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Article

Asymmetric VR Game Subgenres: Implications for Analysis and Design

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Abstract: This paper identifies subgenres of asymmetric virtual reality (AVR) games and proposes the AVR Game Genre (AVRGG) framework for developing AVR games. We examined 66 games "in the wild" to develop the AVRGG and used it to identify 5 subgenres of AVR games including David(s) vs. Goliath, Hide and Seek, Perspective Puzzle, Order Simulation, and Lifeline. We describe these genres, which account for nearly half of the 66 games reviewed, in terms of the AVRGG framework that highlights salient asymmetries in the mechanics, dynamics, and aesthetics categories. To evaluate the usefulness of the AVRGG framework, we conducted four workshops (two with the AVRGG framework and two without) with novice game designers who generated 16 original AVR game concepts. Comparisons between the workshop groups, observations of the design sessions, focus groups, and surveys showed the promise and limitations of the AVRGG framework as a design tool. We found that novice designers were able to understand and apply the AVRGG framework after only a brief introduction. The observations indicated two primary challenges that AVR designers face: balancing the game between VR and non-VR player(s) and generating original game concepts. The AVRGG framework helped overcome the balancing concerns due to its ability to inspire novice game designers with example subgenres and draw attention to the asymmetric mechanics and competitive/cooperative nature of games. While half of those who used the AVRGG framework to design with created games that fit directly into existing subgenres, the other half viewed the subgenres as "creative constraints" useful in jumpstarting novel game designs that combined, modified, or purposefully avoided existing subgenres. Additional benefits and limitations of the AVRGG framework are outlined in the paper.

Keywords: asymmetric VR; game design; game design workshop; game genre; asymmetric games

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1. Introduction

Asymmetric virtual reality (AVR) systems and games are an emerging game genre that has generated increasing interest among virtual reality (VR) game designers, players, enthusiasts, and researchers in recent years (e.g., [1–3]). Players and designers of such games refer to them on Reddit by a variety of names ranging from "Asymmetric VR games" to "flat + VR" to "couch co-op VR" [1]. AVR games typically combine a single VR player with one or more non-VR players who use another interface (e.g., mobile device, computer, TV, or even paper) to interact in the game world [1]. A prominent example is Keep Talking and Nobody Explodes, which has a VR player defuse a bomb with the help of their "expert" friends who use an abstruse bomb defusing manual to recommend actions that the VR player can take. The game has won numerous game awards, is available in 26 languages, and has hundreds of thousands of downloads across numerous platforms [4]. Another example, Acron: Attack of the Squirrels!, has mobile player "squirrels" try and steal acorns from a VR player "tree" who protects the acorns by throwing objects at the squirrels who run around the shared virtual space. The game has hundreds of thousands of downloads

on the Google Play App Store and won Best VR game at the 16th International Mobile Gaming Awards [5]. These examples illustrate the success of existing AVR games and hint at a bright future for the genre, which we are only beginning to understand.

The popularity of AVR games may derive from a variety of factors. The AVR structure helps overcome the technical and social isolation that can occur for a VR player when co-located individuals are not exposed to the VR world [6]. They also provide an option for players who cannot or do not want to use a VR headset. While VR technology has improved in recent years and is more accessible, it still causes motion sickness in some users [7], and many headsets are not recommended for children under 13 years of age. Moreover, VR headsets are not yet as widespread as other common devices, such as smartphones, and their cost can be prohibitive, particularly when considering purchases of multiple headsets. Understanding and developing compelling AVR games can help address some of these concerns, as well as provide insights into games that take advantage of the unique capabilities and limitations of significantly different platforms.

The term "asymmetric" in asymmetric VR refers to a game design concept where players of the same game differ in how they interact with a game and its mechanics [8]. In contrast to symmetric games, where all players abide by the same set of rules, asymmetric games allow for diversity in gameplay between players, leading to more dynamic and personalized experiences. Harris et al. identify several types of asymmetries that can be designed into various game genres [8]. Several researchers have applied [8]'s findings to VR contexts, helping refine and extend their work to account for the unique VR context (e.g., [1–3]). However, existing frameworks have not been developed by examining existing games "in the wild", which are of critical importance when trying to add ecological validity and explore a new design space. Furthermore, no empirical studies using AVR frameworks have looked at their impact on actual AVR game design. This paper tackles and addresses this gap while also taking a fresh approach by applying the lens of genre.

Genre is a common mechanism for classifying categories of games, providing a language to articulate games that invoke familiar experiences [9,10]. Popular online game stores like Steam, Epic Games Store, and Origin, list genre as a key identifying feature in which to browse games. While taxonomic frameworks (e.g., [1,2,8]) define the dimensions, elements, and factors that compose a game, they often do not consider relationships between elements and how they tend to group together [11]. They also help characterize the "phenomenological, pragmatic deployment of actions through the gameplay experience", which is "partly functional and partly aesthetic" [9] (p. 171). Often, in game design, the whole is something more than the sum of its parts. While it can be useful to quantify and describe the individual ingredients of a pasta sauce, there is also value in characterizing types of sauces like Marinara and Alfredo. Genre is not only useful for those classifying and browsing games, but it can also be useful when communicating during the design process, as it can "interrogate" "new and old works against a common baseline" [11] (p. 8). To be useful for designers, there is a need to "describe the salient properties of a genre that affect the player's experience when using genre as a design tool" [11] (p. 7). Using our previous analogy, we might investigate the relevant properties of a pasta sauce, such as saltiness, creaminess, or whether it uses a tomato base. While these properties are important and practical to identifying features of pasta sauces for comparison, they should not be applied to other genres such as syrups. This paper contributes to the literature on asymmetric VR games by identifying the salient features of AVR game subgenres and examining their effect on novices designing AVR game concepts. While these salient features share much in common with existing asymmetric taxonomies [2,3,8,12], they help "bridge the gap between the very specific and the very general" [13] by combining details about the game content and aesthetics with generalizable descriptions of game elements.

This study aims to improve our understanding of AVR games by making three contributions. First, we developed the AVR Game Genre (AVRGG) framework that can be used for classifying subgenres of AVR games and as a prompt for AVR game designers. Second, we identify five subgenres of AVR games based on their shared salient features

that distinguish asymmetric play for VR and non-VR players. The identification of these subgenres allows game designers to gain a better understanding of the different types of AVR games and the unique gameplay elements they offer. Third, we used the AVRGG framework as a tool for novice game designers to create new AVR game concepts and compare the games they designed and the process they used to designers without the framework. This helped us test the viability of the AVRGG framework as a generative design tool as well as the use of detailed subgenres in the design process.

2. Background

2.1. Game Asymmetry

Asymmetry in game design has been explored extensively by the authors of [8], who provide a framework for analyzing and developing asymmetric games, which they define as "games that adopt a design strategy that embraces differences between players, caters to them, and leverages them to create games with multi-faceted appeal while maintaining tightly-coupled social interaction" [8] (pp. 350–351). Their framework identifies different types of asymmetries, which it maps to the mechanics, dynamics, and aesthetics (MDA) categories [14], though it primarily focuses on mechanics and dynamics. Specifically, they identify the asymmetries of ability, challenge, interface, information, investment, and goal/responsibility in the mechanics category and the asymmetries of directional dependence (mirrored, unidirectional, and bidirectional) and synchronicity and timing (asynchronous, sequential, expectant, concurrent, and coincident) in the dynamics category [8]. They point out that the aesthetics in the MDA framework emerge during the experience and do not have detailed asymmetries articulated. In later work, the framework was used to develop variations on a game (e.g., promote interdependence among players), with experimental comparisons showing that asymmetric play outperformed symmetric play in soliciting feelings of social presence, perceptions of connectedness, and other outcomes of interest [15]. The benefit of their framework is its wide applicability to many types of games and contexts, including AVR, as evidenced by the fact that major AVR frameworks rely heavily upon it (e.g., [2,3,12]), as does the current work. However, this high level of abstraction is also a drawback when applying it to a specific genre, such as AVR games, since some elements of the framework are likely to be far more important than others and it may be missing other pieces. The fact that the AVR-specific frameworks have found a need to modify [8]'s original framework (e.g., [2,3,12]) suggests there is value in tailoring it for an AVR context.

Scholars from a variety of academic fields, including game design (i.e., ludology), human–computer interaction, social psychology, CSCW, education technology, and extended reality, have examined asymmetry as it relates to VR technology [3,12,16]. Ouverson and Gilbert synthesize much of this literature into their Composite framework for Asymmetric VR (CAVR) based on a scoping review of relevant conceptual frameworks from these different disciplines [12]. They define AVR as "a form of VR interaction in which co-located users access the same virtual environment using different kinds of technology" [12] (p. 193). This is different than cross-platform multiplayer VR, which indicates the remote use of asymmetric technologies, though their later work recognizes that this distinction may not be critical [1]. Ouverson and Gilbert identify five relevant dimensions, including transportation, spatial co-presence, information richness, team interdependence, and balance of power [12]. Thomsen et al. [3] similarly synthesize frameworks from a variety of disciplines to create a taxonomy of collaboration in AVR settings. They build upon [8] for asymmetric mechanics, [14] for game components, [17] for collaboration mechanics, and also examine hardware components [3]. They then analyze "high" and "low" levels of asymmetry and consider how it might influence learning contexts [3].

A follow-up evaluation of CAVR, based on a content analysis of Reddit messages by AVR users, takes a different but complementary approach, focusing on the identification of "patterns" of asymmetry that are used to help refine the original CAVR framework [1]. They identify eight different asymmetry patterns present in the co-located use of VR:

dueling, cooperative eye-spy, navigator and pilot, boss vs. horde, hide and seek, game mastering, teleguidance, and showcase. These patterns emerged from the user comment data, suggesting that they capture some of the most salient characteristics of asymmetric games from a user experience perspective. Ouverson et al. recommend that future work "analyze the interactions and patterns of asymmetry within asymmetric VR games" [1] (p. 16) (as opposed to Reddit forums), which is precisely what the current paper carries out. Interestingly, our own subgenres map somewhat closely to several of their patterns (e.g., Hide and Seek, which even shares the same name; see the Discussion section for a comprehensive comparison), though their patterns and our subgenres serve different purposes. This similarity is likely because the Reddit commenters were discussing the same games that we analyzed (e.g., Panoptic) [1]. Ouverson et al. also speculate about the usefulness of the CAVR dimensions vs. the patterns of asymmetry in the design process [1], which relates to another contribution of this paper: the examination of how subgenres (which are closer in spirit to [1]'s patterns) can be used in the design process. Our paper, while not utilizing CAVR or the specific patterns they identify, does provide a glimpse into the use of a similar framework during the act of design, which is something that has not yet been conducted with any AVR frameworks.

