heart rate of 94 (± 5.1) beats per minute. This heart rate response indicates minimal cardiovascular effort was necessary to perform the majority of game tasks. See Figure 2 for a timeline of the participant’s heart rate response during gameplay.
Figure 2: Heart Rate During Gameplay: Color Space

Figure 2 shows heart rate data during gameplay of Color Space. A faint dotted line is drawn at 94 beats per minute to represent the average heart rate observed from start to finish.

Game Play Analysis

After the first two minutes of getting the headset fitted, the participant is seen looking around and manipulating the handheld controller intermittently. The immersive nature of VR necessitated the participant’s head movements in multiple directions – left, right, above, and below – to fully experience the virtual environment. Because of VR’s sense of immersion, the participant needs to look around to the left, right, above, and below them to get the full sense of the coloring book. Within the game, emphasis was placed on a ‘point and shoot’ mechanism, whereby the participant directed the controller towards the desired color and effortlessly applied it to various segments of the virtual book. The activity entailed limited physical exertion, primarily involving controller interactions to select and paint through the engaging coloring book interface.
Movement Analysis

There were no incidents of significant or large body movements occurring during gameplay for Color Space™. The extent of the movements during gameplay culminated in simply lifting the hand up to mid-body height as if examining something on a mobile phone accompanied with occasionally turning the head or twisting the torso slightly for a new vantage point. At no point did the participant engage in any lower-body movements as they do not need to step, jump, walk, or crouch through the environment during gameplay. See Table 5 for an overview of the movement statistics reported from Color Space™.

Game Performance

A score was not provided for this game, but the participant finished most of the third page with blue, green, purple, red, and aqua colors chosen.

Game 2: Fruit Ninja

The participant played Fruit Ninja™ for a total of 10 minutes and 2 seconds. Fruit Ninja™ offers multiple game modes to choose from, which meant that the participant would intermittently engage in 1-2 minutes of gaming followed by 30-60 second pauses as they choose either a new game mode or to repeat the same one. The participant played five games within Fruit Ninja™ for a total of 6 minutes and 42 seconds (excluding the pauses between games).

Heart Rate Data

Overall, the participant had a higher average heart rate and a greater maximum heart rate during Fruit Ninja™ than the other games. Figure 3 shows a graph of the participant’s heart rate during gameplay from start to finish. The participant’s heart rate varied from one game to another which is likely due to the game mode they chose. See Figure 4 for an overview of the heart rate differences between game modes.
**Figure 3: Heart Rate During Gameplay: Fruit Ninja**

*Figure 3 shows heart rate data during gameplay of Fruit Ninja. A faint dotted line is drawn at 103 beats per minute to represent the average heart rate observed from start to finish.*

**Figure 4: Heart Rate Range During Gameplay: Fruit Ninja Game Modes**

*Figure 4 shows the different heart rate ranges observed during different game modes within Fruit Ninja. Squares denote the range between minimum and maximum heart rate while the diamonds represent the average heart rate.*
Gameplay Analysis

*Fruit Ninja™* was much more action packed than both *Color Space™* as well as *Sports Scramble™*. The three different game modes to choose from in *Fruit Ninja™* included Arcade mode, Zen mode, and Classic mode. Arcade mode provides the user with an opportunity to rack up combos and large point tallies as they slice as much fruit as they can in 60 seconds. In-game events, such as special bananas, might pop up as opportunities to earn extra bonus points. Zen mode is a 90-second session featuring nothing but fruit to slice up. This mode is ideal to practice, as there are no bombs, and you can drop an infinite number of fruits without dying. Classic mode, on the other hand, has unlimited time but the game ends if the user strikes 3 bombs or drops 3 fruits.

The participant immediately began the game slicing and dicing fruit using the dual-wielded blades for an action-packed game. It is likely that the participant is right-handed, as a majority of the movements were done with the right hand compared to the left. Throughout the entirety of the game, the only major movements seen were repeated swinging motions with the arms.

For this participant, the different game modes of *Fruit Ninja™* varied on the amount of movement they did and how their heart rate responded. For example, all three attempts at classic mode resulted in significantly less movements than both Arcade and Zen modes. Refer to Figure 5: Movements per Second of Gameplay: Fruit Ninja Game Modes for an overview of the difference in movement frequency across games. While the premise of the game is similar, Classic mode features bombs as well as fruit. Accidentally slicing the bombs instead of the fruit can end the game sooner. As such, the frequency of the participant’s movements observed during
Classic mode was dramatically less than the other modes, which may also explain the participant’s lower average HR in Classic mode compared to Zen and Arcade mode. The participant also expressed frustration (shrugging the shoulders, dropping the hands) as well as excitement (gleeful shimmies and mini dances) corresponding to their performance within the various game modes.

**Figure 5: Movements per Second of Gameplay: Fruit Ninja Game Modes**

![Movements per Second of Gameplay: Fruit Ninja Game Modes](image)

*Figure 5 is a chart showing the variability of movements per seconds observed during different game modes of Fruit Ninja. A solid black line is drawn to represent the average amount of movements per second observed across the entire gameplay session.*

**Movement Analysis**

In this game, the user is equipped with a (virtual) sword in each hand and is required to drag the controllers across the virtual screen, creating a slicing effect. Notably, the observed movements in this game display greater amplitude and frequency compared to the other games played.
Table 6: Movement Frequency During Fruit Ninja

The predominant movement observed was a slashing motion of the arm. To accurately quantify the slashing movements, particular attention was given to sudden and forceful sweeping motions across the body. Each complete swing of the sword was considered as one (1) movement. In cases where a long swing occurs in multiple directions without any pauses or shifts, it was still counted as one (1) movement. However, if the direction of the arm changed rapidly or swung in the opposite direction, they were considered as separate and independent swings. It should be noted that arm movements made in preparation for a swing but not followed through was not counted as a swing. Similarly, slow and minor arm movements at the side or in front of the participant, seemingly to position themselves, was not tallied as swings either.

Moreover, quick, jab-like waving movements were occasionally performed during ‘freeze frame’ opportunities and are considered as bonus slices within the game, and therefore should not be included in swing tallies (these swings were too small to be considered a large bodily movement).

Table 6 shows the breakdown of movement frequency recorded during Fruit Ninja gameplay. The only major bodily movements observed were quantified as slashing of the arms.
Additionally, when the participant alternated arms to swing at fruit, each swing was counted independently, regardless of whether it is executed with the left, right, or both arms. At times, the participant predominantly used one arm to perform a majority of the swings while the other arm trailed without engaging in forceful or deliberate swings. In such cases, unless there was a clear purpose behind the trailing arm movement, they were not considered as a swing. For a comprehensive breakdown of the movement analysis, refer to Appendix A: Movement Analysis Instructions and Procedure.

