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# Emotional Experience in Virtual Reality Sports Use

Completed Research Paper

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## Abstract

*Virtual reality (VR) sports have become a new phenomenon and have attracted the attention of both practitioners and academics. Emotion has been suggested to be an important lens to understanding individuals' information system (IS) use experience. However, few studies have attempted to differentiate the factors triggering users' various emotions in VR sports use, which could provide a deep understanding of users' emotional experience in VR sports use. This study investigates the reasons for six discrete emotions (joy, surprise, anger, sadness, fear, and disgust) in VR sports use with user-generated online reviews about 67 VR sports applications. Different factors are found to be associated with the six discrete emotions from the perspectives of content, VR technological features, and social interaction in VR sports use. The current study provides an understanding of the discrete emotions in VR sports and the reasons for these discrete emotions in VR sports use.*

**Keywords:** Virtual reality, discrete emotions, VR sports, user experience

## Introduction

Emerging technologies have dramatically accelerated the digitalization of sports, such as digital sports based on virtual reality (VR) technologies (hereafter VR sports), especially after the breakout of COVID-19. VR sports create an immersive, realistic, and interactive sports experience in a 3D environment via VR technologies, such as VR glasses, headsets, and all-in-one VR lasit (Tian et al., 2014; Waltemate et al., 2018; Harris et al., 2021). During COVID-19, some individuals have switched from attended sports to VR sports which help them stay active to prevent mental and physical illness when following social distance rules as well as to prevent potential virus spread in attended sports (Westmattelmann et al., 2021). According to Bedir and Erhan (2021), VR has a salient influence on the transformation and development of sports, but VR sports are still in the initial stage. It is important to examine users' experience in VR sports, which could provide VR sports designers with the knowledge of users' experience in VR sports use and guide their VR sports design to enhance users' experience.

Extant literature has found that user emotion is an important lens for understanding individuals' IS use experiences and behaviors together with their cognitions (Aranyi & Schaik, 2015; Makri & Turner, 2020; Rosa et al., 2020). Some scholars have examined the factors triggering users' emotions in IS use from different lenses, such as technological features, IS use duration, and users' perceptions about IS use (Bhattacharya et al., 2021; Fahim et al., 2021). For instance, Fahim et al. (2021) found that system reliability and feedback to users are related to users' emotions in their automated system use. Bhattacharya et al. (2021) argued that the duration of video episodes on social network platforms affects users' emotional

intensity. In the sports domain, the emergence of VR has challenged the traditional IS and created a vivid 3D environment where users could get multi-senses and freely move like participating in physical sports (Uhm et al., 2022). Meanwhile, users could also experience different emotions in their immersive and interactive VR sports use (Neumann & Moffitt, 2018). It is necessary to examine users' discrete emotions in VR sports use to understand users' experience, which will provide knowledge to VR sports providers on how to enhance users' experience from the view of users' emotions.

Prior research has examined the factors associated with discrete emotions in VR use, such as happiness (Duong et al., 2022), anger (Harjunen et al., 2018), and sadness (Kothgassner et al., 2017). Technological features of VR are the dominant factors triggering users' different emotions, such as sensory cues (e.g., visual and smell) (Duong et al., 2022) and social exclusion avatar (Kothgassner et al., 2017). Some studies have examined users' emotions in VR sports from the views of general positive emotions (Neumann & Moffitt, 2018) and specific emotions (Xu et al., 2021). To get a deep insight into users' experience in VR sports use, it is important to examine the reasons for multiple users' discrete emotions in their VR sports use. However, few studies have attempted to study different factors triggering users' various emotions in VR sports use in a single study.

In addition, previous studies have mainly applied experiment and survey methods to examine users' emotions in VR sports use (Esmaeili et al., 2017; Marikyan et al., 2020). User-generated online reviews have been widely applied in research to study individuals' emotions in IS use (Feizollah et al., 2021; Wang et al., 2022). Although user-generated online review data regarding VR sports is available on different platforms and could be an appropriate data source to provide a good understanding of users' emotions and experience in VR sports use with less subjective bias, compared to self-reported survey and experiment data (Garner et al., 2022), little research has attempted to use online reviews to examine users' different emotions and detect the reasons for different emotions in VR sports use.

The current study addresses the above research gap by investigating the reasons for six discrete emotions (joy, surprise, anger, sadness, fear, and disgust) in VR sports use with user-generated online review data about 67 VR sports applications. Specifically, we deployed both text mining and content analysis to identify the factors associated with six discrete emotions (joy, surprise, fear, disgust, anger, and sadness) with online reviews of 67 VR sports applications from the mobile app platforms. We further identified the factors associated with the six different emotions from the perspectives of content, VR technological features, and social interaction. The current study enriches emotion research by detecting the different factors associated with the six discrete emotions in VR sports use from the views of content, VR technological features, and social interaction. The investigation of the reasons for different emotions in VR sports use could also provide VR sports application developers with some practical guidelines on how to enhance users' experience and emotions in VR sports use from a multilevel view of the content, technological features of VR, and social interaction.