Research by Rogers et al. develops a framework for understanding asymmetries in VR games specifically, though they posit that some elements may apply to non-game contexts [2]. They perform a systematic review of existing research papers discussing AVR games, most of which were designed by researchers to better understand their unique affordances, impacts, and design considerations (e.g., [18–21]). The framework relies heavily on Harris et al. [8] and the MDA framework [14], which the authors find to be highly relevant to the asymmetric VR games they reviewed, though they recommend several refinements that are applicable to the AVR context [2]. This includes combining [8]'s ability and challenge categories, while separating the goal/responsibility mechanics, removing synchronicity and timing from [8], adding the additional aesthetics of asymmetry dimensions (including some from [14]), adding a social asymmetry category that draws, in part, from [22]'s discussion of flow experiences, and adding a shared control category inspired by [23]. These modifications help identify the most salient features of AVR games when compared to more general asymmetric games. Interestingly, despite our different data sources (academic games vs. games "in the wild") and analysis approaches, we arrived at some of the same insights (see the Discussion section), helping triangulate their findings.

A table comparing these core AVR frameworks is included in Appendix A in Table A1. It demonstrates the unique contributions of this paper in comparison to the frameworks just discussed. Specifically, it highlights the unique aspects of this paper, including: (a) using genre as a theoretical lens to develop the framework, (b) developing the framework based, in part, on analyses of playable AVR games rather than a literature review, and (c) evaluating the framework as a generative tool for game designers coming up with AVR concepts.

2.2. Game Genres

As discussed in the introduction, this paper uses the lens of game genre to examine AVR games. Genre is one of the most common ways in which the gaming community, including players, journalists, developers, publishers, and retailers, classify categories of games [9,10]. Genres are used for many purposes, ranging from taxonomic identification to collocation (e.g., to support browsing in libraries) and retrieval, to commercial marketing, to classification, to education and instruction [24]. Unfortunately, "strict and rigid taxonomies" for games are challenging to develop because of the "blending of multiple genre elements and evolution of video games" [24], not to mention the different purposes they serve. This has not kept researchers from careful attempts to define digital game genres, such as [25]'s identification of five genres derived from user surveys based on the Game Elements-Attributes Model (GEAM). While useful for some purposes, mechanics-based approaches (i.e., "ludology" approaches) run contrary to the "narratology" approaches used to classify genres, creating tension that has been hard to reconcile [26]. Still, others argue that it is

the holistic, lived experience and perception of a player that should dictate genre. As Arsenault puts it, "the genre of a game is tied not to an isolated, abstracted checklist of features, but to a phenomenological, pragmatic deployment of actions through the gameplay experience. Gameplay is partly functional and partly aesthetic" [9] (p. 171). The challenges of genre are particularly pronounced in VR games, which can be inappropriately mapped to non-VR genre definitions, which do not capture the affordances of this relatively new genre [27]. However, despite the challenges of creating mutually exclusive genres that cover every game type, we must accept that genres are used widely in practice and serve a communicative purpose that "offers a language to communicate and generalize about a common likeness between games" [11] (p. 8).

Most relevant to our study is the argument by Goddard and Muskat, that genre can be used as a game design research approach [11] (p. 11). They argue that game genre research can "demarcate 'likenesses' worth investigating", building upon [13] (p. 1)'s argument that genre can help "to bridge the gap between the very specific and the very general" so that "variation, tension and significant detail" will not "fall below the radar of academic game studies". Goddard and Muskat identify several ways that genre can inform game design research, including providing a context to motivate research and situation findings, communicating complex design intersections, and grounding, delimiting, and orienting research [11]. In their view, which we share, "genre should not be critiqued in its capacity to be definitive, but rather, for its capacity to describe, explicate, and understand genre in a capacity useful for design" [11] (p. 8). They suggest that "each genre should be investigated with a particular methodology or analytical frameworks, that is appropriate to the genre's sensitivities and salient characteristics" [11] (p. 11). In our context, we have developed such a framework (Table 1, introduced later) by integrating theory from [8] and our bottom-up analysis of community-identified AVR games. They also state that "a systematic analysis into genre includes a theoretical framework employed, informed by the salient characteristics of genre, a proposed selection of genre candidate games, and the means in which they are analyzed", pointing out that different genres need different theoretical and methodological approaches specific to their affordances and goals genre [11] (p. 11). While they do not provide guidance on how to evaluate the generative nature of genre in the design process, they state that "each systematic analysis should offer designerly insights" that can "reveal more than the specifics of games within that genre, but how these specifics are alike, or otherwise meaningfully connected" [11] (p. 11). This paper is an attempt to achieve that for AVR games.

Table 1. AVR Game Genre (AVRGG) framework, based on [8] but customized for AVR games.

Mechanics	
Competitive or Cooperative	Describes whether a game is competitive or cooperative. If a game is both, note which players (VR or non-VR) are cooperative and which are competitive.
Number of Players	Includes the number of players for each platform.
Asymmetric Mechanics	
Goals	Defines how the goal of the game differs between VR and non-VR players. The goal is the main mechanic that determines if a player wins or loses a game.
Abilities	Determines the moves that VR and non-VR players can take to help them reach their goal.
Challenge	Describes how players must use the abilities that they have to reach their goal.
Interface	Explains how the interfaces and controllers between VR and non-VR players differ. This mechanic is universally asymmetric across all AVR games.
Information	Outlines what information a player has access to as they play a game. Information may or may not be asymmetric between VR and non-VR platforms.

Table 1. *Cont.*

	Dynamics
Dependence	Determines if and how players rely on the actions of one another to effectively play a game. Three types of directional dependencies are used: Mirrored dependence: Players rely on each other in the exact same manner. Unidirectional dependence: One player depends on the other to act; however, this dependence is not reciprocated. Bidirectional dependence: Both players rely on each other in different ways.
Synchronicity and Timing	Delineates the timeframes in which VR and non-VR players act respective to one another. Five types of directional dependencies are defined: Asynchronous timing: It does not matter to the other player when one player takes an action. Sequential timing: One player must complete an action before the other. Expectant timing: A player may trigger an action if the other is ready and waiting. Concurrent timing: Both players must continuously take an action at the same time. Coincident timing: Both players must take a specific action at the same discrete time.
	Aesthetics
Theme	Explains how players perceive the game world. This may include descriptors such as narrative, fantasy, sensation, fellowship, etc.
Roles	Describes the asymmetries in how players perceive each other's position in the game world.

3. Methods

3.1. AVR Game Review

We began this research by conducting a review of AVR games to determine the types of genres present in AVR games. There was no comprehensive list of all AVR games, so we searched several common game sources including lists of AVR games from Reddit, Steam, and YouTube [28–30] (data captured on 18 Febuary 2021). Games were included if they had at least one VR player, at least one non-VR player, and players using different platforms had different roles. This meant that some games were excluded from our analysis, including (1) "hot seat games" (n = 7), where players share a single VR headset but only play one at a time (e.g., Dick Wilde), and (2) "symmetric" VR games that had the exact same gameplay for players, except for the interface (e.g., the Tabletop Simulator game where players can play using a VR or desktop device, but the gameplay is identical other than the input device) (n = 23). While future work could analyze such games, our focus in this paper was on AVR games with different types of asymmetries in addition to interface asymmetries (see [8]), since they are the most illustrative of the potential of AVR games and provocative to designers. Six games were also removed because they were unplayable and did not have a video walkthrough with sufficient detail to understand the gameplay. This resulted in 66 AVR games where the player's platform was integral to their assigned mechanics instead of games that simply had an option for the same player roles on different platforms. As a validity check, we conducted various google searches related to asymmetric VR games looking for additional games that we missed. None were identified. Since we do not claim that the subgenres we identified are comprehensive, it is not critical that our search included all AVR games. However, our searches gave us confidence that our dataset included the vast majority of AVR games available in February 2021. A full list of the games along with the producer and year (of the version we played) is found in Appendix B Table A2.

3.2. Subgenre Categorization and Framework

Next, the researchers played the games in the list, or watched game walkthrough videos, and looked for design patterns in their mechanics using an iterative approach. The researchers documented the mechanics of each game in a structured form (Appendix C), specifically noting asymmetry in mechanics between VR and non-VR players and their roles in the games. The researchers then grouped games that shared key mechanics, roles,

and asymmetries, which resulted in five groupings of games that were candidates for subgenres. Each candidate subgenre included at least three game examples with common features.

The candidate subgenres were then further refined using [8]'s framework that defines qualities of asymmetric games based on their mechanics, dynamics, and aesthetics, as described in the MDA framework [14]. We relied heavily on [8] as a starting point, after which we iterated on defining the most salient features relevant to AVR games, including the content (e.g., topics), the look and feel of the game, and dealing with competitive games (as opposed to only cooperative games). At least two researchers iteratively reviewed and discussed criteria for the list of salient features until agreement was reached. We added elements to our list that we thought were important, such as whether the game was competitive or cooperative, the number of players, the theme of the game, and the roles of the players. This forced the team to standardize the salient features of our candidate subgenres in a way that worked for all the games we examined.

Once finalized, we used the list of salient features of AVR games to create the AVR Game Genre (AVRGG) framework (see Table 1). Next, we evaluated how each of the games categorized in the candidate subgenres fit into each of the categories of the framework. The researchers then looked for common patterns between the salient features of the games in the candidate subgenres and created an AVRGG framework template for the final version of each subgenre. The five subgenres are reported in Section 4 (Asymmetric VR Game Subgenres) of this paper. In the end, 32 (48.5%) of the games fell cleanly into these subgenres. Games that did not have common mechanics to our subgenres or included a combination of mechanics from different games were not included, since the focus of this paper was on identifying subgenres with shared characteristics.

3.3. Design Workshops

After we created the AVRGG framework, we held four workshops with novice game designers between October 2021 and June 2022 at a large Western university. Design workshops are often used to give insight into how effective a design framework is in generating new ideas (e.g., [31,32]). Two of the workshops were conducted after the researchers presented the AVRGG framework (framework workshops). The remaining two workshops were conducted with only an introduction to the idea of AVR games, with example games shown, but not the framework (no-framework workshops). By analyzing differences between the two types of workshops, the researchers could determine how the framework influenced the designers as they developed new game ideas.

A total of 34 people participated in this study (see Table 2): 16 participants were in the no-framework workshops and 18 were in the framework workshops. We recruited participants from student clubs and classes at Brigham Young University that were oriented towards games, design, game development, and virtual reality. The framework workshops included more individuals with experience in game design and VR game play, while the no-framework workshops included more individuals with VR game design experience. However, all the participants would be considered novice game designers, in that they had not designed games professionally.

The workshops started with the participants filling out a pre-survey to gather information about their previous experience with VR (see results in Table 2). The survey covered areas such as the amount of VR game design experience, general game design experience, and VR gaming experience for each participant. After completing the survey, the participants listened to a ten-minute presentation on AVR games. Additionally, the participants in the framework workshop were introduced to the five subgenres and the AVRGG framework found in Table 1, after which they were given a survey to test their knowledge of the subgenres. After the survey was complete, the correct answers were reviewed. Next, all the workshop participants were divided into groups of 2–3 people and given 30 min to complete a design activity where they created a novel idea for an AVR game. The participants were highly engaged during the process, using paper, stickers,

markers, and the framework (for the two framework workshops) to capture their game ideas. An example paper prototype of a game created by one of the teams can be seen in Figure 1. Once the activity was complete, each group presented their game to the other participants (see Figure 1). A focus group was then held to discuss the games and how the groups conceptualized their ideas. All the design sessions, presentations, and focus group discussions were recorded and transcribed for further analysis. Our analyses included descriptive statistical analyses of survey data, basic chi-squared statistical tests comparing the framework and no-framework groups, as well as a thematic analysis of the open-ended survey responses, team presentations, design sessions, and focus group transcripts [33]. Artifacts from the design session were also reviewed.