**Game Performance**

Scores for each round can be found in Figure 6: Game Performance: *Fruit Ninja™*. The scores for Classic mode were significantly lower than Arcade and Zen mode, possibly attributed to the effect of bombs and dropped fruits affecting overall scores. During gameplay, the participant was visibly frustrated when they struck a bomb and/or ended the round early due to running out of lives. Despite scoring lowest in Classic mode, this was also the game mode the participant chose to play most frequently.
Figure 6: Game Performance: Fruit Ninja

Figure 6 shows the variance in game performance (represented as a score) across the different game modes during Fruit Ninja gameplay. A thick black line is drawn to represent the average score across all 5 modes.

Game 3: Sports Scramble

The participant played *Sports Scramble™* as the last game for 13 minutes and 52 seconds. *Sports Scramble™* is an arcade-like sports game where the user can choose to play a variety of sports with a twist. The participant selected to play baseball, and at the beginning of the game they engaged in a brief tutorial to learn the controls of catching and throwing a baseball as well as swinging the bat. Throughout the gameplay, the participant alternated between playing as the pitcher on defense as well as the batter on offense. Movements seen in *Sports Scramble™* were described as either catching (a virtual ball), throwing (a virtual ball), or swinging (a virtual bat/racket).
Heart Rate Data

During *Sports Scramble™* gameplay the participant’s heart rate showed a greater range than *Color Space™* but not higher than *Fruit Ninja™*. The participant’s average heart rate during gameplay was 95 BPM which was 2 BPM more than the average during *Color Space™*, but 12 BPM less than the average during *Fruit Ninja™*. Figure 7 shows an overview of heart rate data during *Sports Scramble™* gameplay.

**Figure 7: Heart Rate During Gameplay: Sports Scramble**

*Figure 7 shows heart rate data during gameplay of Sports Scramble. A faint dotted line is drawn at 95 beats per minute to represent the average heart rate observed from start to finish.*

Gameplay Analysis

Overall, the participant produced more movements during *Sports Scramble™* gameplay compared to *Color Space™* but less movements than during *Fruit Ninja™*. Most movements occurred in the upper body as the participant switched between positions playing either the role of the pitcher or batter. It should be noted that baseball, even in its virtual form, involves non-
continuous movements, with actions separated by each pitch and their in-game outcome. For example, when assuming the role of the pitcher, the participant’s interaction with the game is limited to throwing and watching the ball whenever the AI-controlled opponent makes contact. At times, the participant can be observed tracking the ball with their head and torso, anticipating the outcome (e.g., his teammate catches the ball for an out, or they drop the ball, and the opponent scores a point). As a batter, the participant’s movements are likewise divided by each pitch. Their batting success directly impacts the level of physical activity they experience. For example, achieving more successful hits leads to extended innings and increased opportunities for movement during gameplay.

Table 7: Movement Frequency During Sports Scramble

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>Upper Body Movement</th>
<th>Lower Body Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arms: Slashing</td>
<td>Legs: Squatting</td>
</tr>
<tr>
<td></td>
<td>Arms: Punching</td>
<td>Legs: Jumping</td>
</tr>
<tr>
<td></td>
<td>Arms: Throwing (Ball)</td>
<td>Legs: Kicking</td>
</tr>
<tr>
<td></td>
<td>Arms: Catching Ball</td>
<td>Legs: Stepping</td>
</tr>
<tr>
<td></td>
<td>Arms: Swinging (Bat)</td>
<td>Legs: Lunging</td>
</tr>
<tr>
<td>0:00 - 0:59</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>1:00 - 1:59</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2:00 - 2:59</td>
<td>n/a</td>
<td>3</td>
</tr>
<tr>
<td>3:00 - 3:59</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4:00 - 4:59</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>5:00 - 5:59</td>
<td>2</td>
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<tr>
<td>6:00 - 6:59</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>7:00 - 7:59</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8:00 - 8:59</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>9:00 - 9:59</td>
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<tr>
<td>10:00 - 10:59</td>
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</tr>
<tr>
<td>13:00 - 13:59</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14:00 - 14:59</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 7 shows a breakdown of movement frequencies analyzed each minute during gameplay. The first two minutes were excluded in the analysis as the participant was adjusting the headset to their comfort and was not engaged in gameplay. A description of the various movements analyzed can be found in Appendix A: Movement Analysis Instructions & Procedure.

The game’s limited movement is also affected by the participant’s intention and engagement levels. For example, swinging a real bat requires explosive rotation of the torso,
involving both the legs, hips, and arms to forcefully drive the bat across the body. However, in a VR game, swinging the bat requires significantly less total movement compared to swinging a real bat. For example, an experienced player can achieve successful bat swings with minimal effort instead of the full body contribution needed in a real swing. Occasionally the participant simply ‘flicked their wrist’ to simulate swinging the bat. The participant in this pilot study also exhibited visible emotional engagement with this game, expressing both frustration (e.g., shrugging shoulders, throwing hands up) and excitement (e.g., celebratory dances or shimmying) during gameplay. However, these emotional expressions were not quantified in the analysis as they were not unique to the gameplay but rather reflected the participant’s individual characteristics.

Movement Analysis

The participant primarily engaged in catching and throwing a virtual ball, alongside swinging a virtual bat. Occasionally, they moved within the 2’x2’ playing area, taking a step or two to adjust their positioning in relation to the virtual environment. However, it’s important to note that the gameplay in Sports Scramble’s Baseball mode does not necessitate any lower body movements, such as squatting, jumping, kicking, or consistent stepping. As a result, the overall amount of lower body movement observed was minimal. Over the span of 832 seconds of gameplay, 97 total movements were recorded and tallied. Refer to Table 7 for an overview of the various movements observed and tallied during their gameplay.
**Game Performance**

There were no numerical scores associated for this game mode, therefore the result was not recorded. However, the participant achieved the accomplishment of unlocking a golden bat, one of many accolades the user can collect throughout playing *Sports Scramble™*.

**Comparison of Data Across Games**

**Heart Rate Data**

Heart rate varied across the games in parallel to the frequency of body movements and quality of physical activity during gameplay. Refer to Table 5 for descriptive statistics and an overview of the heart rate data across the different games. The participant’s gameplay during *Fruit Ninja™* was more dynamic and resulted in higher average and maximum (103 and 126 BPM) heart rates compared to *Color Space™* (94 and 110 BPM) and *Sports Scramble™* (95 and 114 BPM). Refer to Figure 8 for a visual representation of the heart rate differences.
Figure 8 shows the variance in heart rate ranges across the different games. White squares represent the minimum and maximum observed heart rate (beats per minute) while black diamonds represent the average heart rate (beats per minute).

While this data is only from a single participant, the heart rate differences between games suggest that Fruit Ninja™ resulted in a higher level of physical activity or excitement, as evidenced by the increased heart rate.