The remainder of this paper is structured as follows. We first discuss the literature on discrete emotions, research on VR sports, and research on factors associated with discrete emotions in VR use to provide the theoretical background for this study. Then, we describe the research method applied in this study, including data collection and data analysis, followed by a discussion of the research results. Finally, we discuss the theoretical and practical implications of the current study and highlight the limitations of the current research and potential avenues for future research.

## **Theoretical Background**

### ***Discrete Emotions***

Emotion refers to a type of psychological process controlled by the nervous system, which then generates a series of specific physiological expressions, such as facial muscles movement, and feelings (Lindquist, 2013). Russell and Mehrabian (1977) argued that valence (e.g., pleasure vs. displeasure), the degree of arousal (e.g., low vs. high), and dominance (e.g., dominance vs. submissiveness) could help define discrete emotions and emotional states. The three views have been widely employed in the literature to examine individuals' emotional reactions to a range of stimuli (Mauss & Robinson, 2009; Hamby & Jones, 2022). Some scholars have adopted a motivation approach to predict individuals' behavior likelihood and avoidance tendency based on individuals' discrete emotional reactions to stimuli (Mauss & Robinson,

2009). Drawing on the appraisal theory of emotions, some researchers argued that cognitive appraisals such as arousal or valence responding to various contexts or external environments are the fundamental determination of emotions (Hamby & Jones, 2022; Fan et al., 2022). In contrast to moods that respond to the uncertain environment, discrete emotions result from certain and specific causes of environmental cues (Felnhofer et al., 2015).

Prior research has illustrated the effect of emotions on users' cognition and behavior from different views. Such as Pourtois et al. (2013) argued that emotional reactions could enhance sensory processing, and thereby amplify users' attention and perception. Alsina and Gutiérrez (2010) argued that emotions could magnify the presence of the virtual environment, for example when students are in an anxiety test classroom, they feel a higher degree of presence than in a neutral classroom environment. Some scholars found that emotions affect users' attitudes, behavioral intentions, and behavior. For instance, Marikyan et al. (2020) found that smart home users with anger caused by the underperformance of smart applications would be less likely to change their negative attitude toward smart applications at home and might initiate withdrawal behavior.

In the literature, the six discrete emotions raised by a series of studies by Ekman et al. (Ekman & Friesen, 1971; Ekman et al., 1987; Ekman & Cordaro, 2011) have been widely applied to study individuals' emotions, which consists of anger, disgust, fear, joy, sadness, and surprise. Some scholars have applied the six discrete emotions in various IS contexts to investigate users' discrete emotions in IS use as well as the antecedents and the behavioral consequence of users' emotions (Zeng et al., 2009). The six discrete emotions could also be an appropriate theoretical base for this study. On one hand, these six different emotions consist of both positive and negative emotions from the valence view and also reflect the degree of arousal of both negative and positive emotions, which could provide a deep understanding of the valence and degree of arousal of user emotions in VR sports use. On the other hand, the wide application of the six discrete emotions in IS research also indicates that the six discrete emotions could be applied in the VR sports context to understand users' emotional experiences in VR sports use. Thus, in the current study, we employ these six emotions as the theoretical base to examine users' emotions in VR sports use.

### ***Research on VR Sports***

VR sport is a kind of digital sport based on VR technology applications. VR could make a high-quality presentation of the virtual environment and facilitate users' interaction with the environment or other users based on the multiple sensory stimulations in the VR sports environment (Kowalczyk et al., 2021). As immersive VR headsets could integrate VR features of realistic presentation and immersion into physical sports, especially sports movements, VR headsets have a large potential in leisure sports and daily fitness such as ball sports, climbing, fishing, dancing, and running, etc. (Neumann & Moffitt, 2018; Bai et al., 2021; Uhm et al., 2022).

VR sports have been used for different purposes. Some VR sports have been designed for athletes and coach training (Ng et al., 2019). VR sports could simulate a realistic 3D environment as a replica of a physical sports environment, such as surfing, golf, shooting, and tennis, to improve athletes' skills and mental training (Farley et al., 2020). Müller et al. (2022) examined how to incorporate the visual anticipation of VR simulator design in VR sports to better understand athletes' skill improvement and performance. Recently, VR has been introduced to leisure sports for the public. Such as some individuals have chosen VR sports like running, climbing, and dancing in their daily life at home as an alternative way of exercising in the gym or stadiums when there is inconvenient time and distance or lack of partners and opponents (Uhm et al., 2022). In the VR leisure sports field, VR sports could mimic real sports and offer a mixed experience of sports and entertainment with different sports (Neumann & Moffitt, 2018; Choi et al., 2020; Chen & Zhu, 2022).