Table 2. Workshop participant demographics and experience levels.

	Framework Workshops (*n* = 18)	**No-Framework Workshops (*n* = 16)**
Age Ranges	18–25: 16 (88.9%) 26–29: 2 (11.1%)	18–25: 11 (68.75%) 26–29: 4 (25%) 30–39: 1 (6.25%)
Game Design Experience	None: 2 (11.1%) Some: 12 (66.7%) Moderate: 2 (11.1%) Extensive: 2 (11.1%)	None: 3 (18.75%) Some: 6 (37.5%) Moderate: 6 (37.5%) Extensive: 1 (6.25%)
VR Game Design Experience	None: 14 (77.8%) Some: 4 (22.2%) Moderate: 0 Extensive: 0	None: 9 (56.25%) Some: 3 (18.75%) Moderate: 3 (18.75%) Extensive: 1 (6.25%)
VR Game Play Experience	None: 1 (5.5%) Some: 8 (44.4%) Moderate: 5 (27.7%) Extensive: 4 (22.2%)	None: 0 Some: 6 (37.5%) Moderate: 5 (31.25%) Extensive: 5 (31.25%)

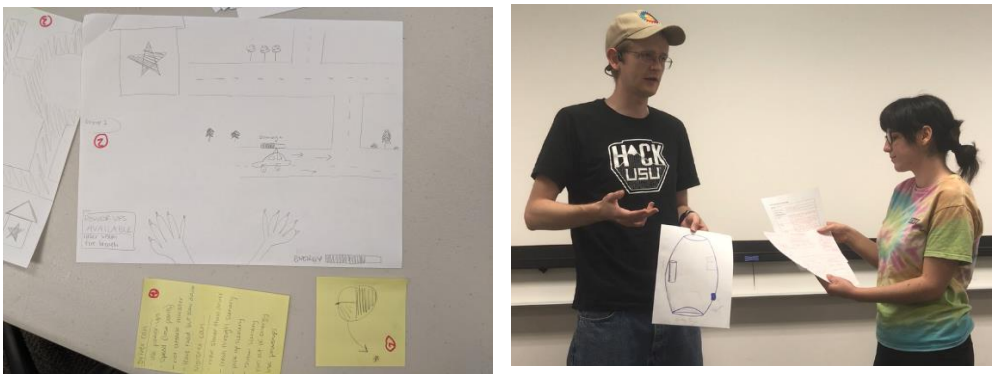

Figure 1. (**left**) Game design artifact created by a workshop group, (**right**) workshop design pair presenting their game concept.

4. Results Part I: Asymmetric VR Game Subgenres

We identified five distinct subgenres of asymmetric VR games: David(s) vs. Goliath, Hide and Seek, Perspective Puzzle, Order Simulation, and Lifeline. Table 3 lists the most popular games that fell in each subgenre. See Table A2 in Appendix B for a full list of all games reviewed with additional details such as city and country of producers. We describe each of these subgenres using the AVRGG framework in the following sections.

Table 3. Examples of asymmetric games for each of the five subgenres.

AVR Subgenre	Example Games
Perspective Puzzle	Seeker: My Shadow (2021) by Jestercraft; Carly and the Reaperman—Escape from the Underworld (2018) by Odd Raven Studios; Eye in the Sky (2017) by VinLia Games; VR Giants (TBA) by Wolfgang Tschuako
David(s) vs. Goliath	Nemesis Realms (2018) by Evocat Games; ACRON: Attack off the Squirrels (2019) by Resolution Games; Late for Work (2017) by Salmi Games; Chicks and Tricks (2019) by Shapeshift Entertainment ApS; Crazy Farm (2018) by Jamong Inc.
Hide and Seek	Panoptic (2020) by Team Panoptes; Mass Exodus Redux (2017) by Polymerse; Jake and the Giant (2018) by Moonshine Games; Hide and Spook (2016) by Murray Lorden; Epochalyptic (2018) by Don Nakashima and Jason Pham; Will of the Sea (2017) by Virtuous Reality Studio
Lifeline	Keep Talking and Nobody Explodes (2019) by Steel Crate Games; Black Hat Cooperative (2016) by Team Future LLC.; Sommad (2017) by Rovango Studio; Cure Creation (2016) by KvasBrag Studios; Operation Armstrong (2021) by Fullbeans Studios; Cop Academy (2019) by Cursing Otter
Order Simulation	Pizza Master VR (2020) by Plectrum XR; Batter Up! VR (2017) by Polygon Duster Entertainment Ltd.; VR the Diner Duo (2016) by Whirlybird Games; Wacktory (2019) by Technical Fowl Games

4.1. David(s) vs. Goliath

In the David(s) vs. Goliath subgenre (see Table 4), a large VR player—referred to as Goliath—battles one or more smaller non-VR players in a shared virtual space. The VR player has limited movement but can access everything within arm's reach. These games typically use the full 360-degree rotation of VR headsets, requiring the VR player to rotate around to see potential attackers, thus reducing motion sickness. In David(s) vs. Goliath games, the VR player can attack by swiping and hitting their opponent. The VR player can also often physically pick up objects in the game and throw them at the non-VR player(s). Non-VR players control an avatar within the same 3D space as the VR player using a 2D interface such as a game controller, a screen, or a smartphone. The non-VR players must dodge and avoid attacks from the VR player, which may require jumping, shielding, or dashing. They must also approach the VR player to launch their own attacks.

Table 4. The AVRGG framework form completed for the David(s) vs. Goliath subgenre.

David(s) vs. Goliath Mechanics	
Competitive or Cooperative	Competitive between VR and non-VR. Cooperative between non-VR.
Number of Players	1 VR, 1+ non-VR.
Asymmetric Mechanics	
Goals	VR: Defeat the non-VR player. Non-VR: Defeat the VR player. May include battle or stealing items.
Abilities	VR: Swiping, grabbing, or throwing objects at the opponent. Non-VR: Attacking, jumping, running, and dodging.
Challenge	VR: Uses arms and body via natural gestures (and/or VR controllers) to combat other player(s). Non-VR: Controls in-game avatar, knows the moves they can use, and gets close to VR player w/o getting caught or hit.
Interface	Inherently asymmetric as an AVR game.
Information	Symmetric: Players typically see stats like health and location for themselves and their opponent.
Dynamics	
Dependence	Mirrored: VR and non-VR player(s) rely on each other to battle on another. Bidirectional Dependence: VR and non-VR player(s) rely on each other in different ways (e.g., VR player tries to keep non-VR player(s) from stealing items).
Synchronicity and Timing	Concurrent: Both players are continuously engaged in attacking and/or defending against the other.
Aesthetics	
Theme	Typically set in an epic battle.
Roles	VR: Perceived as a powerful giant. Slow and clumsy but hits harder. Boss or protector. Non-VR: Perceived as small and weak, but agile and hard to hit. Can do lots of damage over time. Underdog or thief.

4.2. Hide and Seek

In the Hide and Seek subgenre (see Table 5), a large VR player tries to find a small non-VR player in a 360-degree environment who is trying to hide while also achieving tasks that will lead to the VR player losing. The VR player's primary objective is to locate the non-VR player, while the non-VR player's goal is to remain hidden while reaching a specific location or set of locations. Initially, the VR player has no knowledge of the non-VR player's whereabouts, while the non-VR player can see the VR player most of the time and determine where they are looking. As a result, the VR player must wait and look for clues that depend on the actions of the non-VR player. Themes in this subgenre typically revolve around escaping from or overthrowing the all-powerful VR player.

Table 5. The AVRGG framework form completed for the Hide and Seek subgenre.

Hide and Seek Mechanics	
Competitive or Cooperative	Competitive between VR and non-VR player(s).
Number of Players	1 VR, 1+ non-VR.
Asymmetric Mechanics	
Goals	VR: Find and prevent the non-VR player(s) from achieving tasks. Non-VR: Complete tasks that require navigating the environment.
Abilities	VR: Search the map for non-VR player(s) and (optionally) use tools to remove or reset player(s) that are found. Non-VR: Traverse the map, including hiding and (optionally) using abilities that relate to their given task to win the game.
Challenge	VR: Physically move head to search 360-degree area and use arms (and/or controls) to activate tools to help search and destroy. Non-VR: Use game controls to stealthily move in-game avatar and trigger events to win.
Interface	Inherently asymmetric as an AVR game.
Information	Asymmetric: The non-VR player has visibility of the VR player's actions and gaze, while the VR player remains unaware of the non-VR player's location, creating a challenging dynamic.
Dynamics	
Dependence	Bidirectional: The VR player relies on the non-VR player(s) to move through the game in order to have something to catch. The non-VR player(s) must tailor the way they move through the game to account for the VR player who seeks them. While, technically, the non-VR player(s) could play and win if the VR player takes no action (making it Unidirectional), this would defeat the purpose of the intended gameplay.
Synchronicity and Timing	Concurrent: The VR player searches for non-VR player(s) while they attempt to complete a task. Expectant: The VR player sometimes must wait for the non-VR player to move (and vice versa) before they can take decisive action.
Aesthetics	
Theme	Typically takes place in a large room where the non-VR player(s) must escape from the VR player.
Roles	VR: A large and powerful entity that can crush non-VR players without a fight. Non-VR: Small and weak, but sneaky.

4.3. Perspective Puzzle

The Perspective Puzzle subgenre (refer to Table 6) involves a VR player helping a non-VR player to safely navigate an environment from point A to point B (e.g., a platformer game). The VR player has a broader perspective than the non-VR player and is often a large entity in the game that can view the entire map. They have access to information and tools that the non-VR player does not, including the ability to move objects around within the environment to help the non-VR player. The non-VR player uses standard mechanics such as jumping, running, and walking to traverse the environment. In some games, the non-VR player may also access small rooms that the VR player cannot enter. The two players have access to most of the same information and must work together to complete the game's

objective. This can include all of the different types of synchronicity and timing, due to the flexibility of a cooperative platformer game.

Table 6. The AVRGG framework form completed for the Perspective Puzzle subgenre.

Perspective Puzzle Mechanics	
Competitive or Cooperative	Cooperative
Number of Players	1 VR, 1 non-VR.
Asymmetric Mechanics	
Goals	VR: Help the non-VR player navigate a platformer level/puzzle. Non-VR: Navigate the puzzle to reach the end.
Abilities	VR: Moves platforms or obstacles using VR controls. May not be able to move across the environment. Non-VR: Standard walking and jumping as in platformer game. Interacts with objects to solve puzzles or advance.
Challenge	VR: Primarily puzzle-solving, since they can see more than the non-VR player. Must physically use their arms and body to activate abilities and look around the map. Non-VR: Mastery over platforming mechanics, like running and jumping with precision.
Interface	Inherently asymmetric as an AVR game.
Information	Asymmetric: Information can be asymmetric when the VR player can see elements the non-VR player cannot because of their larger perspective.
Dynamics	
Dependence	Bidirectional: Both players rely on each other to progress, but in unique ways the other cannot perform.
Synchronicity and Timing	Asynchronous, Sequential, Expectant, Concurrent, and Coincident: Different types of puzzles can require all of the types of synchronicity and timing (e.g., a VR player may need to complete actions before, after, or exactly during the actions of non-VR player(s) and vice versa, and they are continuously navigating individual puzzles).
Aesthetics	
Theme	Often, both players are trapped in an environment and must solve a puzzle to progress.
Roles	VR: A giant character that is powerful, but benevolent. Non-VR: A smaller, sweet character that needs assistance.