Movement Data Across Games

The results show significant differences in the participant’s movement across the three games. Refer to Table 5 for movement data observed during gameplay. In Color Space™, there were no recorded movements during the 506 seconds of gameplay, indicating a minimal requirement for large bodily movements. In contrast, during Fruit Ninja™ the participant displayed a much higher level of movement with a total of 311 movements in 601 seconds of gameplay, resulting in an average movement rate of approximately 0.52 movements per second. The participant had the second lowest movement rate during Sports Scramble™, with only 97
movements observed in 832 seconds of gameplay, leading to an average movement rate of approximately 0.12 movements per second. Movements per second is an important variable to compare because the total playing time varied between the games, which could skew the total number of movements in favor of longer playing times. However, these findings suggest that this participant had a higher level of physical activity during Fruit Ninja™ compared to both Color Space™ and Sports Scramble™ with both a higher total number of movements as well as movements per second. Refer to Figure 9 for an overview of movement comparison across the games.

**Figure 9: Movement Comparison Across Games**

![Movement Comparison Across Games](image)

*Figure 9 shows differences between both the total number of movements as well as movements per second during gameplay.*

**Post Gaming Survey and Feedback Comparison Across Games**

The participant was asked to report feedback from each gaming session to compare variables such as enjoyment and ease of use, as well as items from the EIFI. Table 8 shows an
overview of the participant’s reported scores, and Figure 10 shows a chart comparing differences of the EIFI subscales across games. Based on the results from the post-gameplay feedback surveys, we can interpret some valuable insights to their experiences with the different VR games.

Table 8: Game Feedback Surveys

<table>
<thead>
<tr>
<th>Game</th>
<th>First Impressions</th>
<th>Exercise Induced Feeling Inventory Subscales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enjoyment</td>
<td>Positive Engagement</td>
</tr>
<tr>
<td>Color Space</td>
<td>4</td>
<td>3.67</td>
</tr>
<tr>
<td>Fruit Ninja</td>
<td>5</td>
<td>4.67</td>
</tr>
<tr>
<td>Sports Scramble</td>
<td>5</td>
<td>4.67</td>
</tr>
</tbody>
</table>

Table 8 shows the feedback scores reported by the participant. First Impressions included questions on enjoyment and difficulty using a scale of 1 (it was not very fun; very difficult) to 5 (it was very fun; it was easy). Exercise Induced Feeling Inventory involved 4 subscales (Positive Engagement; Revitalization; Tranquility; Physical Exhaustion) from items presented on a scale of 1 (not very much) to 5 (very much so).

**Enjoyment**

The participant rated *Fruit Ninja™* and *Sports Scramble™* highest, both receiving a score of 5 out of 5, indicating that these games were particularly enjoyable for them. *Color Space™* also received a positive rating of 4 out of 5, suggesting that the participant found it enjoyable, though slightly less than the other two games.

**Simplicity**

The participant perceived *Fruit Ninja™* as the most difficult game, with a rating of 2 out of 5, indicating that they found it the most challenging among the three. *Sports Scramble™* received a mid-range rating of 3 out of 5, suggesting it provided a moderate level of challenge. Lastly, *Color Space™* was considered as the easiest game, with a rating of 4 out of 5.
Positive Engagement

Both *Fruit Ninja™* and *Sports Scramble™* scored high in Positive Engagement, with an average rating of 4.67, suggesting that these games effectively engaged the participant. *Color Space™* also received a positive rating, albeit slightly less than the other two, at 3.67.

Revitalization and Tranquility

*Fruit Ninja™* received the highest ratings in both revitalization and tranquility, with scores of 4.5 and 4.33 out of 5, respectively. *Sports Scramble™* also scored well in these dimensions with a 4 on revitalization on and 4.33 on tranquility. However, the participant gave *Color Space™* lower scores on both, 2.5 and 3.67, respectively.

Physical Exhaustion

All three games received the same rating of 1 out of 5 for physical exhaustion, indicating that the participants did not feel physically exhausted after playing any of the games.
Figure 10: Exercise Induced Feeling Inventory: Subscales

Figure 10 shows the differences in reported scores for each of the subscales within the Exercise Induced Feeling Inventory.

Overall, the feedback survey reveals that *Fruit Ninja™* and *Sports Scramble™* were particularly enjoyable, engaging, and invigorating for the participant, while *Color Space™* provided an easier and moderately engaging experience. Additionally, all three games were perceived as low in physical exhaustion, suggesting that they may not have led to significant physical fatigue for the participants.
Discussion

This pilot case study explored the potential of Virtual Reality (VR) gaming as a means to promote physical activity and mitigate sedentary behaviors among children. The study aimed to investigate how different VR games elicited various levels of movement and physiological responses, and to assess the child’s enjoyment and engagement with these games. By examining three distinct VR games (Color Space™, Fruit Ninja™, and Sports Scramble™), we sought to shed light on using VR gaming as an active intervention with potential for improving children’s health and well-being. Through a combination of gameplay analysis, heart rate measurements, and post-gameplay feedback, this discussion presents a detailed exploration of how each game elicited varying levels of physical activity and enjoyment among the participant. Furthermore, we discuss the implications of these findings in the context of promoting active lifestyles and addressing health concerns associated with excessive screen time in the digital era as well as identifying limitations that could improve study protocols for future research.

As heart rate was the primary physiological variable measured, we aimed to identify specific gaming characteristics that could explain differences seen in both heart rate ranges as well as the average heart rate during gameplay. Fruit Ninja™ and Sports Scramble™ had the greatest amount of movement and therefore produced the greatest heart rate response. The observed disparities in movement patterns can be attributed to the distinct gameplay mechanics of each VR game. Fruit Ninja’s time-sensitive nature, requiring swift and forceful arm swings to slice virtual fruit, demands rapid and frequent movements from the players. Likewise, Sports Scramble™, with its simulated baseball gameplay, entails catching, throwing, and hitting actions that contribute to the overall movement demands. Conversely, Color Space™ adopts a more
laid-back approach, simulating a virtual coloring book where participants primarily engage in a “point and shoot” concept, resulting in fewer necessary movements.

These findings carry implications for the design of VR games aimed at promoting physical activity while maintaining an enjoyable gaming experience for children. Games like *Fruit Ninja™* and *Sports Scramble™*, with their higher movement demands, offer the potential to increase physical activity levels among players. Game developers can leverage the success of these more active gameplay styles when designing future VR games to encourage greater movement and exercise in the context of virtual entertainment. However, it is essential to strike a balance, ensuring that increased physical activity does not compromise the overall enjoyment and engagement of the players, particularly when targeting a younger audience.