A stream of scholars has examined users' affective, cognitive, and behavioral reactions to VR sports. For instance, Neumann and Moffitt (2018) compared VR-simulated running in comparison with non-VR conditions and found that users have a more positive emotional state and engage more in physical effort when they run in a VR-simulated situation than in non-VR conditions. Uhm et al. (2022) found that VR tennis sports trigger users' feelings of fun and flow in their VR tennis use. Sohail et al. (2022) experimented to examine users' experience with VR glasses use and found that users experience good well-being in VR glasses usage. In mega sports event environments, users have felt high curiosity and enjoyment with their VR device use and have a high intention to adopt VR in future events (Capasa et al., 2022). Bai et al. (2021)

found that the usage of emotional virtual avatars helps users evoke a related emotional experience in VR volleyball games.

Prior literature on VR sports has mainly focused on either VR sports design or users' cognition, emotion, and behavior (Waltemate et al., 2018; Harris et al., 2021). Though some scholars have examined users' emotions in VR sports use (Uhm et al., 2022) and investigated the factors inducing certain users' emotions in VR sports (Esmaeili et al., 2017; Neumann & Moffitt, 2018; Xu et al., 2021). But these studies either researched general positive emotions (Neumann & Moffitt, 2018) or specific emotions (Xu et al., 2021) in the laboratory design setting (Esmaeili et al., 2017). There is a lack of knowledge on users' discrete emotions in VR sports use and the detailed reasons for different emotions though VR is advocated by some scholars as an effective medium and users might have rich emotions in VR sports use (Riva et al., 2007). In addition, prior studies have mainly applied survey and experiment methods to examine users' emotions in VR sports with self-reported data, which has been argued to have the potential subjective bias (Esmaeili et al., 2017; Marikyan et al., 2020). Little research has attempted to investigate users' emotions in VR sports with the available user-generated online reviews though online reviews have been argued to be with less subjective bias and have already been widely applied in research to understand users' emotions in different research contexts (Garner et al., 2022). Researchers should also take advantage of the large amounts of available online reviews to understand users' emotions in VR sports use as well as to differentiate the reasons for discrete emotions to enrich the current literature on users' experience in VR sports from the discrete emotions view.

### ***Research on factors associated with discrete emotions in VR use***

As Collange and Guegan (2020) suggested, VR has the potential to manipulate stimuli in certain scenarios and generate targeted emotional reactions. Prior research has mainly investigated factors that could trigger users' emotions in VR use from the VR technology view. Some scholars suggested that the quality of Head-mounted display (HMD) such as a high 3D level would enhance the intensity of emotional valence and arousal in VR use (Cadet & Chainay, 2020) whereas other scholars argued that environmental cues with multiple sensory stimuli and interaction with virtual avatars in VR environments induce certain discrete emotional experiences for VR users, such as joy, anger, and sadness (Felnhofer et al., 2015; Serrano et al., 2016; Mousas et al., 2018).

For instance, some scholars have examined how multiple sensory cues with visual, smell, and haptic in the VR environment could trigger users' emotions in the experiment of a relaxation house and found that VR technology renders the stimulation of touch and smell cues, which enhance the relaxation experience and increase joy and decrease sadness (Serrano et al., 2016). Some negative emotions could also be induced in some VR scenarios with rich sensory cues. Such as Bender and Sung (2021) examined the cues related to fear in VR use with an experimental scenario where users entrap in a dark room with auditory cues based on a VR device. They found that these visual and audio cues trigger users' fear which is almost at a double level compared with the scenario without these VR-based settings.

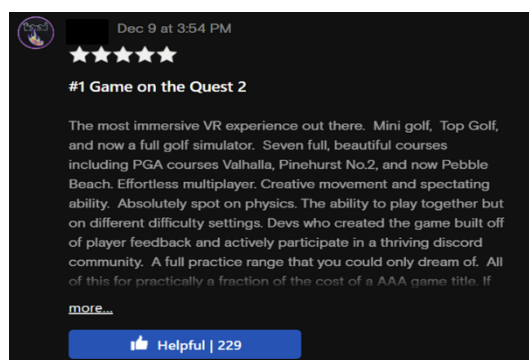
Some research has found that simulated interactions with virtual avatars in a VR environment could induce users' discrete emotions. For instance, some social norms in the physical world as touch or facial expression are found to induce discrete emotions in VR-based interaction with virtual avatars (Harjunen et al., 2018). Kothgassner et al. (2017) also found that avatars reflecting social exclusion increase users' negative emotions like anger and sadness and decrease their happiness in VR use because social exclusion threatens humans' temporal social needs, such as self-esteem, self-control, belonging, and meaningful existence.