Themes in Perspective Puzzle games are typically fun and friendly, taking elements that players might enjoy from puzzle platformer games and adding cooperative, asymmetric elements. The perception of the VR player from the non-VR player's perspective is usually that of a big, intimidating but benevolent friend, while the VR player sees the non-VR player as a small friend who needs assistance.

4.4. Lifeline

In the Lifeline subgenre (see Table 7), a single VR player must complete a critical or dangerous task while non-VR player(s) act as their lifeline to guide them. Unlike the other subgenres, players in Lifeline games do not typically share the same virtual environment, which means they need to communicate effectively to solve puzzles with limited ability to share visual information. A unique aspect of this subgenre is that players can use the "real world" as their platform, making it easier for players to access and play. The VR player's goal in a Lifeline game is to complete a task that they cannot accomplish alone due to missing information, while the non-VR player's goal is to provide the necessary information to help the VR player complete their mission. Effective communication is key to success in these games. This is the only defined subgenre that primarily operates on sequential discrete timing, at least for versions of the game like "Keep Talking and Nobody Explodes", where non-VR player(s) cannot directly impact the virtual world. The narrative often places the VR player in a dangerous situation where the non-VR player(s)

must then help them escape. These games may appeal to players who enjoy a sense of urgency. Non-VR player(s) may perceive the VR player as a daring field operative, while the VR player may perceive a non-VR player as an important informant, or the proverbial "guy in the chair", or "lifeline".

Table 7. The AVRGG framework form completed for the Lifeline subgenre.

Lifeline Mechanics	
Competitive or Cooperative	Cooperative
Number of Players	1 VR, 1+ non-VR.
Asymmetric Mechanics	
Goals	VR: Complete a given task before the time expires. Non-VR: Assist the VR player with said given task.
Abilities	VR: Abilities vary widely. Uses standard VR controls to manipulate the environment. May or may not traverse the environment. Must communicate with non-VR player(s) for instructions. Non-VR: Can access information that is valuable to the VR player. Can communicate with the VR player to help them reach the goal.
Challenge	VR: Must accurately execute instructions from non-VR player(s) and provide precise descriptions of their surroundings. Non-VR: Must take information from their interface and combine it with descriptions from the VR player to assist the VR player, often requiring logic puzzle solving.
Interface	Inherently asymmetric as an AVR game. Non-VR may include paper-only interface.
Information	VR: Can physically see their surroundings unlike the non-VR player(s). Non-VR: Has pertinent information relevant to the goal that the VR player does not have access to.
Dynamics	
Dependence	Bidirectional Dependence: The VR player relies on the non-VR player(s) unique information (and possibly actions), while the non-VR player(s) rely on different information and unique actions of the VR player.
Synchronicity and Timing	Sequential is the optimal gameplay strategy: 1. The VR player shares information. 2. The non-VR player advise the VR player. 3. The VR player follows the advice. 4. Repeat the sequence. In games where non-VR player(s) can take actions that effect the world, then all other types of synchronicity and timing are possible.
Aesthetics	
Theme	Get the VR player out of a dangerous situation.
Roles	VR: Daring field operative. Must take decisive action from the non-VR player's advice. Non-VR: Informative player(s) that have important advice for the VR player. The proverbial "guy in the chair" or "lifeline".

4.5. Order Simulation

In the Order Simulation subgenre (see Table 8), players collaborate to fill and deliver orders on time to satisfy non-player characters (NPCs). The VR player and non-VR player(s) work together to assemble and deliver specific orders in a timely manner, following a sequence of steps. Unlike the Lifeline subgenre, asymmetry of information is not a necessary mechanic in Order Simulation games. Players rely on each other to perform different tasks, which are often customized to their interface. The timing of tasks typically includes elements of sequential, concurrent, and expectant, as players coordinate their actions and sometimes wait for others to complete tasks. These games often simulate real-life experiences, such as working in a restaurant or factory (although the experience is simplified and even glorified to an extent). The level of interdependence in these games leads to more equal perceptions between players than in other subgenres. Typically, the VR player acts as a manager, remaining in one spot, while the non-VR player(s), who can move more efficiently, acts as a floor operator.

Table 8. The AVRGG framework form completed for the Order Simulation subgenre.

Order Simulation Mechanics	
Competitive or Cooperative	Cooperative
Number of Players	1 VR, 1+ non-VR.
Asymmetric Mechanics	
Goals	Symmetric: Work together to obtain a high score by filling orders under time pressure.
Abilities	VR: Use VR controls to assemble objects, deliver items and objects to non-VR player(s), and communicate with non-VR player(s). Non-VR: Deliver and move objects around the floor, take orders from NPCs if the VR player cannot see, and communicate with the VR player.
Challenge	VR: Manipulate objects physically to assemble them accurately and quickly while following instructions from non-VR player(s). Non-VR: Control avatar to take and fulfil orders accurately and quickly. May need to remember orders and deliver them accurately to the non-VR player.
Interface	Inherently asymmetric as an AVR game.
Information	VR: (Sometimes) instructions for assembly. Non-VR: (Sometimes) orders that must be fulfilled.
Dynamics	
Dependence	Bidirectional: VR player and non-VR players rely on each other to receive, fulfill, and complete orders using different abilities.
Synchronicity and Timing	Sequential: A player must complete a task (e.g., bake a cake) before another can take one (e.g., deliver it). Concurrent: All players are continuously taking actions at the same time (e.g., receive and fill orders). Expectant: A waiter must wait until a cook delivers the meal before they can take it around.
Aesthetics	
Theme	Often a restaurant or factory.
Roles	VR: Overwhelmed manager or chef in back room. Non-VR: Busy floor operator or waiter taking and delivering orders.

5. Results Part II: Evaluating the AVRGG Framework and Subgenres for Design

One goal of the AVRGG framework and the five subgenres was to help game designers generate new ideas. Our hypothesis was that game designers could leverage our framework to easily conceptualize new game ideas that enhance AVR experiences while building upon existing game structures. They could use the subgenres as a starting point. The intent was not to promote cookie-cutter games but to provide designers with the ability to modify, combine, or build upon subgenres to create engaging AVR games. To evaluate the effectiveness of the framework and subgenres, we conducted four design workshops, two of which employed the framework and subgenres while the other two did not. Our investigation focused on assessing whether designers could understand and apply the AVRGG framework and subgenres. Additionally, we sought to identify the primary challenges when designing AVR games in this context.

5.1. Can Designers Understand and Apply the AVRGG Framework and Subgenres?

Understanding and applying the AVRGG framework is a necessary, but not sufficient, requirement for its usefulness as a design tool. During the two framework workshops, the participants were introduced to the AVRGG framework, with examples of the different types of asymmetries, as well as the five subgenres. They were then shown a trailer video for five different games and asked which of the five subgenres it belonged to. Overall, 91% of the answers were correct. The 5 incorrectly labeled instances, out of 55, were with games that fell in the Perspective Puzzle and Lifeline subgenres, likely because they both were cooperative games that shared several mechanics. Observations of the design sessions and transcripts indicated that the framework workshop participants were confident in their understanding of many of the key asymmetries and the core idea of AVR games. The groups accurately discussed the competitive/cooperative distinction, the number of players, game

themes, and the core asymmetric mechanics. For example, their papers included accurate notations in the different asymmetric mechanics categories. The one exception was the investment category (discussed in [8]), which was not used or discussed by any groups, except to indicate confusion about it. We decided to remove it from the finalized AVRGG framework (Table 1) since it was not important to any of our AVR subgenres or used by any design groups.

Overall, the game designers in the framework groups ranked the usefulness of the framework as a 7.4 on a scale from 1 to 10, with 10 being the most useful. They were also asked why they found it useful, if they did. Several of the framework workshop participants mentioned how the framework helped the groups be "efficient" and "communicate" more effectively: "Having the same language to describe our options made communicating really easy" and "Having the framework. . .helps organize thoughts". Others mentioned how the framework helped them when "deciding on an idea". Another mentioned how "outlining basic goals and abilities really helped things go faster. I think all the parts of the framework were nice to be aware of though because there are lots of details to think about" (F-10). Some mentioned that "the genres were useful", while most mentioned specific game mechanics (e.g., goals, competitive vs. cooperative, abilities, information, challenges, abilities). Many groups started their design sessions by discussing if they wanted a competitive or cooperative game. Another common starting point was to discuss the theme of the game, such as dinosaurs or space. Goals and abilities were also commonly mentioned mechanics: "The goals and abilities sections were most useful because it helped me keep the end goal in mind for both the VR player and non-VR player and think about whether it would be interesting enough. I also liked the abilities section to help keep thoughts organized and remember what the abilities were for each type of player" (F-5). Nobody mentioned the dynamics categories as being the most important, though some did discuss them in their design sessions and made annotations about them. Designers also rarely used the dynamics sections, especially the synchronicity and timing section (see Table 1), though this may have been due to the fact that we only had time to design the core concepts of the game and dynamics decisions often come later in the design process.

In addition to capturing self-assessments of the AVRGG framework's usefulness, we analyzed the output of the 16 groups' game concepts. Tables 9 and 10 show a title, description, and an assessment of the subgenre that matches best (if any) for each game concept. A comparison of the no-framework workshop games (Table 9) and the framework workshop games (Table 10) suggests how the framework influenced the final game concepts.

Table 9. Games designed by the eight groups in the no-framework workshops.

Group	Game Description	Closest Potential Subgenre
"Minions vs. Giants"	Multiplayer online game where VR players are giants and non-VR players are minions. Both giants and minions can be on the same team and fight other teams.	David(s) vs. Goliath *
"Space Race"	VR players fly a ship to try and escape a space station. Non-VR players can either help or hinder the ship.	None
"Apollo 13"	VR player(s) play astronauts completing tasks on a space station. Non-VR player is ground control and must assist while also trying to mitigate a cyberattack.	Lifeline
"Cops and Robbers"	Non-VR players can play as cops or robbers retrieving jewels on a map, while a VR player acts as a security guard to activate traps and help the cops.	Hide and Seek *
"Parks and Wreck"	Three roles: a helicopter player (VR), a T-Rex (VR), and park guests (non-VR). The T-rex tries to eat everyone, and the helicopter pilot tries to save the park guests. The park guests maintain power, build an escape vehicle, and help others survive.	David(s) vs. Goliath *
"Dino wants Pizza"	PC players are delivery drivers trying to deliver pizza to houses. The VR player is a monster trying to stop the PC players. Each has unique power ups.	David(s) vs. Goliath + Order Delivery

Table 9. *Cont.*

Group	Game Description	Closest Potential Subgenre
"Star Trek"	A multiplayer spaceship sim where players have different roles such as navigation, weapons, resource collection, and drone piloting. Some players are VR while others play on different platforms.	None
"Storming the castle"	VR player is a villain with a booby-trapped lair that uses security footage to trigger traps against non-VR players. Non-VR players aim to enter the lair to capture the villain without direct combat.	David(s) vs. Goliath *

* This game concept does not fit exactly with definitions of this subgenre but has similar mechanics.