Earlier research conducted by Stewart et al. (2022) demonstrated that relatively physical VR games (e.g., *Fruit Ninja™*, *Beat Saber™*, and *Holopoint™*) elicited lower perceived exertion rates than actual observed exertion rates in college-aged students likely due to the dissociative attentional focus during immersive VR gaming. Furthermore, a study by Baños et al. (2016) showed that VR could be used to distract overweight children from uncomfortable bodily experiences during exercise. The dissociative features of VR and the entertaining aspects of video games may promote extended periods of active gaming, akin to how children immersed in sports might forget about the physical exertion involved. Indeed, the participant in our case study rated his experience with VR gaming both enjoyable and positively engaging while reporting a low level of physical exhaustion. It is prudent to note, however, that the heart rate data from the three games do not suggest that the participant was exerting themselves significantly, thus it is unlikely they would report discomforts associated with fatigue.
Physical activity during VR gaming is closely tied to the specific tasks and interactions within each game, and this, in turn, influences the overall experience perceived by the participant. It is essential to consider that with only one participant in the study, their level of engagement and enjoyment may be influenced by their background and familiarity with video games. As evidenced by the participant’s verbal and physical expressions of enjoyment, particularly during successful moments in games like Fruit Ninja™ and Sports Scramble™, it is apparent that they were fully immersed and engaged with the VR gaming experience, especially in games that prompted increased physical activity.

The participant’s reported background of playing traditional sports as well as sports-focused video games like FIFA™ may have contributed to their choosing of and then positive reception of physically engaging games. It is plausible that participants with different backgrounds and experiences may interpret their VR gaming experiences differently, emphasizing the need for a larger and more diverse sample size to gain comprehensive insights into how children from various backgrounds perceive and engage with VR games, both those that require physical movement and those that do not. Further studies involving a more extensive participant pool would allow for a more nuanced exploration of the relationship between physical activity, enjoyment, and individual differences in gaming experiences.

The gameplay data from Fruit Ninja™ provided a rich dataset for interpretation by offering various game modes that allowed the participant to choose their preferred playstyle without being constrained by the game’s rules. For instance, a user could opt for the Classic Mode, seeking an invigorating yet challenging test of accuracy and decision-making skills. However, during Classic Mode, our participant became visibly frustrated as they accidentally
struck bombs instead of fruit, leading to a loss of lives and an early termination of the round. Notably, in all instances of Classic Mode, the participant achieved lower game scores, had fewer movements per second, and exhibited an overall lower heart rate compared to the other game modes.

In contrast, Fruit Ninja™ offers alternative game modes, such as Arcade and Zen Modes, where the user can enjoy the game without facing the consequences of miss-swings or critical mistakes. In our study during these two modes, the participant obtained the highest scores, the greatest frequency of movements, and the highest average heart rate. These findings suggest that incorporating multiple game modes within a video game, including both competitive and care-free practice modes, can provide users with diverse and engaging experiences. By offering such variety, video game developers may enhance player enjoyment, allowing them to choose gameplay that best aligns with their preferences and desired level of challenge.

Our pilot study can shed light on the diverse nature of physical activity and engagement levels observed during VR gameplay among children. The results demonstrated that different VR games elicited varying degrees of movement, with Fruit Ninja™ and Sports Scramble™ prompting higher levels of physical exertion compared to the more sedentary gameplay in Color Space™. While the movement observed during active VR gaming surpasses sedentary behavior, it is essential to acknowledge that the magnitudes of these movements may not be sufficient alone to combat clinical conditions such as obesity and diabetes.

Nevertheless, our observations suggest that active VR gaming presents a promising opportunity to foster positive attitudes towards physical activity among children in an age range where there can be a decline in physical activity (de Araujo et al., 2018). By merging
entertainment and gamified exertion, VR games have the potential to engage children in enjoyable and immersive experiences that may prompt higher levels of movement than traditional sedentary gaming. As game developers continue to innovate and explore ways to integrate physical activity into VR gaming, there may be an opportunity to develop a positive relationship between children and regular physical activity through these gamified experiences (Finkelstein & Suma, 2011; Krause & Benavidez, 2014).

**Limitations & Future Studies**

As a pilot study, our primary aim was to assess how children play VR games rated as “E” for Everyone and to establish a viable protocol for measuring variables like movement, enjoyability, and exercise-induced feelings. However, we acknowledge the limitations of our single-subject design, which hindered the ability to draw statistically significant and generalizable conclusions about the broader population of children engaging in VR gaming. Indeed, this current protocol's feasibility is limited to an 11-year-old child with prior video game experience. The obtained results are purely exploratory, providing valuable insights into the potential impact of various VR games on physical activity and enjoyment among children. However, caution must be exercised when interpreting these findings as they lay the groundwork for future research requiring larger and more diverse samples. Subsequent studies implementing a similar protocol may reveal significantly different VR experiences among children of varying developmental stages and video game backgrounds.

Another limitation is the small sample size and lack of a control group. With only one participant, making comparisons between individuals becomes challenging, given the wide range of developmental differences, diverse video game experiences, and attitudes towards physical
activity among children aged 8 to 12. Future studies should include a more diverse pool of participants and incorporate a control group engaged in sedentary gaming and traditional physical activities to enable direct comparisons.

Another limitation lies in the relatively short duration of our study. While we were able to capture immediate physiological responses and movement patterns during VR gameplay, a longer-term investigation would be necessary to understand both the sustainability of VR gaming as well as the potential health benefits of prolonged engagement. Naturally, a short bout of VR gaming can elicit acute physical activity. More important, however, would be the exploration of VR gaming’s ability to both captivate and maintain motivation over a longer period of time. Future studies should consider using a longitudinal approach to explore whether children can maintain their enthusiasm for active VR gaming and whether it leads to sustained improvements in their physical activity levels and overall health.

This pilot study revealed several potential challenges within the current study protocol. First, younger children might lack the physical development necessary to effectively handle the controllers and experience optimal VR fidelity, especially if the headset is not well-fitted to smaller heads. Alternatively, researchers should prepare a series of games that can be played using the VR software’s ability to recognize hand movement and gestures as controls to the game instead of relying on the hand-held controllers. Second, successful data collection demands a cohesive team of researchers capable of multitasking, including capturing the participant’s movements on video recordings and logging significant gameplay moments alongside corresponding heart rate data, and synchronizing these observations with in-game recordings of the participant’s POV. In the current study, occasionally, heart rate data became desynchronized
from the participant’s videogame play and required extensive backtracking to identify the exact
time the participant stopped and started various game segments. In future studies, a seamless
synchronization of data is needed, as heart rate data should accurately reflect the occurrence of
significant body movements during gameplay.