Prior research shows the importance of VR technological factors and social interaction in VR use in triggering discrete emotions, which provides reference lenses to detect the detailed reasons for discrete emotions in the VR sports context (Harjunen et al., 2018; Mousas et al., 2018; Cadet & Chainay, 2020). In addition, VR sports render various sport exercise, events, or campaigns for users to participate. Prior literature suggested considering the related factors from the content view when investigating the reasons for users' discrete emotions in VR sports, for example, (un)predictable/(un)certain loss of task in VR sports could trigger users' different emotions (Chang & Inoue, 2021). Thus, the present research examines the factors associated with the six discrete emotions including joy, surprise, fear, anger, sadness, and disgust from the views of content, VR technological features, and social interaction in VR sports.

## Research Method

### Data Collection

Meta Oculus is one of the popular VR glasses, which has versions of Meta Oculus 1 and 2. All the VR applications facilitated by Meta Oculus could be found on its website or its mobile app, such as entertainment tours, sports, training, education, etc. There has been a boom in Meta Oculus glasses sales during the COVID-19 pandemic and VR sports have become popular during the pandemic, such as mini-golf, boxing, and tennis. Thus, we selected VR sports with Meta Oculus as the research context in this study. Users who use Meta Oculus to participate in VR sports can provide comments about their VR sports use experience on the mobile app with their mobile phone or the websites of Meta Oculus. Specifically, users can rate VR sports apps on a scale from 1 to 5 stars, generate review text with details about their VR sports use experience, and upload pictures. VR sports users could also engage with the generated online reviews via commenting on an online review and voting on an online review to measure the helpfulness of the review. VR sports app developers could interact with and respond to users in their comments. The following is an example of an online review generated by a VR sport user.



**Figure 1. An Example of Online Reviews Generated by a VR Sport User**

We collected the user-generated online review data about VR sports based on Meta Oculus 1 and 2 from the Apple app store and Google Play store mobile platforms via a program developed based on hypertext preprocessor language. The online reviews of 67 VR sports generated by users from May 2019 to October 2022 were collected. In total, we collected 72,841 reviews with a range of review length from 1 to 1,569 words. These 67 different VR sports consist of rhythm dancing (N=17, 25%), fitness (N=11, 17%), and athletic sports (e.g., baseball, tennis, and climbing) (N=39, 58%).

### Data Analysis

Text mining has been widely applied to extract meaningful information from unstructured text information and to extract knowledge from the magnitude of the data set (Garner et al., 2022), such as user sentiment and emotions (Krawczyk et al., 2021). Following previous studies, text mining was applied in this study to detect users' emotions in using VR sports with the collected online review data.

With the assistance of the R “NRC” package, we first quantitatively mined all representative words of the six discrete emotions in the 72,841 online review data set. The R “NRC” package is a standard sentiment lexicon to label words in a text with different emotions, such as joy, surprise, fear, anger, sadness, and disgust (Naldi, 2019). Second, for each emotion, we detected the top ten representative words with the highest frequency in all online reviews. Third, for each emotion, we applied each representative word to select 15 pieces of reviews where each representative word appears with higher frequency than in the other unselected reviews. We then got 900 pieces of reviews for the six discrete emotions. Afterward, we made a content analysis of the selected 900 pieces of online reviews to identify the factors associated with users' discrete emotions.

Specifically, the first author read the 900 pieces of reviews and manually open-coded the factors related to the six discrete emotions. Then, we did axial code for these factors to specific factors to draw connections with codes developed from the open coding, such as optional series/kits, themes, features of task/campaign,

event, manipulation, navigation, multiple senses cues (e.g., visual and audio cues), virtual avatars, familiarities, and multiplayer interaction. After the coding, we mapped these factors from the three views of content, technological features of VR, and social interaction. Details of the data analysis steps can be found in Table 1.