Table 10. Games designed by the eight groups in the framework workshops.

Group	Game Description	Closest Potential Subgenre
"Spaceship game"	One non-VR player is a spaceship captain running out of oxygen, while the VR players act as drones. The captain guides the VR players through the ship to fix it and save the captain's life. Most games with immobile characters who can see maps feature the VR player as the immobile character. This game reverses that notion.	Lifeline *. Game switches roles with non-VR players aiding the VR player.
"Missile defense 3D"	The VR player defends themselves against non-VR players. The non-VR players are in spaceships and fire missiles at the VR player, and the VR player has a sword they can use to hit the spaceships.	David vs. Goliath
"Spaceship sim CTF"	The VR players fly spaceships and compete against other VR players in a capture the flag style competition. The non-VR player has an overview of the battlefield and can advise the VR players. The VR players can place probes on the ground to expand the line of sight for the non-VR player.	None
"City builder/destroyer"	The non-VR players hide from the VR player and rebuild the city while the VR player destroys the city and tries to find the non-VR players. The non-VR players collect building materials, evade the VR player, and win the game if time runs out before they are found.	Hide and Seek + David and Goliath
"Rouge AI ship vs. ship crew"	The VR player is an evil AI with control of a mainframe of a spaceship computer. The VR player can close doors, drain rooms of oxygen, and open the airlock to thwart non-VR players. The non-VR players attempt to shut down the rogue AI (the VR player) by shutting off power sources and getting to the mainframe computer.	David vs. Goliath
"Rat Race"	Several non-VR players must get to the end of a labyrinth before an AI enemy catches them. One VR player assists by removing obstacles along their path.	Perspective Puzzle
"Keep Them Out"	Non-VR players must assemble ammo for a VR player who must shoot enemies trying to breach a keep.	Order Simulation *
"Sharks and Minnows"	Hiders (non-VR players) must get from one point to another without being captured by the seeker (VR player). Different themes include underwater, forest, and grocery store.	Hide and Seek

* This game concept does not fit exactly with definitions of this subgenre but has similar mechanics.

Nearly all games designed in the no-framework workshops did not align directly with a single subgenre. This is not too surprising, since these workshop participants did not learn about the subgenres. The one exception was the "Apollo" game, which cleanly fit into the Lifeline subgenre. Two of the games showed no connection to the subgenres, and the remaining games were modifications of our subgenres but did not technically fit the subgenre descriptions entirely. The games that matched or were similar to a subgenre occurred because the design teams drew inspiration from games they were already familiar with that happened to belong to one of our subgenres. These were sometimes brought to their remembrance because we introduced AVR games using one example from each subgenre, even though we did not describe the subgenre or framework.

In contrast, four of the eight groups in the framework workshop designed a game that aligned directly to one of our subgenres. It is important to note that we did not tell the groups to match any subgenres, though they received a handout with the AVRGG framework and the summary of each of the five subgenres. One group combined key

elements of two subgenres, two others had slightly modified subgenres, and one was not close to any subgenre. Although the subgenres were used extensively during the design process, as evidenced by their design artifacts and observations, the framework groups did not feel constrained to match one of the subgenres directly. For example, the "Spaceship game" is like the Lifeline subgenre, but instead of one VR player looking for help, there are several VR players helping a non-VR player. "City builder/destroyer" combined the Hide and Seek subgenre and the David(s) vs. Goliath subgenre. "Spaceship sim CTF" took mechanics from David(s) vs. Goliath, but the final product does not match any of the described subgenres. This was a conscious choice, as indicated by a team member who stated that: "We wanted to try to make a game that didn't fit in the given subgenres. We talked about familiar games and what we personally liked/didn't like. We helped each other flesh out the ideas". Interestingly, the group still used the AVRGG framework documents and concepts to flesh out their idea, indicating value in them, even when there was not a desire to use one of the five provided subgenres. Overall, providing existing subgenres along with a genre framework seemed to promote some adherence to the provided subgenres (half of the groups) while also supporting creative exploration of the space through modification, combination, and/or intentional avoidance of provided subgenres.

5.2. What Are the Primary Challenges of Developing AVR Games?

There were several challenges identified by the participants and observed by the researchers during the design workshops. The participants were asked "What were some of the biggest challenges you faced when designing your game?" in the post-workshop survey. Additionally, this question was brought up in the focus group at the end of each design workshop, and the researchers analyzed the design sessions for additional insights. By far, the two most significant challenges identified were balancing game mechanics (to ensure the game was interesting for both VR and non-VR players) and making the games original. We discuss these challenges below, along with the impact of the AVRGG framework on them.

5.2.1. AVR Game Balancing

Balancing the game between VR and non-VR players was the most common challenge raised by the workshop participants. In total, just over half (52%, 17 of 33 participants) of the participants discussed some aspect of game balancing in the open-ended post-workshop survey question about the "challenges faced when designing a game". Several participants mentioned the need to make it "fun" and "engaging" for VR and non-VR players: "finding fun things for both the PC user and the VR user" (NF-2); "hard to find gameplay models where PC and VR were equally fun" (NF-5); "it was difficult to decide how both VR and non-VR players could feel engaged" (NF-6). Others mentioned the need to balance gameplay mechanics in a way that made VR and non-VR players feel like their actions were important (in collaborative games) and fair (in competitive games): "Our biggest challenge was deciding how the non-VR player can support the VR player in our reverse order simulation idea" (F-3); "...anticipating how to make the playing field level for the asymmetric players" (F-7); "...making the differing capabilities between roles balanced and important" (F-14); "trying to make sure that each role would have enough things to do and in making sure that one role did not have a significant advantage over another" (NF-16); "...decide how to make the game fair between both versions of players" (NF-13); "...I tried to make sure to have a balance of abilities so every player could have a fun experience and feel like their actions had a real impact on the outcome of the game..." (NF-4). A few participants described balancing in the context of working around "the limitations of VR technology" (NF-11); "I think the biggest struggle was balancing a game in a 3D world where the VR player is supposed to stay relatively stationary compared to others" (F-6).

The focus group discussions reinforced the individual survey responses in emphasizing the difficulties of balancing asymmetric VR games. When asked what was difficult

about the design, one participant responded "Definitely balancing. There's so many ideas that sound really fun when you're a VR player and some of these sound fun for the PC player; having one that sounds fun for both is kinda hard" (NF group). Another participant described how balancing was uniquely challenging for asymmetric games: "I think for me, it's very natural to think of a symmetric game where you start out with one player and you think of a goal for that one player and everyone's going to be the same level. And so it's hard to immediately think of the asymmetric aspect of how two different things are going to come together and work together and be balanced" (F group). Another participant describing a collaborative game mentioned that "you don't want [the game] to be boring for one player; and then, you know, have everyone else doing all the work" (F group).

When observing the design sessions, we noticed many discussions about game balancing. For example, the "Storming the Castle" group started by conceptualizing what the VR player could do and then shifted to a discussion about making sure the non-VR players would have enough to do. After discussing the role of the VR player, one of the designers summarized "That's some good gameplay for the VR player. How do we make it more interesting for the PCS players?" (NF 15 and 14). The "Rogue AI Ship" framework group designed a David vs. Goliath game and discussed the need for balance by emphasizing that "a good way to constrain the VR player is to have a limited amount of power" (F-12 and 7).

Impact of Framework on AVR Game Balancing

The framework seems to have helped the participants conceptualize how to balance AVR games. Six of the seventeen (35%) participants in the framework group mentioned game balancing compared to eleven of the sixteen (69%) participants in the no-framework group. A chi-squared test comparing the percentage of participants in each type of workshop was significant at the 10% level: χ^2 (1, N = 33) = 3.694, p = 0.055. Thus, those with the framework mentioned game balancing challenges less often than those without the framework, suggesting that the framework helped to address this challenge.

The AVRGG framework helped with game balancing in two primary ways. First, the AVRGG framework (see Table 1) explicitly prompts those using it to consider how different mechanics apply to VR and non-VR players (e.g., challenges, actions, information). Many design sessions from the framework group discussed these mechanics for both VR and non-VR players as they worked their way through the blank framework document provided to them. As a result, the framework helped them consider all player types as they made key design decisions about core game mechanics. Second, as discussed earlier, many of the groups chose an existing subgenre to base their game off. Because existing games use time-tested structures to balance AVR games, novice designers do not run into as many problems as they would have without such a template. Interestingly, most of the framework participants did not explicitly articulate how the AVRGG framework and subgenres helped them with game balancing, though they did recognize their overall benefits, as discussed earlier. For example, one participant mentioned how the framework was useful because they would think about how existing Order Simulation games "overcame similar hurdles", though they did not mention game balancing explicitly (F-3).

When asked how the framework could be improved, they wanted to see more explicit details focused on game balancing. For example, one participant stated "I would add a section discussing to make the asymmetric players more equal" (F-7), while another recommended: "Maybe have a place to enumerate the top 3 contributions of each role to help designers consider the balance between those roles" (F-14).

5.2.2. Game Originality

The second most common challenge of designing AVR games for designers with and without the framework was making the games original in some way. In total, 9 out of 33 participants (27%) brought up originality in the survey question asking about challenges they faced during the design process. For example, one participant described the most

difficult challenge as "thinking of an idea that didn't copy other already existing games" (NF-6). It seemed to be a challenge at the start of the ideation process for several participants: "It was hard to see how potential ideas could be different from existing games at first" (F-5); "The biggest challenge was to come up with an idea for an asymmetric game. I was trying to think of an experience more unique, but everything that came to mind was too generic" (F-15); "It was difficult. . .thinking of an idea that didn't copy other already existing games" (NF-6). A smaller subset of survey respondents mentioned the need for unique game mechanics, such as NF-10, who described the biggest challenges as "not cloning mechanics from existing asymmetric monster games".

The participants debated about the importance of having a highly original game during some of the focus group and design sessions. In one no-framework design session, a more experienced designer emphatically defended the idea that new game designers often focus on originality, while more experienced game designers stick closely to existing genres that can sell familiar games, while innovating in the nuances of how they are implemented. One of the framework participants mentioned how "If something is too far out there and too different, then it'll be hard to find the fan base". This idea also emerged in a no-framework focus group discussion that illuminated the possible limitations of being too original:

"Speaker One: So it's okay to have been inspired by other games?"

"Speaker Two: "I know that was something I had a hard time realizing; that originality isn't always good, because if it's something really alien to, like, the regular player, they might be less likely to get it. There's a balance between familiarity and originality".