Conclusion

This pilot study has demonstrated that VR gaming may be able to promote physical
activity among children. The increased movement in certain games suggests that active VR
games have the potential to be effective in encouraging children to be more physically active.
Our findings suggest that gamified exertion during VR gaming is possible, which may foster a
positive relationship towards physical activity, potentially contributing to children’s overall
health and well-being through their childhood.
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Appendix A: Movement Analysis Instructions & Procedure

You will be assigned one or multiple video clips from a previously recorded VR gaming session and be asked to identify and quantify how many instances one or more of the movements occur. You are only responsible for filling in the yellow highlighted section of the spreadsheet. Each assigned clip is 60 seconds long and begins at the minute mark and ends at the 59-second mark (i.e., 3:00 - 3:59; 5:00 - 5:59).

You will tally and total the number of movement incidents that occur for each minute mark. If a movement starts in one minute block but ends in the following minute block, it should be tallied corresponding to when the movement started.

Please use the key and description of movements below to understand what they are and how to identify them.

Movements

**Upper Body Movement(s):** This group of movements includes large and dynamic movements from the shoulders and/or arms.

- **Slashing (Arms):** The entire arm and/or lower arm (from elbow to wrists) performs a sweeping motion in one or multiple directions, as though they are swashing a machete through a dense rainforest. These movements can be long and traverse across the body, or be short, jab-like slashes that start and end abruptly just in front of the body. Slashing movements can occur in multiple planes (up and down as well as side-to-side).

  - In some games, it may be difficult to distinguish one movement from another if they appear to be successive (e.g., in FruitNinja™ bonus points are rewarded for rapid and successive slices) which can result in swinging and slashing movements to blend into one long continuous movement without a clear distinction when one stopped, and another started. To rectify whether the swing (or another similar movement) should be counted as one continuous swing or multiple independent swings, adjust the playback speed to 0.5x and watch carefully to see if the arm pauses momentarily before initiating a new movement. If the arm continues uninterrupted, treat the movement as one continuous movement. An example can be found on Participant # 2 Game # 2 at 02:22, where the right arm swings upwards at a fruit and continues downward and across the body. This swing will
be tallied as 1 (long) swing/slash. If the arm travels in a distinguishably different direction, it can be counted as an individual slash.

- **Punching/Chopping (Arms):** These movements, commonly observed in karate or fighting games, are characterized by a closed fist (or open hand for a chop) with striking-like movements. Punching/chopping can include a traditional punch, a jab, a hook, or an uppercut, as well as a karate chop (as seen when fighters break wooden planks).

- **Throwing (a virtual ball) (Arms):** Throwing (a virtual ball) can be identified when an individual performs a throwing-like movement despite not holding an object to be thrown.Often, throws are made overhead (the hand and arm are brought above and behind the head, followed by a quick acceleration of the arm towards the front of the body) or underhand (the hand and arm are cocked back behind the body, followed by a quick acceleration of the arm towards the front of the body).

  Example of Throwing (a virtual ball): Participant #2
  Game #3: 12:01

- **Catching (a virtual ball) (Arms):** Without an object being caught, catching (a virtual ball) will appear as though a hand and arm are brought up and/or out to the side as if stopping or catching an incoming object. Catching movements in VR are quicker and less natural than real catching but can be identified in a similar manner. In VR, the user will appear to “snatch” something out of thin air followed by also “taking” the virtual ball out of the hand with the opposite hand as they get ready to throw the virtual ball again.

  Example of Catching (a virtual ball): Participant #2 Game #3: 12:22 - 12:25

- **Swinging (a virtual bat/racket) (Arms):** Without a physical object being swung, swinging (a virtual bat) may appear as a slashing move as well. The context of the game will help determine which movement is being performed. Swinging (a virtual bat/racket) can take place with either one or both hands appearing to hold the bat/racket, followed by a rapidly accelerating motion of the arms either across the body (baseball swing) or from an overhead position downwards (tennis serve). For simplicity purposes, we do not need to differentiate between the two.

  Example of Swinging (a virtual bat/racket): Participant #2 Game #3: 13:27

**Lower Body Movement(s):** This group of movements involves large and dynamic movements of the hips, knees, and/or feet and ankles to move the lower half of the body.
• Squatting/Ducking (Legs): Movements that lower the body, as seen during a ducking movement, where the knees and hips bend. An example of this occurs when a participant is sitting onto a chair or box.

• Jump/Hop (Legs): A movement originating from the legs that cause the body to propel upwards and off of the ground momentarily.

• Kick/Kicking (Legs): A forceful action performed with the leg or foot, directed toward a (virtual) target. It involves a swift movement where the leg is extended outward in front or to the side in order to make contact with the intended object or opponent.

• Step/Stepping/Walking (Legs): A step is a brief movement where one foot is lifted from the ground and placed back down in a new position. It involves shifting the weight from the supporting leg to the lifted leg, followed by a controlled placement of the lifted foot on the ground. A step is typically a small movement used to reposition or adjust one's stance or to initiate forward movement.

• Lunge/Kneeling (Legs): A movement initiated with one leg moving or stepping forward with the opposite leg remaining stationary. Simultaneously, the body is shifted downwards to the ground, similar to a squat but with feet in a tandem-like position instead of side-by-side. A lunge can be forwards, backward, or to the side.

Identifying Movements within the Game: What to Look For

Game 1: Color Space™

In this game, there are very few large movements that would produce physiological stimuli, such as increased HR, elevated respiration, or extra muscular exertion. The extent of the movements can be described by brief moments where the participant seems to be using the controllers to interact with the virtual world, occasionally turning their head and torso to obtain better vantage. There may not be any gross body movements to tally in this game mode.

Game 2: Fruit Ninja™

In this game, the user wields a sword in each hand and must drag the controllers across the (virtual) screen, simulating a slicing effect. The movements seen in this game are significantly greater and more frequently occurring than in the previous game. The primary movement that will be seen is a slashing movement with the arm. To count the slashing movements, look for sudden and abrupt sweeping motions across the body. Each time a swing is
performed, it counts as one (1) movement. When a long swing is observed to travel in multiple directions, it should count as one (1) movement only if there is a continuous sweeping movement without a pause or shift. If a long swing is observed where the direction of the arm changes rapidly or in the opposite direction, they will be counted as independent swings. Occasionally, the participant cocks the arm up, back, or to the side in preparation for the swing, but does not follow through with the swing. These will not be tallied as swings. Occasionally, the participant moves the arm slowly at the side or in front of themself, as if to get into a good position. These should not be counted as swings. Occasionally, the participant makes quick, very short jab-like waving movements with the hands at the end of a swing. These are bonus slices within the game and must be performed quickly and rapidly during a ‘freeze frame’. When the participant appears to be waving their hand in this manner, it should not be counted as a swing. An example of this can be seen with the left arm between 08:09 - 08:11 from Participant # 2 Game #2. Only if the arm(s) move significantly should it be counted as a swing. Lastly, the participant sometimes alternates arms to swing. Count each swing independently regardless of if it is with the left or the right arm. Occasionally the participant will use predominantly one arm to perform most of the swings while the opposite arm trails accordingly, appearing to make movements despite not performing any swings. Do not count these as a swing unless there is a clear purpose behind the movement.