Steps	Joy	Surprise	Fear	Anger	Sadness	Disgust
<b>Step 1:</b> Find the top ten words with the highest frequency for each emotion in all reviews	fun love music pretty enjoy perfect favorite money hope star	catch break expect unique surprised/surprisingly/ surprising randomly occasional trick sudden(ly) spectacular	change flying ghost forced thrill horrible crash fear afraid uncanny	hit boxing annoying fighting complaint grab frustrated battery strike whip	music impossible regret fall lower difficulties fault disappointing tough unable	toxic weird mess crap garage backward gutter ugly greedy nausea
<b>Step 2:</b> Choose 15 pieces of reviews for each top word	150 reviews	150 reviews	150 reviews	150 reviews	150 reviews	150 reviews
<b>Step 3:</b> Manual code the 900 pieces of reviews to detect the factors related to each emotion and map these factors to the three views	150 reviews	150 reviews	150 reviews	150 reviews	150 reviews	150 reviews
<b>Table 1. Steps of Data Analysis</b>						

## Results

The reasons for the six discrete emotions (e.g., joy, surprise, fear, disgust, anger, and sadness) are analyzed from the perspectives of content, VR technological features, and social interaction. Regarding positive emotions, joy stems from optional kits/series, nostalgic themes, and competitive or challengeable tasks/campaigns with a proper duration from the content point of view. For technological features of VR, multiple senses backgrounds, clear navigation with appropriate movements, and interaction/relationship with affiliative avatars are found to produce joy. Social interaction with friends in the virtual sports world would generate joy. Surprise, as another positive emotion, is mainly incurred by unexpected content surpassing users' potential expectations. And super precise control, realistic moves in the manipulation of VR, and 3D realistic visual background rendered by the VR technological features trigger users' surprise in their VR sports use.

Technological features of VR are a major reason for sadness, anger, fear, and disgust. Such as fear is incurred by scary visual themes and light, by the height in space and flying moves when maneuvering a VR headset, and by the proximity interaction with scary avatars. Anger is induced by users' self-efficacy of VR use, such as a low accurate understanding of the navigation and manipulation of VR. Besides if users cannot customize the mute/unmute annoying multiplayer in their social interaction they feel angry. Lack of autonomy of movement and impossible achievable tasks in VR sports leads to sadness as users feel the loss of control in sports. Disgust is produced by distorting orientation caused by noises of technology such as jerky frame rate, track of camera, and dense frequent flips among images. Meanwhile, low explicit simulation of movements and mismatch of real-life movements and virtual presence are observed to incur disgust as well. In addition, a couple of factors related to the views of the content and social interaction are also reported as the reasons for sadness and anger, such as music background, context complexity, tasks in exercise, and interaction with other users. More details of the reasons for the six discrete emotions in VR sports use are presented as follows.

## ***Joy***

In this study, we observed different factors related to the content of VR sports, technological features of VR, and social interaction which induce users' joy in their VR sports use (See Table 2).

Regarding the content of VR sports, users require more optional and customized kits or series to enrich their VR sports experiences and get a joyful experience. Nostalgic themes have been found to link with fun as well. Three factors related to tasks and campaigns in VR sports, including competition, the duration of the campaign, and the basic/challenge of certain tasks, are found to induce joy. Rhythms of music fitting sports movements could motivate physical movements such as arms and upper body movement and lead users to have a sense of real dancing, thus, inducing joy among users.

From the view of VR technological features, multi-sense in use, clear navigation and manipulation of VR use, and virtual avatar design are closely associated with joy in VR sports use. Such as VR headsets provide virtual journeys with multiple senses, including visual and auditory senses. Visual elements such as smoothness are found to induce joy. For example, one user wrote in the feedback that "The graphics are extremely smooth and is amazing, to say the least". Audio cues could trigger joy when clear voice instruction of navigation is provided to users or when users communicate with other users or virtual avatars with verbal communication. More free movements and live-sized space in the manipulation of VR devices in sports use could induce joy. For example, "It's the feeling of being in a crowded baseball stadium that's live-sized. It's amazing and immersive sight and sometimes I'll jump into a game simply to witness it". Interaction with virtual avatars who have friendly and human-like personalities makes users feel joy in joining VR sports.

Social interaction with familiarities such as friends in VR sports generates joy as well. In a word, joy can be triggered by the content of VR sports such as optional kits, nostalgic themes, and features of tasks/campaigns, by technological factors of VR such as precise navigation, full of movements in the manipulation of VR, smoothy visual cues and audio enhanced background, and affiliative avatars, and by social interaction with friends in VR sports.