Some of the designers recognized the limitations of VR headsets and sought to give more variety to VR players who often have similar mechanics: "I wanted to come up with an idea that gives the VR player more to think about then just looking and walking a bit and flailing arms. They need an environment to move in, and gameplay beyond what most VR games offer them currently. Too many have you stand in one place and VR can be more. I also wanted something unique, as there is a glut of games that are all the same for VR, and they tend to be shallow" (NF-14). Another NF participant mentioned trying to "break the conventions of a lot of games we saw" by making the VR player "a little actor in a big world rather than the other way around as most of the game had it".

In summary, the participants in both the framework and no-framework groups frequently considered the originality of the game they were designing. There was generally a desire to create original games but also a recognition by the more experienced designers that creativity could be expressed within the confines of a recognized genre.

Impact of Framework on AVR Originality

As a research team, we were curious how the framework would impact the originality of the games that were designed by the participants. Would they stick strictly to one of the genres presented to them? Would they feel comfortable deviating from them or combining or ignoring them? Would those in the no-framework group create games that matched the genres simply based on the example games that were presented? As described in Section 5.1, the games that were designed in the framework workshops tended to match the AVRG subgenres more often than those in the no-framework workshops. Four of the eight groups (50%) in the framework group had games that fit one of the five subgenres exactly, compared to only one out of the eight games (12.5%) in the no-framework group. A chi-squared comparison was not quite significant at a 10% value, though the sample size was small: χ^2 (1, N = 16) = 2.618, p = 0.106. Despite there being more subgenre matches in the framework workshops, it is important to note that half of the games (4/8) did not match a subgenre directly, but instead combined subgenres (n = 1), modified a subgenre (n = 2), or did not relate to any subgenre (n = 1). Thus, over half of the designers did not feel compelled to stay strictly within the subgenre descriptions. This was consistent with comments from the workshop participants who indicated a willingness to mash-up subgenres: "I thought it would be a cool idea to incorporate several genres in one game" (F-10); "I was unaware of existing AVR genres, and having some samples of ideas helped to

synthesize new ones" (F-12); and "Some of my ideas came from video games that I've seen and drew inspiration from, and other ideas came from my partner and I trying to cater to the Lifeline genre" (F-11).

When asked about the most challenging aspect of designing AVRGs, around the same number of people in the framework and no-framework group mentioned making games original. Another chi-squared test was performed comparing the percentage of participants (framework vs. no-framework) that mentioned coming up with a new idea as a challenge faced. Four of the seventeen (24%) participants in the framework group brought up originality, compared to five out of the sixteen in the no-framework group (31%). The results were not significant at a 10% value: χ^2 (1, N = 33) = 0.248, p = 0.062. This suggests that coming up with an original game is a perceived challenge for those with or without the framework.

Comments from framework participants and observations of their design sessions helped to unpack how the framework impacted their ability to create original games. Some designers started by choosing an existing subgenre, which made it easier to make progress right away: "Our thought process started by considering what genre we liked the most, finding a modern or futuristic scene to place the game in, and determining how to make the two player types equal having different abilities and scope" (F-7). Others mentioned that "we first narrowed down our subgenre and then described the mechanics specific to our game" (F-3). Our observations and review of the transcripts suggest that many groups started by discussing which genre they wanted to focus on, though other groups chose a theme or core idea and then discussed its relation to subgenres later. For example, "I thought about types of games I already knew about, and whether or not they could be made into asymmetrical games within asymmetrical subgenres. . ." (F-13). This process of starting with specific games rather than genres was also common in the no-framework workshops.

Several of the participants directly discussed the impact of the framework on creativity, with most of the participants feeling that it helped them be more creative or at least understand what was and was not original. One participant mentioned that the subgenres "kinda pigeon hole me somewhat, but that's the world of video games. . .There is always a drive to be original, but it helps to try to make a more grounded game idea when I'm focusing on an existing genre" (F-1). Another described the framework as "very useful" because after picking the "lifeline" subgenre, "It made it really easy to brainstorm and talk about it. Creativity is cool when you're exploring category constraints" (F-16), an idea reiterated by others who mentioned liking the usefulness of constraints. Some participants mentioned that the framework helped them "identify where you are and aren't blazing a new trail" (F-1). For example, F-13 mentioned that the framework "helped to know what already existed so as to help me get an idea of the kind of limitations that exist in designing this type of game". Participant F-6 mentioned how the subgenres "were very helpful to expand the possibilities. Most of the games I immediately thought of were David v Goliath and thinking about the other categories helped make the game more unique". These quotes and observations illustrate how the designers leveraged the subgenres in their design process in different ways but overall felt that it enhanced their creativity rather than overly constraining it.

6. Discussion

In this paper, we presented the AVRGG framework and used it to identify five subgenres of AVR games, including David(s) vs. Goliath, Hide and Seek, Perspective Puzzle, Order Simulation, and Lifeline. The five subgenres we identified describe nearly half of all the AVR games in our corpus. The goal was not to define subgenres that covered every type of AVR game. Instead, the goal was to identify the most explored areas of the AVR game design space. The fact that half of the AVR games did not fit into these five subgenres suggests that there were no other clear clusters in the design space. We expect that as

more AVR games are released, new clusters will emerge and warrant the identification of additional subgenres by future research.

Unlike prior AVR frameworks based on reviews of the academic literature [2,12] or Reddit comments [1], this paper directly examined AVR games available to play (e.g., via STEAM at https://store.steampowered.com/, assessed on 31 December 2023). We see these as complementary approaches. Identifying specific subgenres using our AVRGG framework helps identify quadrants of the overall AVR game design space that are particularly productive. On a practical note, we suggest that game designers consider not only high-level game genres (e.g., AVR games) but also subgenres such as those we have identified. While game designers often pull from example games, there is value in grouping those games into subgenres to better see the variety of games that use similar game mechanics.

The AVRGG subgenres shared some key gameplay characteristics, yet there was a surprising range of variation. For example, there was only one VR player in all the subgenres, while most allowed for one or more non-VR players. This is likely because most households only own a single VR headset while owning multiple mobile devices and/or computers. As VR headsets become more popular, we expect to see more games that allow for multiple VR players, similar to some games our novice designers came up with. We also saw most genres use a large, stationary avatar that rotates 360 degrees for the VR player. This reduces motion sickness, since it keeps the movements of the VR player more consistent with the movements of the VR avatar, reducing the mismatch that can lead to cybersickness [34]. Despite these similarities, the subgenres illustrated very distinct experiences ranging from competitive to cooperative, realistic to fanciful, battle-oriented to strategic. There was also significant variation within specific subgenres, given the different themes and ways that mechanics and dynamics were implemented. On a practical level, game developers may consider developing "templates" for game subgenres that make developing new games of the same subgenre more efficient. While this approach necessarily puts constraints on games, our findings suggest that there is still a large range of games that can be created within the same subgenre. Our subgenre analysis provides an early look at the emerging AVR game landscape, helping to identify synergistic combinations of mechanics, dynamics, and aesthetics that could be developed into such "templates".

In addition to identifying common subgenres, our AVRGG framework was designed to help characterize the core asymmetries and inspire new AVR games. Our framework is similar to two other AVR frameworks that were developed at the same time as ours was being developed and tested [2,12], though our framework was designed based on different sources and for an explicitly generative design purpose. For example, all three frameworks draw heavily on Harris et al.'s paper [8] on asymmetric gameplay, though they seek to tailor it to AVR contexts. The similarities of the independently created frameworks help build a strong case for the common elements (as also noted by [1]) while also suggesting that our workshop findings may also apply to the other frameworks. For example, our study based on games "in the wild" and design workshops found that the "investment" mechanic was not useful, which was consistent with Rogers et al.'s finding that no research papers had games that used that mechanic [2]. Furthermore, Rogers et al. [2] found that the Harris et al.'s [8] timing and dynamics categories were hard to apply to AVR games (especially competitive games), which was consistent with our finding that the novice designers struggled in using them as meaningful springboards for design. Similarly, all three frameworks showed the value of applying concepts from Harris et al.'s work [8] while also recognizing the need to extend and modify it to AVR contexts.

An evaluation of the CAVR Framework [12] based on Reddit comments, most of which discussed AVR games, provides perhaps the closest work to our genre analysis [1]. As part of their analysis, Ouverton et al. identified "patterns" that describe the "types of asymmetries" that emerged from the comments, several of which relate to the core mechanics and AVR subgenres identified in this work [1]. The closest matches included: our David(s) vs. Goliath genre with their patterns of Dueling, as well as Boss vs. Horde,

which they describe as a subset of Dueling; our Hide and Seek genre with their Hide and Seek pattern; our Perspective Puzzle with their Navigator and Pilot; and our Lifeline with their Teleguidance [1]. Although they are similar and even reference some of the same games, they differ in that our genres are a full collection of mechanics, dynamics, and aesthetics rather than a single theme. Still, the consistency from different sources (Reddit comments vs. actual games reviewed) provides support for the importance of these concepts. Their description of team interdependence in these games recognizes the importance and limitations of the idea of competitive and cooperative mechanics, arguing for the need to consider these in conjunction with the goals of each player [1]. Our framework characterizes the entire game as cooperative or competitive (or both, such as when multiple "Davids" collaborate to compete against a "Goliath"), but the nuances of the players' goals are captured in a separate mechanics section of the framework. Finally, they identify that the "symmetric balance of power is difficult to maintain" [1], which is similar to our observations from designers that game balancing between VR and non-VR players is a significant challenge. They make the point that games that have an asymmetric balance of power seem to be the most desirable [1], which is consistent with our genre analysis wherein all of the common genres we identified have such a balance. The authors recommend that future work "analyze the interactions and patterns of asymmetry within asymmetric VR games", which is the focus of this paper [1].

Despite the similarities, there are some key differences between the AVR game frameworks as well. While the AVRGG framework was explicitly designed to help designers and included the subgenres as a mechanism to assist, the other frameworks were explicitly conceptual, though they included aspirations to be generative [1,2,12]. While all papers extended the Harris et al. framework [8] to apply to AVR, they did so in different ways. Ouverson and Gilbert's Composite framework of co-located asymmetric VR (CAVR) used elements from asymmetric games research, but it did not focus solely on a games context [12]. Rogers et al. added aesthetics categories, social asymmetries, and shared control to their framework, which focused specifically on supporting AVR games [2]. Our AVRGG framework was less detailed, though it added the aesthetic categories of theme and roles, which we found to be flexible enough for designers to use in creating AVR games. However, it is possible that having the more detailed categories of Rogers et al. would lead to novel ideas for AVR games. Furthermore, both the Rogers et al. [2] and CAVR [12] frameworks include details on the differences between players (e.g., age, skill level), which our AVRGG framework did not. Most existing AVR games target a broad range of players, making this a secondary concern for many designers, though it would become increasingly important if designing more targeted games, such as for educational purposes. Since our AVRGG framework is the only one that has been tested with designers, it is hard to say how appropriate the other two are for designers. Based on our experience, we believe that the more abstract the framework, the harder it will be for designers (in our case novice, designers) to apply. Thus, frameworks that include a high level of abstraction, such as CAVR [12], may be more difficult for game designers than our AVRGG framework or the Rogers et al. framework [2], though this remains to be seen.