Game 3: Sports Scramble™

Sports Scramble is a fun sports game where the participant can play a variety of common playground sports with a fun twist - such as using a tennis racket for baseball or a bowling ball in soccer. The movements observed within Sports Scramble depend on the game but include activities such as catching and throwing (a virtual ball), swinging (a virtual bat/racket), kicking (a virtual ball), jumping, and/or stepping/walking. The participant chose to play baseball, so the primary movements you’ll see are catching, throwing, and swinging. While swinging (a virtual bat) and slashing (a sword) may appear similar, they will be tallied differently as they are game-specific, and in this case, there are no slashing movements.
Appendix B: The Exercise Induced Feeling Inventory

Adopted from Gavin and Rejevski (1993) The Exercise Induced Feeling Inventory Development and Initial Validation.

**Instructions:** Please use the following scale to indicate the extent to which each word below describes how you feel at this moment in time. Record your responses by filling in the appropriate number next to each word.

1 = Do not Feel (DNF)
2 = Feel Slightly
3 = Feel Moderately
4 = Feel Strongly
5 = Feel very Strongly (FVS)

1. Refreshed - DNF 0 1 2 3 4 5 FVS
2. Calm - DNF 0 1 2 3 4 5 FVS
3. Fatigued - DNF 0 1 2 3 4 5 FVS
4. Enthusiastic - DNF 0 1 2 3 4 5 FVS
5. Relaxed - DNF 0 1 2 3 4 5 FVS
6. Energetic - DNF 0 1 2 3 4 5 FVS
7. Happy - DNF 0 1 2 3 4 5 FVS
8. Tired - DNF 0 1 2 3 4 5 FVS
9. Revived - DNF 0 1 2 3 4 5 FVS
10. Peaceful - DNF 0 1 2 3 4 5 FVS
11. Worn Out - DNF 0 1 2 3 4 5 FVS
12. Upbeat - DNF 0 1 2 3 4 5 FVS

**Scoring for the Exercise Induced Feeling Inventory**

The EIFI consists of 4 distinct subscales. Subscale scores are obtained by summing or averaging the numerical values chosen for the adjectives within a particular subscale. The four subscales include: (1) Positive Engagement (items 4, 7, & 12), (2) Revitalization (items 1, 6, & 9), (3) Tranquility (items 2, 5, & 10), and (4) Physical Exhaustion (items 3, 8, & 11).
Appendix C: Prior Media & Intake Form
Part 1: Assent Form
- Explain assent and have child sign

Part 2: Heart Rate Monitor
- Have YMCA staff or Parent help put the Heart Monitor on
- Ensure Heart Rate is being recorded on the app (put instructions here)
- Take Resting HR

Part 2: Surveys and Resting Heart Rate

So to begin, I would like you to fill out this survey that will give me an idea of your experience with media such as video games. I can help you with the questions or read them out loud for you. We will do the survey on the iPad. This next survey will ask you questions about any physical activity you may do at home or at school (Explain the rating scale for Physical Activity Questionnaire).

Children's Media Survey Interview
We want to find out some information about you and some of the games you've played before and how you feel about things. There are no right or wrong answers to any of these questions!

1. What grade are you in? 5th

2. What is your birthday? (MMDDYYYY) 1/13/2017 11 years 11 months

3. Have you heard of virtual reality games (like the Oculus or on Playstation)? Yes No

4. Have you played Virtual Reality games? Yes No If No skip to #8

6a. On what kind of system did you play VR? Oculus + PlaySta****
1. **Category #1 Puzzle games**: These are games that have a puzzle-like structure. The choices are: *Fruit Ninja*, *Angry Birds*, *The Curious Tale of the Stolen Pets*, *Cubism*.

2. **Category #2 Story-mode/role-play or world-building games**: These are games that have a narrative adventure style or allow children to build and explore a virtual world. These games are: *Little Cities*, *Luna*, and *Seuplt*.

3. **Category #3 Exploration games**: These are passive games that allow the player to experience different virtual locations across the world, under the ocean or in space. These are games: 
   a. *Ocean Rift*, and *National Geographic Explore TRIPP Bogo*, *Category #4 Exercise/fitness games*: Games that require more intense physical movement. Pick 2. These choices are: *Fishing VR*, *Beat Saber*, *Sports Scramble*, *Gorilla Tag*, *RacketNX* and *Walkabout MiniGolf*.

<table>
<thead>
<tr>
<th>Game Order</th>
<th>Category</th>
<th>First Choice</th>
<th>Second Choice</th>
<th>Third Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Warm up</td>
<td>First Steps</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Optional 2nd Warm up (or cool down: )</td>
<td>ColorSpace can also use Henry</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Puzzle</td>
<td><em>Fruit Ninja</em></td>
<td><em>Curious Tale of the Stolen Pets</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Story/World Building</td>
<td><em>Gorilla Tag</em></td>
<td><em>Walkabout Golf</em></td>
<td><em>Gorilla Tag</em></td>
</tr>
<tr>
<td></td>
<td>Exploration</td>
<td><em>Sports Scramble</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Part 6: Playing the VR games**
13. Game: Sports Scramble (Exercise)
   a. Did you like how that game looked?  Yes  No
   b. Why did you like/dislike it?
      - different sports and mixed ability levels
      - played different sports and played with different people
   c. Would you want to play that game ever?  Yes  No
   d. If yes, do you want to try to play that game today? Yes  No

14. Game: Beat Saber (Exercise)
   a. Did you like how that game looked?  Yes  No
   b. Why did you like/dislike it?
      - listen to different songs while
      - easier boxes
   c. Would you want to play that game ever?  Yes  No
   d. If yes, do you want to try to play that game today? Yes  No

15. Game: Walkabout Mini Golf (Sport)
   a. Did you like how that game looked?  Yes  No
   b. Why did you like/dislike it?
      - tracks your strength and can change most right
      - other friends and non-weight exercise
   c. Would you want to play that game ever?  Yes  No
   d. If yes, do you want to try to play that game today? Yes  No

16. Game: RacketNX (Exercise)
   a. Did you like how that game looked?  Yes  No
   b. Why did you like/dislike it?
      - detailed and playful
      - allow friends and non-weight exercise
   c. Would you want to play that game ever?  Yes  No
   d. If yes, do you want to try to play that game today? Yes  No

17. Game: Gorilla Tag (Exercise)
   a. Did you like how that game looked?  Yes  No
   b. Why did you like/dislike it?
      - use arms to move and play
      - friends in different ways
   c. Would you want to play that game ever?  Yes  No
   d. If yes, do you want to try to play that game today? Yes  No