Words	Views	Specific factors	Review samples
fun love music pretty enjoy perfect favorite money hope star	Content	Optional kits/series	<ul style="list-style-type: none"> <li>... I also hope the developer adds more songs over time, to keep the game fresh.</li> </ul>
		Nostalgic themes	<ul style="list-style-type: none"> <li>... So was so nostalgic getting to finally play again.</li> </ul>
		Task/Campaign: -Competitive (a) -The duration of the campaign (b) - Basic/challenge (c)	<ul style="list-style-type: none"> <li>... I discovered that it is my favorite type of VR game to play the bow &amp; arrow physics are fantastic, and it is extremely competitive (a).</li> <li>The game is pretty fun the campaign is pretty short though (b).</li> <li>Star: The hard mode is also extremely hard and a real challenge! (c).</li> </ul>
		Music (Fitting sports, rhythm)	<ul style="list-style-type: none"> <li>I liked to get into the flow with the music, sometimes making slightly excessive corresponding movements with my arms and upper body, it felt like dancing. Being one with the music, perfectly tuned to the rhythm. That was a major fun factor with Boxvr.</li> </ul>
	Technological features	Navigation (Precision)	<ul style="list-style-type: none"> <li>It's pretty fun, and if you hold down the side button on your controller you can see the contours of the course and the directional arrow helps with your aim.</li> </ul>
		Manipulation - Free move with hands (a) -More moves (b) - Live-size space (c)	<ul style="list-style-type: none"> <li>Luv getting to use hands instead of controllers (a).</li> <li>When you play Audio Trip you start to feel like maybe you're building up some high-end dance moves along the way, which feels a bit cool. I especially enjoy how this app has me ducking, moving my arms up, and down, almost like boxing moves at times, but this app never feels like anything but fun, fun play (b).</li> <li>It's the feeling of being in a crowded baseball stadium that's life-sized. It's an amazing and immersive sight and sometimes I'll jump into a game simply to witness it. Easily one of the coolest feelings you can get while playing VR (c).</li> </ul>
		Multiple senses cues: audio	<ul style="list-style-type: none"> <li>... The instructor's voice-over is a nice touch to the gameplay so during the sessions it won't feel boring.</li> </ul>
		Multiple senses cues: visual	<ul style="list-style-type: none"> <li>The graphics are extremely smooth and amazing, to say the least.</li> </ul>
		Avatar -Beautiful, cool, personality, friendly (a) -Real-personal interaction (b)	<ul style="list-style-type: none"> <li>The new art style, the phone gimmick, the colorful club atmosphere, the act of befriending the dancers/giving them more personality (a). Star: They look cool, and the game is absolutely beautiful (a).</li> <li>Love this game and I play it every day for a fun workout! It's great especially now during social distancing! You feel as though you are at a dance club! You feel as though the characters are familiar friends you meet up with (b).</li> </ul>
	Social interaction	Familiarities interaction	<ul style="list-style-type: none"> <li>... for being fun to play AGAINST/WITH friends (in games).</li> </ul>
<b>Table 2. Factors Related to Joy in VR Sports Use</b>			

## Surprise

In this study, we found different factors related to the content of VR sports and technological features of VR which could trigger surprise among users, including unexpected contents, realistic moves and precise control in the VR manipulation, and 3D effects and super spectacular aesthetic visual cues in the virtual environment in VR sports (See Table 3).

Specifically, for the content view, surprise is incurred when unexpected content is provided in VR sports. For example, users feel surprised when they finish a challenging task. e.g., “This is the most relaxing yet exciting game I have played yet, it’s nice and chill when you’re fishing in saltwater then all of a sudden BANG shark on your line and it becomes that bit of excitement you needed...”. And occasional events such as tournaments generate surprise in the single-player sport context. On the other hand, the surprise would attenuate or disappear with many failures and repetition of usage. For instance, “I loved this game & quickly made it through all 20 levels. I stopped playing because, after hundreds of attempts to catch a big fish, without success, it became boring. I have yet to catch a big fish though they’re all that appears on my line. They always get away...”.

Moreover, in the VR fishing and golfing context, VR creates a realistic 3D environment where super accurate manipulation of VR, and realistic simulation of movements induce surprise among users when playing VR sports. For example, “It’s surprisingly accurate. You can replicate your movement when you’d bowl in real life and the results are surprisingly similar”.

Words	Views	Specific factors	Review samples
catch break expect unique surprised/surprisingly/ surprising randomly occasional trick sudden(ly) spectacular	Content	Occasional event	<ul style="list-style-type: none"> <li>Perhaps a way to level up in single-player, and the occasional tourney for multiplayer would be amazing.</li> </ul>
		Challengeable tasks	<ul style="list-style-type: none"> <li>It’s nice and chills when you’re fishing in saltwater then all of a sudden BANG shark on your line and it becomes that bit of excitement you needed.</li> </ul>
	Technological features	Manipulation -Precise control (a) -Realistic moves (b)	<ul style="list-style-type: none"> <li>It’s surprisingly accurate. You can replicate your movement when you’d bowl in real life and the results are surprisingly similar (a).</li> <li>Very fun game with surprising accuracy minus the serving and slices. Tons of fun (b).</li> </ul>
		3D effect	<ul style="list-style-type: none"> <li>It’s very relaxing if you sit there or exciting if you try to catch the big fish. The mix of 3D elements like water and animals and overlaid real photos are pretty stunning.</li> </ul>
		Multiple senses cues: visual	<ul style="list-style-type: none"> <li>... The levels are stunningly beautiful... something spectacular. The fish are beautiful and realistic looking (enough to make me scream when I caught my first shark, and it came up over my head 🐟🐟).</li> </ul>

**Table 3. Factors Related to Surprise in VR Sports Use**

## Fear

In this study, we found that some technological features of VR induce fear in VR sports, including the realistic moves of the manipulation, multiple visual cues such as dark, scary light, and color scheme, and the proximity interaction with scary avatars (See Table 4).