Our workshop findings demonstrated the value of using an AVR game framework to inspire new AVR game designs. The results suggest that the AVRGG framework can help novice game designers find inspiration from patterns in existing AVR subgenres, communicate game ideas more effectively, better balance asymmetric mechanics in AVR games between VR and non-VR players, and inspire new and unexplored ideas within the AVR genre. The asymmetric mechanics drove the differences in subgenres more than the dynamics and aesthetics, though those were also critical components. Future work could build upon our AVRGG framework by finding new ways to present the information and encourage its use. For example, card decks that highlight the different mechanics, dynamics, and aesthetics could be used for a more playful approach to game concepting. Alternatively, an online AVR game design tool, based on the AVRGG framework, could sup-

port game concept design using an interactive web tool for selecting different combinations of mechanics, dynamics, and aesthetics.

Our study also identified the two most salient challenges faced by those designing AVR games: (a) game balancing across VR and non-VR players and (b) developing original games. Although the AVRGG framework helped the designers with both issues, several designers called for even more guidance on how to make games fun and engaging for VR and non-VR players in a balanced way. While using the AVRGG framework and subgenres led to more games that matched the subgenres (arguably less "original" games), half of the designers modified, combined, or purposefully avoided the subgenres presented to them. This suggests that designers need not worry that presenting subgenres will over-constrain novice designers. Instead, as several of our designers recognized, having a subgenre can provide the "creative constraints" necessary to jumpstart novel game designs. It is our hope that game designers and researchers will continue to use the subgenres we presented as a launch pad for creating new and original AVR games. By looking at the existing selection of AVR subgenres outlined in our framework, game designers can combine or flip elements to expand their games beyond the limits of what currently exists and create unique interactions that leverage the strengths of AVR. As more developers create more games of this genre, more research will be needed to keep up with how the genre evolves.

Besides AVR, more research is also needed to evaluate genre as a design tool. Although our study included 36 participants spread across four design workshops (with and without the AVRGG framework), which is typical of this type of work, it was still limited. Future studies should examine more diverse designers (e.g., experienced and novice designers) and not only focus on creating game concepts. For example, designers who must implement AVR games may find some of the elements of the framework more important (e.g., dynamics) or desire other elements missing from AVRGG. Studies of game jams that are long enough to implement games or semester-long courses where students create them seem promising. Recent work that develops tools to support the creation of AVR games may enable the rapid prototyping of AVR games [16], lowering the barriers for the implementation of games. Additionally, the AVR games we studied were based on those available in 2021, and the space continues to evolve rapidly. While our study captures a baseline of the AVR subgenres at this early stage, future work can explore how these subgenres develop as the availability of headsets and their capabilities increase, as well as how new AVR game subgenres emerge over time. It is our hope that this work will inspire future researchers and designers investigates the salient features of different AVR game genres.

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Appendix A. AVR Framework Comparison Table

Table A1. AVR framework comparison.

AVR Framework	Goal(s)	Incorporated Theories	Framework Development: Sources and Methods	Framework Validation: Sources and Methods
AVR Game Genre Framework (AVRGG) [this paper]	Identify common AVR game genres. Help game designers create new AVR games.	MDA framework [14], asymmetric game framework [8]	Genre analysis of 66 playable AVR games.	Comparison of design workshops, wherein novice game designers developed game concepts with and without the use of the AVRGG framework and example AVR subgenres.
Composite Framework for Asymmetric VR (CAVR) [1,12]	Integrate conceptual frameworks for asymmetric interaction, mediation technology, and computer-supported cooperative work (CSCW) to clarify the dimensions of asymmetry into a composite framework of asymmetric VR communication. Not focused solely on games.	Asymmetric game framework [8], communication in teleoperations interfaces [35], shared mixed-reality spaces [36], dimensions and antecedents of team virtuality [37], communication in virtual teams [38]	Scoping review of 18 relevant "framework papers" from communications, game design, and CSCW [12]. Refinement based on analysis of asymmetric patterns identified by Reddit comments [1].	Analysis of Reddit comments about AVR systems to identify patterns of co-located use in VR [1].
"Best Fit" A Priori Framework for Asymmetric Multiplayer VR games [2]	Develop a "best fit" framework of AVR games based on existing literature and games discussed in research papers.	MDA framework [14], asymmetric game framework [8], group flow experiences in gameplay [22], Shared control patterns in multiplayer games [23]	"Best fit" a priori framework developed based on four core theoretical articles on asymmetric gameplay or gameplay more generally.	"Best fit" framework synthesis of a priori framework including analysis of 25 articles identified via a systematic review. Resulted in updated post hoc "best fit" framework.
Taxonomy of Asymmetric Interfaces for Collaborative Immersive Learning [3]	Characterize how asymmetric game mechanics influence communication and collaboration between learners. Not focused solely on games.	MDA framework [14], asymmetric game framework [8], 3D user interfaces [39], visual display information [40], communication channels [35]	Narrative literature review.	No evaluation provided.

Appendix B. AVR Games Reviewed

Below is the list of AVR games that we reviewed along with the game publisher, location (if available), year published as of our data collection period (if available), and the subgenre they corresponded to, if any (X indicates it did not match any of the subgenres). Note that some games have been rereleased due to significant updates.

Table A2. List of AVR Games Reviewed.

Name	Publisher	Year Published	AVR Subgenre
Acron, V 1.14	Resolution Games, Stockholm, Sweden	2019	Davids vs. Goliath
Chicks and Tricks	Shapeshift Entertainment ApS	2019	Davids vs. Goliath
Crazy Farm	Jamong Inc., Daegu, Korea	2018	Davids vs. Goliath
Davigo	Davigo Studios, Vancouver, BC, Canada	2021	Davids vs. Goliath
FatFoods VR	Team 21 Studios, Aiken, SC, USA	2018	Davids vs. Goliath
Late for Work	Salmi Games, Munich, Germany	2017	Davids vs. Goliath
Nemesis Realms	Evocat Games, Helsinki, Finland	2018	Davids vs. Goliath
NovaSwarm	PB&JoyGames, Manchester, CT, USA	N/A	Davids vs. Goliath
Takelings House Party	DimnHouse, Los Angeles CA, USA	2019	Davids vs. Goliath
Blue Effect VR	DIVR Labs, London, UK	2016	Hide and Seek
Epochalyptic	Jason Pham and Don Nakashima, N/A	N/A	Hide and Seek
Hide and Spook	Muzboz Games, Melbourne, Australia	2016	Hide and Seek
Mass Exodus	Altaire, N/A	2017	Hide and Seek
Panoptic	Team Panoptes, Brussels, Belgium	2020	Hide and Seek
Will of the Sea	VirtuousRealityStudio, N/A	N/A	Hide and Seek
Black Hat Cooperative	Team Future LLC, Cambridge, MA, USA	2016	Lifeline
Cop Academy	Rubika Supinfogame, Valenciennes, France	2019	Lifeline
Cure Creation	KvasBrag Studios, Perth, Australia	N/A	Lifeline
Icesolation	Happy Hobgoblin, Oulu, Finland	2019	Lifeline
Keep Talking and No One Explodes	Steel Crate Games, Ottawa, Canada	2015	Lifeline
Operation Armstrong	Fullbeans Studio, Melbourne, Australia	2021	Lifeline
Batter Up! VR	Polygon Dust Entertainment, BC, Canada	2017	Order Simulation
Pizza Master VR	Plecturm XR, Auckland, New Zealand	2020	Order Simulation
VR the Diner Duo	Whirlybird Games, Skövde, Sweden	2016	Order Simulation
Wacktory	Technical Fowl Games, UC Santa Cruz, CA, USA	2019	Order Simulation
Playroom VR	Sony Interactive Entertainment, San Mateo, CA, USA	2016	Party Game, X
Quiz Night Tonight	Mardonpol, Ottowa, ON, Canada	2017	Party Game, X
Ruckus Ridge VR	Foreignvr, Silicon Valley, CA, USA	2016	Party Game, X
Carly and the Reaperman	Odd Raven Studios, Stockholm, Sweden	2018	Perspective Puzzle
Eye in the Sky	VinLia Games, Eindhoven, The Netherlands	2017	Perspective Puzzle
Jake and the Giant	MoonshineGames, UK	2018	Perspective Puzzle
My Shadow	Jestercraft, Jyväskylä, Finland	2021	Perspective Puzzle
Sommad	Rovango Studio, Aalborg, Denmark	2017	Perspective Puzzle
Vapor Rave	XanderHD, N/A	N/A	Perspective Puzzle
VR Giants	Risa Interactive, Graz, Austria	2021	Perspective Puzzle
Animal Force	ISVR, Beijing, China	2018	X
Banana for Scale	Hypothermic Games, Italy	2020	X
Constructionary	Brian Fitzgerald, N/A	2019	X
DoodleVR	VR-House, Utrecht, Nehterlands	2018	X
Drunkn Bar Fight	The Munky, Hermosa Beach, CA, USA	2016	X
Fort Awesome	Full Bore Studios, LLC, Joplin, MO, USA	2017	X
Fragments	Pulsarium, N/A	2017	X
GGANG!	HomerunBall, N/A	2019	X
Goalie VR	Hailstone Games, Toronto, ON, Canada	2017	X
GORN	Devolver Digital, Austin, TX, USA & London, UK	2019	X
Holo Ball	Tree Fortress, Edmonton, AB, Canada	2016	X
Lair of the Titans	Team 21 Studio, Aiken, NC, USA	2018	X
Levers and Buttons	5 Hours of Sleep, N/A	2019	X
Light, Camera, Reaction	Fluxean, N/A	2020	X

Table A2. *Cont.*

Name	Publisher	Year Published	AVR Subgenre
Minesweep VR	Funny Twins Games, Yekaterinburg, Russia	2018	X
PartyLine VR	4th Wall Breakers, Memphis, TN, USA	2019	X
PLANNES	Jundroo, Glen Carbon, IL, USA	2016	X
Puppet Fever	Coffee Stain Publishing, Stockholm, Sweden	2018	X
Reiko's Fragments	Pixel Canvas Inc, Los Angeles, CA, USA	2019	X
Slow Bullet VR	Firez Studios, Boston, MA, USA	2019	X
Smush.tv	Cyberian Studios, Mississauga, ON, Canada	2020	X
Sophie's Guardian	GameCoder Studios, Render Farm Studios, Mexico City, Mexico	2018	X
Space Security Guard Simulator	Amarillo, Lima, Peru	N/A	X
Supa Kila Monsta Hunta	MediaAtlas, Sevnica, Slovenia	2016	X
Super Virtual Intruder 2000	Meerkats of Doom, N/A	N/A	X
Terra Farma	Thomas Street, Seattle, WA, USA	2016	X
ToledoVR	SomeDudes, Bern, Switzerland	2017	X
Tractorball	Ninja Whale Studios, Moss, Norway	2017	X
Traffic Jams	Vertigo Games, Rotterdam, The Netherlands	2021	X
Waltz of the wizard	Aldin, Reykjavík, Iceland	2016	X
We Were Here	Total Mayhem Games, Rotterdam, The Netherlands	2017	X

Appendix C. Template for Initial Gameplay Notes for Each AVR Game

Below is a template we used to take notes on each of the AVR games as we played through (or, in some cases, watched online video walkthroughs).