18. Game: TRIPP start @30 sec (Meditation)
   a. Did you like how that game looked?  Yes  No
   b. Why did you like/dislike it?
      - explore worlds and different styles and noticed little details
   c. Would you want to play that game ever?  Yes  No
   d. If yes, do you want to try to play that game today? Yes  No
7. Game: ScupltVR (World Building)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? can make different things and color and explore
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

8. Game: Little Cities (Building)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? - make your city and can make daily jobs
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

9. Game: Ocean Rift (Exploration)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? - explore the sea, different animals and learn about animals
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

10. Game: National Geographic (Exploration)
    a. Did you like how that game looked? Yes No
    b. Why did you like/dislike it? - explore different parts of the world and take pictures
    c. Would you want to play that game ever? Yes No
    d. If yes, do you want to try to play that game today? Yes No

11. Game: BOGO (Exploration)
    a. Did you like how that game looked? Yes No
    b. Why did you like/dislike it? - can explore and find different animals
    c. Would you want to play that game ever? Yes No
    d. If yes, do you want to try to play that game today? Yes No

12. Game: Bait (Fishing / Sport)
    a. Did you like how that game looked? Yes No
    b. Why did you like/dislike it? - catch fish and different types of fish
    c. Would you want to play that game ever? Yes No
    d. If yes, do you want to try to play that game today? Yes No
(Start the playlist, explain the name of the game, then pause after each video to answer questions)

1. Color Space
   a. Did you like how the game looked? Yes No
   b. Why did you like/dislike it? Change shade of color & movement
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

2. Game: Fruit Ninja (Puzzle)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? Slice fruits and can do in real life
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

3. Game: Angry Birds (Puzzle)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? Shoot different angles
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

4. Game: Curious Tale of Stolen Pets (Puzzle)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? Exploring
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

5. Game: Luna start video @40 seconds (Puzzle Adventure)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? See different animals, make stuff and explore around
   c. Would you want to play that game ever? Yes No
   d. If yes, do you want to try to play that game today? Yes No

6. Game: Cubism (Puzzle)
   a. Did you like how that game looked? Yes No
   b. Why did you like/dislike it? Make different things and 3D models
   c. Would you want to play that game ever? Yes No
21a. Why? Played soccer, helps see position think more about how play

22. What video game systems do you have in your home? Circle any that you own.
   - Nintendo DS
   - Nintendo GameCube
   - Nintendo Wii
   - Sony PlayStation (Version #: ) \(2 + 3 + 4\)
   - Sony PSP
   - Switch Nintendo
   - Xbox (Version #: )
   - Other: ________

23. How often do you do each of the following things?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Every Day</th>
<th>Several Times a Week</th>
<th>Several Times a Month</th>
<th>Less Often</th>
<th>Never</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. How often do you watch television?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. How often do you play computer games?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. How often do you play physically active video games?</td>
<td>(___\)</td>
<td>(___\)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>d. How often do you play video games?</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>e. How often do you play handheld video games?</td>
<td>(____)</td>
<td>(___)</td>
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<tr>
<td>f. How often do you play games on a phone?</td>
<td>X</td>
<td></td>
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<tr>
<td>g. How often do you play games on a tablet?</td>
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</table>

**Physical Activity Surveys**

**Physical Activity Enjoyment Scale (PACES):** This part of the survey asks whether you've ever played specific sports, and how much you do or do not want to play them.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Have You Ever Done This Activity?</th>
<th>Don't Like to Play</th>
<th>Kind of Like to Play</th>
<th>Definitely Like to Play</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Baseball</td>
<td>Yes   No Don't Know</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
109

18. Do you think that people can get in better shape by playing active video games?
   Yes  ☑  No  ☐  I don't know

17. Have you ever played any Other Video Games - you could play them on a computer, phone, tablet or console?  Yes  ☑  No  ☐
   If No skip to #21

18. How often do you play other video games?
   a. Almost Every Day
   ☑  A few times a week
   c. About once a week
   d. Every now and then
   e. Just once or twice

19. Do you like playing other video games?
   ☑  I really like playing
   b. I sort of like playing
   c. I sort of don't like playing
   d. I really don't like playing

   Fifa Soccer, Apex legends / Fortnight (sometimes)
   Roblox, Fifa mobile

20. What other video games have you played?
   Mario Kart (Somedays)
   Used to play Tetris


21. What are your favorite video games?  ☑  Fifa
Participant ID #:

<table>
<thead>
<tr>
<th>How often do you play VR games?</th>
<th>Do you like playing VR games?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Almost Every Day</td>
<td>a. I really like playing</td>
</tr>
<tr>
<td>b. A few times a week</td>
<td>b. I sort of like playing</td>
</tr>
<tr>
<td>c. About once a week</td>
<td>c. I sort of don't like playing</td>
</tr>
<tr>
<td>d. Every now and then</td>
<td>d. I really don't like playing</td>
</tr>
<tr>
<td>e. Just once or twice</td>
<td></td>
</tr>
</tbody>
</table>

7. What VR games have you played?  
- Ball Tag  
- Beat Saber  
- Sport, Fruit Ninja, Walkabout Mini Golf

8. Why do you think people use Virtual Reality?

9. Have you ever heard of video games that are like exercise, we call them active video games?  
   Yes  No  I don't know

10. What active video games have you heard of?  
    actual exercise-stops

11. Have you played active video games?  
    Yes  No
    If No skip to #15  
    once

12. Which active video games have you played?

13. How often do you play active video games?  
    a. Almost Every Day
    b. A few times a week
    c. About once a week
    d. Every now and then
    e. Just once or twice

14. Do you like playing active video game?  
    a. I really like playing
    b. I sort of like playing
    c. I sort of don't like playing
    d. I really don't like playing

15. Why do you think people use active video games?  
    a) Mostly for exercise
    b) Mostly for fun and games
Appendix D: VR Game Feedback Forms (Completed)
Child VR Feedback
Note: this form will be used for each game they play

Now that you played this game we want to get your feedback on what you liked or didn’t like. There are no right or wrong answers to any of these questions! Your answers will help us understand what kinds of games kids like you enjoy playing!

Game Name: Color Space

Part 1: First impressions
How much did you enjoy the game you just performed?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was no fun at all</td>
<td>somewhat not fun</td>
<td>It was somewhat fun</td>
<td>Kind of fun</td>
<td>It was a lot of fun</td>
</tr>
</tbody>
</table>

Can you explain why you liked or disliked this game?
*Can choose what to paint with different sections, like earth & man*

How easy was the game you just performed?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very difficult</td>
<td>a little difficult</td>
<td>It was neither easy nor difficult</td>
<td>Kind of easy</td>
<td>Very easy</td>
</tr>
</tbody>
</table>

Can you explain why you thought the game was easy or difficult?
Paint stuff that’s still and easy to switch colors, kind of easy when coloring moving objects

Did you have any problems while playing the game? Or feel discomfort of any kind?
*Nothing*
8. I feel peaceful

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td>Very much so</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. I feel worn out

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td>Very much so</td>
<td></td>
<td></td>
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</tbody>
</table>

10. I feel upbeat

<table>
<thead>
<tr>
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<th>1</th>
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<th>5</th>
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<td>Not at all</td>
<td>Somewhat</td>
<td>Very much so</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part 3: These questions are open ended. There are no right or wrong answers!