The virtual environment design for immersive and realistic experiences could trigger users’ fear of VR sports use. Such as the flying sense in VR sports could induce users’ fear. Some visual cues such as scary color schemes could also lead to users’ fear of VR sports. For example, users get afraid of scary reddish light-like skin and dark backgrounds. Meanwhile, height sense in space is one reason for fear of VR sports use. For example, “climbing high mountains where I am afraid to look down...”. Some users might be acrophobic, but they could set a relatively low level of height by themselves so that they can still enjoy VR

sports. The scary avatar fighters could also trigger users' fear when users feel the avatars are so close to them. Such as users feedbacked that "I wish I hadn't customized my avatar opponent. They are so close; it feels like you're alone with an uncanny valley entity staring into your soul" and "In my opinion fighters are forced to stand far too close to each other. I feel like I'm forced to stand virtually chest-to-chest which I do not like, is hard to get used to, and feels wrong". Thus, users' perceptions of the proximity of spatial distance between the users and virtual avatars in VR space could incur users' fear.

Words	Views	Specific factors	Review samples
change flying ghost forced thrill horrible crash fear afraid uncanny	Technological features	Manipulation -The realistic moves: flying (a) -Height in space (b)	<ul style="list-style-type: none"> <li>From standing atop a mountain ready to dive into the valley below, to flying through narrow ravines and skimming evergreen trees, or a snowy paste to gain speed it's a truly immersive experience. At first, I wondered if the GFX were a bit too basic, but the experience of flying is so real that GFX is forgotten (though when this improves it will make it that much more of a thrill) (a).</li> <li>It puts me in the moment, and I feel like I'm climbing a mountain. I don't know if it will be the same experience for someone comfortable with heights, but I can tell you I find myself hugging the side of the mountain during the climb. I am afraid to look down. I have to close my eyes when I inevitably fall to my VR death (b).</li> </ul>
		Multiple senses: visual	<ul style="list-style-type: none"> <li>Option to change colors of key objects, change night into day, and vice versa. For example, in the "calm" trip with the lanterns, I felt scared because the environment was dark, and the lanterns looked like reddish flesh and reminded me of skin. It's one of the trips I don't like doing because of the scary color scheme.</li> </ul>
		Avatar (Too close position)	<ul style="list-style-type: none"> <li>In my opinion fighters are forced to stand far too close to each other. I feel like I'm forced to stand virtually chest-to-chest which I do not like, is hard to get used to, and feels wrong.</li> </ul>
<b>Table 4. Factors Related to Fear in VR Sports Use</b>			

## Anger

In this study, we found that anger is mainly aroused by the low quality of content and the lack of accurate manipulation of VR (See Table 5). Specifically, users get angry when VR sports content is too complex which leads to a lot of failures for users. For instance, "The orb is finicky. I had my basic blast wand spell and a sword spell on my attack side. The sword was at the top and the wand was just a little next to it. No matter how often I tried to quickly pull the orb to the side to get my wand it kept grabbing the sword".

In addition, the lag and unsmooth manipulation of VR sports cause troubles with usage, and users are reported to induce annoying, e.g., "Another complaint about the AI I saw a lot besides this was that your opponent doesn't ever really back up unless you push them. A big part of boxing is maneuvering around, and sadly with this problem the experience is slightly hindered immersion-wise". When users experience the low accuracy of control, track, navigation, and realistic moves, they will get angry. "But there is one problem there are some faulty grab points in the game and they have killed me most of the time, I think you should still buy it just take your time when you are climbing on curved ledges, and you jump on one and try to grab on to the closest side of the wall".

Furthermore, lack of customization in social interaction, such as if users cannot mute/unmute to interact with annoying multiplayer could cause anger among users, and even impede their VR sports use.