Header Information

Game Title:
Producer/Developer:
Platforms (specify controllers, headsets, all input devices) (bold platforms you used to test):
Store:
Version:
Number of Players (possible):
Number of Players (used to test):
Demographics of Playtesters (age, gender):
Total Playtime:
Date Tested:

Qualitative Details

What's the premise of the game (from a narrative perspective):
What are the key/defining game mechanics?:
Briefly describe whether it is cooperative, competitive, or both?:
Describe each role, actions they can take, and how the player triggers those actions:
Describe key interface elements:
Briefly describe the genre (action, puzzle, sport, shooter, fighting):
How is the game unique?:

Ratings

Fun rating/10 (why?):
VR:
Non-VR:
Other:
Innovation/Uniqueness/10 (why?):

VR:
Non-VR:
Other:
Polish/Quality/10 (were there any bugs? Was it well made? Professional?):
VR:
Non-VR:
Other:

Screenshots or Pictures of Noteworthy Elements.

References

1. Ouverson, K.M.; Scherber, C.; Oldham, E.; Gilbert, S.B. What Does 'Asymmetric VR' Mean? A Directed Content Analysis of Co-Located Use of VR by Users on Reddit. *Front. Virtual Real.* **2021**, *2*, 765881. [CrossRef]
2. Rogers, K.; Karaosmanoglu, S.; Wolf, D.; Steinicke, F.; Nacke, L.E. A Best-Fit Framework and Systematic Review of Asymmetric Gameplay in Multiplayer Virtual Reality Games. *Front. Virtual Real.* **2021**, *2*, 694660. [CrossRef]
3. Thomsen, L.A.; Nilsson, N.C.; Nordahl, R.; Lohmann, B. Asymmetric collaboration in virtual reality: A taxonomy of asymmetric interfaces for collaborative immersive learning. *Tidsskr. Læring Og Medier LOM* **2019**, *12*, 20. [CrossRef]
4. Ismail, R. Keep Talking and Nobody Explodes Press Kit. Available online: https://www.keeptalkinggame.com/presskit/sheet.php?p=keep_talking_and_nobody_explodes (accessed on 20 February 2023).
5. Resolution. Acron: Attack of the Squirrels! Available online: https://www.resolutiongames.com/acron (accessed on 20 February 2023).
6. Boland, D.; McGill, M. Lost in the rift: Engaging with mixed reality. *XRDS Crossroads ACM Mag. Stud.* **2015**, *22*, 40–45. [CrossRef]
7. Chang, E.; Kim, H.T.; Yoo, B. Virtual Reality Sickness: A Review of Causes and Measurements. *Int. J. Hum. Comput. Interact.* **2020**, *36*, 1658–1682. [CrossRef]
8. Harris, J.; Hancock, M.; Scott, S.D. Leveraging Asymmetries in Multiplayer Games: Investigating Design Elements of Interdependent Play. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play, Austin, TX, USA, 16–19 October 2016; CHI PLAY '16. Association for Computing Machinery: New York, NY, USA, 2016; pp. 350–361. [CrossRef]
9. Arsenault, D. Video Game Genre, Evolution and Innovation. *Eludamos J. Comput. Game Cult.* **2009**, *3*, 149–176. [CrossRef] [PubMed]
10. Clearwater, D. What Defines Video Game Genre? Thinking about Genre Study after the Great Divide. *Loading* **2011**, *5*, 8.
11. Goddard, W.; Muscat, A. Towards Genre as a Game Design Research Approach. In Proceedings of the DiGRA Conference, Melbourne, Australia, 2–6 July 2017.
12. Ouverson, K.M.; Gilbert, S.B. A Composite Framework of Co-located Asymmetric Virtual Reality. *Proc. ACM Hum. Comput. Interact.* **2021**, *5*, 1–20. [CrossRef]
13. Klevjer, R. Genre blindness. In *DiGRA Hardcore Column*; 2006.
14. Hunicke, R.; LeBlanc, M.; Zubek, R. MDA: A formal approach to game design and game research. In Proceedings of the AAAI Workshop on Challenges in Game AI, San Jose, CA, USA, 25–26 July 2004; p. 1722.
15. Harris, J.; Hancock, M. To Asymmetry and Beyond! Improving Social Connectedness by Increasing Designed Interdependence in Cooperative Play. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, UK, 4–9 May 2019; CHI '19. Association for Computing Machinery: New York, NY, USA, 2019; pp. 1–12. [CrossRef]
16. Cho, Y.; Park, M.; Kim, J. XAVE: Cross-Platform Based Asymmetric Virtual Environment for Immersive Content. *IEEE Access* **2023**, *11*, 71890–71904. [CrossRef]
17. Gutwin, C.; Greenberg, S. The mechanics of collaboration: Developing low cost usability evaluation methods for shared workspaces. In Proceedings of the IEEE 9th International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises (WET ICE 2000), Gaithersburg, MD, USA, 14–16 June 2000; pp. 98–103. [CrossRef]
18. Bortolaso, C.; Bourdiol, J.; Graham, T.C.N. Enhancing Communication and Awareness in Asymmetric Games. In *Entertainment Computing and Serious Games*; van der Spek, E., Göbel, S., Do, E.Y.-L., Clua, E., Hauge, J.B., Eds.; Lecture Notes in Computer Science; Springer International Publishing: Cham, Switzerland, 2019; pp. 250–262. [CrossRef]
19. Gugenheimer, J.; Stemasov, E.; Frommel, J.; Rukzio, E. ShareVR: Enabling Co-Located Experiences for Virtual Reality between HMD and Non-HMD Users. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, Denver, CO, USA, 6–11 May 2017; CHI '17. Association for Computing Machinery: New York, NY, USA, 2017; pp. 4021–4033. [CrossRef]
20. Karaosmanoglu, S.; Rogers, K.; Wolf, D.; Rukzio, E.; Steinicke, F.; Nacke, L.E. Feels like Team Spirit: Biometric and Strategic Interdependence in Asymmetric Multiplayer VR Games. In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, Yokohama, Japan, 8–13 May 2021; CHI '21. Association for Computing Machinery: New York, NY, USA, 2021; pp. 1–15. [CrossRef]
21. Yassien, A.; Soliman, M.A.; Abdennadher, S. QuarantivityVR: Supporting Self-Embodiment for Non-HMD Users in Asymmetric Social VR Games. *i-com* **2022**, *21*, 55–70. [CrossRef]
22. Kaye, L.K. Exploring flow experiences in cooperative digital gaming contexts. *Comput. Hum. Behav.* **2016**, *55*, 286–291. [CrossRef]

23. Sykownik, P.; Emmerich, K.; Masuch, M. Exploring Patterns of Shared Control in Digital Multiplayer Games. In *Advances in Computer Entertainment Technology*; Cheok, A.D., Inami, M., Romão, T., Eds.; Lecture Notes in Computer Science; Springer International Publishing: Cham, Switzerland, 2018; pp. 847–867. [CrossRef]
24. Clarke, R.I.; Lee, J.H.; Clark, N. Why video game genres fail: A classificatory analysis. *Games Cult.* **2017**, *12*, 445–465. [CrossRef]
25. Heintz, S.; Law, E.L.-C. The Game Genre Map: A Revised Game Classification. In Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play, London, UK, 5–7 October 2015; CHI PLAY '15. Association for Computing Machinery: New York, NY, USA, 2015; pp. 175–184. [CrossRef]
26. Apperley, T.H. Genre and game studies: Toward a critical approach to video game genres. *Simul. Gaming* **2006**, *37*, 6–23. [CrossRef]
27. Foxman, M.; Beyea, D.; Leith, A.P.; Ratan, R.A.; Chen, V.H.H.; Klebig, B. Beyond Genre: Classifying Virtual Reality Experiences. *IEEE Trans. Games* **2022**, *14*, 466–477. [CrossRef]
28. Top 10 Asymmetrical VR Games. [Online Video]. Available online: https://www.youtube.com/watch?v=JLTFaIc1Sqg (accessed on 30 November 2019).
29. Steam Curator: VR Plus Couch Multiplayer. Steam Curator: VR Plus Couch Multiplayer. Available online: https://store.steampowered.com/curator/36810233-VR-plus-Couch-multiplayer/ (accessed on 18 February 2021).
30. R | VIVE: Virtual Reality Community Forum. R | VIVE: Virtual Reality Community Forum. Available online: https://www.reddit.com/r/Vive/wiki/multiplayer#wiki_introduction (accessed on 18 February 2021).
31. Hansen, D.L.; Hughes, A.L.; Cram, S.; Harker, A.B.; Ashton, B.; Hirschi, K.; Dorton, B.; Bothwell, N.; Stevens, A. The DELAY Framework: Designing for Extended LAtencY. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, Honolulu, HI, USA, 25–30 April 2020; pp. 1–13.
32. Sintoris, C. Extracting game design patterns from game design workshops. *Int. J. Intell. Eng. Inform.* **2015**, *3*, 166–185. [CrossRef]
33. Braun, V.; Clarke, V. Thematic Analysis. In *APA Handbook of Research Methods in Psychology, Research Designs: Quantitative, Qualitative, Neuropsychological, and Biological*; Cooper, H., Camic, P.M., Long, D.L., Panter, A.T., Rindskopf, D., Sher, K.J., Eds.; American Psychological Association: Washington, DC, USA, 2012; Volume 2, pp. 57–71. [CrossRef]
34. Bos, J.E.; Bles, W.; Groen, E.L. A theory on visually induced motion sickness. *Displays* **2008**, *29*, 47–57. [CrossRef]
35. Kraus, M.; Kibsgaard, M. A Classification of Human-to-Human Communication during the Use of Immersive Teleoperation Interfaces. In Proceedings of the 2015 Virtual Reality International Conference, Virtual, 8–10 April 2015; VRIC '15. Association for Computing Machinery: New York, NY, USA, 2015; pp. 1–8. [CrossRef]
36. Benford, S.; Greenhalgh, C.; Reynard, G.; Brown, C.; Koleva, B. Understanding and constructing shared spaces with mixed-reality boundaries. *ACM Trans. Comput. Hum. Interact.* **1998**, *5*, 185–223. [CrossRef]
37. Kirkman, B.L.; Mathieu, J.E. The Dimensions and Antecedents of Team Virtuality. *J. Manag.* **2005**, *31*, 700–718. [CrossRef]
38. Marlow, S.L.; Lacerenza, C.N.; Salas, E. Communication in virtual teams: A conceptual framework and research agenda. *Hum. Resour. Manag. Rev.* **2017**, *27*, 575–589. [CrossRef]
39. LaViola, J.J.; Kruijff, E.; McMahan, R.P.; Bowman, D.A.; Poupyrev, I. *3D User Interfaces: Theory and Practice*, 2nd ed.; Addison-Wesley Usability and HCI Series; Addison-Wesley: Boston, MA, USA, 2017.
40. Buck, J.R. Visual displays. In *Human Factors: Understanding People-System Relationships*; Wiley: Hoboken, NJ, USA, 1983; pp. 195–231.