1. How do you think this game could be improved for kids like you?
   
   added more sports

2. What else would you like to tell us about your playing experience or VR?
   
   - No

3. How would you describe what you just did to someone who has never played VR?
   
   - fun way to boost your mood and play with others
### Part 2 Post Exercise if an active game- Exercise Induced Feeling Inventory

Instructions: Please respond to the following scale to indicate the extent to which each word below describes how you feel at this moment in time after playing. There are 10 questions.

1. I feel refreshed

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td></td>
<td>Very much so</td>
<td></td>
</tr>
</tbody>
</table>

2. I feel calm

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td></td>
<td>Very much so</td>
<td></td>
</tr>
</tbody>
</table>

3. I feel tired

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td></td>
<td>Very much so</td>
<td></td>
</tr>
</tbody>
</table>

4. I feel enthusiastic

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td></td>
<td>Very much so</td>
<td></td>
</tr>
</tbody>
</table>

5. I feel relaxed

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
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<td>Not at all</td>
<td>Somewhat</td>
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<td>Very much so</td>
<td></td>
</tr>
</tbody>
</table>

6. I feel energetic

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Not at all</td>
<td>Somewhat</td>
<td></td>
<td>Very much so</td>
<td></td>
</tr>
</tbody>
</table>

7. I feel happy

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td></td>
<td>Very much so</td>
<td></td>
</tr>
</tbody>
</table>
Child VR Feedback
Note: this form will be used for each game they play

Now that you played this game we want to get your feedback on what you liked or didn’t like. There are no right or wrong answers to any of these questions! Your answers will help us understand what kinds of games kids like you enjoy playing!

Game Name: Sports Scramble

Part 1: First impressions
How much did you enjoy the game you just performed?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 ✔</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>It was no fun at all</td>
<td>Some what not fun</td>
<td>It was somewhat fun</td>
<td>kind of fun</td>
<td>It was a lot of fun</td>
</tr>
</tbody>
</table>

Can you explain why you liked or disliked this game?
- play different sports, get different objects to bat increase or decrease

How easy was the game you just performed?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3 ✔</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very difficult</td>
<td>a little difficult</td>
<td>It was neither easy nor difficult</td>
<td>kind of easy</td>
<td>Very easy</td>
</tr>
</tbody>
</table>

Can you explain why you thought the game was easy or difficult?
- bats / AI made challenging to get / game's outs / strikes

Did you have any problems while playing the game? Or feel discomfort of any kind?
- No
8. I feel peaceful

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>✓</th>
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<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
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<td>Very much so</td>
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</table>

9. I feel worn out

<table>
<thead>
<tr>
<th></th>
<th>1 ✓</th>
<th>2</th>
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<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
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10. I feel upbeat

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<th>4 ✓</th>
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<td>Not at all</td>
<td>Somewhat</td>
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<td>Very much so</td>
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</table>

Part 3: These questions are open ended. There are no right or wrong answers!

1. How do you think this game could be improved for kids like you?
   - No exploding coconuts and bombs, not so sensitive

2. What else would you like to tell us about your playing experience or VR?
   - No

3. How would you describe what you just did to someone who has never played VR?
   - Good game to test reaction time and eyesight
Part 2 Post Exercise if an active game - Exercise Induced Feeling Inventory

Instructions: Please respond to the following scale to indicate the extent to which each word below describes how you feel at this moment in time after playing. There are 10 questions.

1. I feel refreshed

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<tr>
<td>Very much so</td>
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2. I feel calm

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<tr>
<td>Very much so</td>
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3. I feel tired

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4. I feel enthusiastic

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5. I feel relaxed

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6. I feel energetic

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7. I feel happy

<table>
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</tbody>
</table>
Child VR Feedback

Note: this form will be used for each game they play

Now that you played this game we want to get your feedback on what you liked or didn't like. There are no right or wrong answers to any of these questions! Your answers will help us understand what kinds of games kids like you enjoy playing!

Game Name: Fruit Ninja

Part 1: First impressions

How much did you enjoy the game you just performed?

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<th>1</th>
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<th>4</th>
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<td>somewhat not fun</td>
<td>it was somewhat fun</td>
<td>kind of fun</td>
<td>It was a lot of fun</td>
</tr>
</tbody>
</table>

neutral

Can you explain why you liked or disliked this game?

- got to chop fruits and use different blades to slice fruits

How easy was the game you just performed?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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<td>a little difficult</td>
<td>it was neither easy nor difficult</td>
<td>kind of easy</td>
<td>Very easy</td>
</tr>
</tbody>
</table>

neutral

Can you explain why you thought the game was easy or difficult?

- even though I didn't get bombs, chill exploded, it was not good feeling

Did you have any problems while playing the game? Or feel discomfort of any kind?

- No issues
**Participant ID#**

8. I feel peaceful

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 ✓</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<tr>
<td>Somewhat</td>
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</tbody>
</table>

9. I feel worn out

<table>
<thead>
<tr>
<th></th>
<th>1 ✓</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
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<td>Somewhat</td>
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</tbody>
</table>

10. I feel upbeat

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3 ✓</th>
<th>4</th>
<th>5</th>
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</tbody>
</table>

**Part 3: These questions are open ended. There are no right or wrong answers!**

1. How do you think this game could be improved for kids like you?
   - User can move objects and add more color options.

2. What else would you like to tell us about your playing experience or VR?
   - Nothing.

3. How would you describe what you just did to someone who has never played VR?
   - Good for people who like to draw and have fun at the same time.
Part 2 Post Exercise if an active game- Exercise Induced Feeling Inventory

Instructions: Please respond to the following scale to indicate the extent to which each word below describes how you feel at this moment in time after playing. There are 10 questions.

1. I feel refreshed

<table>
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<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Somewhat</td>
<td>✓</td>
<td>Very much so</td>
<td></td>
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</tbody>
</table>

2. I feel calm

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<tbody>
<tr>
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<td>✓</td>
<td>Very much so</td>
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3. I feel tired

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<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>✓</td>
<td>Somewhat</td>
<td>Very much so</td>
<td></td>
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</table>

4. I feel enthusiastic

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<td>✓</td>
<td>Very much so</td>
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5. I feel relaxed

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<td>Somewhat</td>
<td>Very much so</td>
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</tr>
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</table>

6. I feel energetic

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7. I feel happy

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