Words	Views	Specific factors	Review samples
hit boxing annoying fighting complaint grab frustrated battery strike whip	Content	Complexity of contents	<ul style="list-style-type: none"> <li>The orb is finicky. I had my basic blast wand spell and a sword spell on my attack side. The sword was at the top and the wand was just a little next to it. No matter how often I tried to quickly pull the orb to the side to get my wand it kept grabbing the sword. I mistakenly grabbed that one so often it got incredibly frustrating.</li> </ul>
	Technological features	Manipulation -The accuracy of control (a) -The accuracy of track (b) -The realistic moves (c)	<ul style="list-style-type: none"> <li>Maybe it's an issue with my controller (although no issues in other games) but when I hit with my left hand 20% of the time, I get the no-ring hit. It's like I can't hit the target properly (a).</li> <li>I often miss cause the system doesn't properly detect my hit. Nothing more frustrating than giving all your energy and good motion in a punch to receive the base hit no-ring effect (b).</li> <li>Another complaint about the ai I saw a lot besides this was that your opponent doesn't ever really back up unless you push them. A big part of boxing is maneuvering around, and sadly with this problem, the experience is slightly hindered immersion-wise (c).</li> </ul>
		Navigation (The accuracy of instruction)	<ul style="list-style-type: none"> <li>But there is one problem there are some faulty grab points in the game and they have killed me most of the time, I think you should still buy it just take your time when you are climbing on curved ledges, and you jump on one and try to grab on to the closest side of the wall.</li> </ul>
	Social interaction	Players' interaction - Customized interaction (a) - Unnatural interaction (b)	<ul style="list-style-type: none"> <li>90% of the people on voice chat are young &amp; annoying. No push to talk or mute/unmute self-button on the controller (a).</li> <li>The other player's movements and ball throw look very jerky and seem very unnatural. Or it will look like your opponent's ball misses the mark by a mile and it turns out, it's a strike (b).</li> </ul>
<b>Table 5. Factors Related to Anger in VR Sports Use</b>			

### Sadness

In the current study, sadness is found to occur when users feel a sense of being out of control accompanying a low self-efficacy, such as users feeling that they are not able to finish exercises and experience failure. Such as users reported that they feel sad when they lose control of tasks and feel impossible to achieve task goals. For instance, "I get the prowess to carve in a good challenge, but the most basic medals are next to impossible to achieve. 18k pts is extremely unrealistic, let alone being the first tier". Sadness could be also induced by lacking autonomy in moves in VR manipulation, such as "It just doesn't allow you to fall. Not entirely. You drop a few feet and are restarted at the last checkpoint". A list of the factors triggering users' sadness is presented in Table 6.

Words	Views	Specific factors	Review samples
music impossible regret fall lower difficulties fault disappointing tough unable	Content	Music (Lack of optimization)	<ul style="list-style-type: none"> <li>Unfortunately, I went through and listened to most of the music, and I could only find two or three songs.</li> </ul>
		Tasks (Impossible to achieve)	<ul style="list-style-type: none"> <li>Just lower the difficulty on normal mode. If anyone wants more, they will choose other difficulty modes. But making it impossible for the average person is not the way, that I can assure you.</li> </ul>
	Technological features	Manipulation (Lack of autonomy of movement)	<ul style="list-style-type: none"> <li>Falling. It just doesn't allow you to fall. Not entirely. you drop a few feet and are restarted at the last checkpoint.</li> </ul>
<b>Table 6. Factors Related to Sadness in VR Sports Use</b>			

## **Disgust**

In this study, we found that disgust in VR sports use is triggered by technological manipulation of VR, such as distorting space or disorientation and moves. For instance, the unstable images presented and the sway of space in the virtual environment led users to feel sick. e.g., “Whenever the bosses were on screen or a lot of enemies at once, I noticed an increasingly jerky frame rate. At times it felt a bit of a mess and I started to feel a little nausea just because of the jerky motion”. And frequently technological tracking and sudden camera rotation of VR cause super annoyance and nausea among users. In addition, a quick flip of images and lag of the stuck screen also led to disorientation and nausea, for example, one user feedbacked that “sometimes it won’t know what image to show and quickly flip between two images, which is distracting at best and caused nausea for me sometimes”.

The low quality of the simulation of moves in VR sports is another important reason for disgust in VR sports use, such as the lack of explicit simulation of real sports and movement, and the mismatch of simulated movements and real physical environment. For instance, in VR cycling, the digital alternative does not simulate typical movements uphill and downhill, causing nausea among users. One user indicated that “If I go uphill, it should feel slower, but if I’m cruising downhill then it should speed up, but it just goes one constant speed that’s way too slow. Also, I had to set my bike on an easy setting where my legs were pedaling like crazy for my cadence to pick up and get the biker moving in the app...”. In VR boating, the movement in the virtual world is opposite to what users see in the virtual scenes, which induces sickness among users, e.g., “then rowing you are having the opposite movement you would have in the boat. I have gotten motion sickness when trying to row in this app”.

The confused visual and audio cues in the virtual environment also trigger users’ disgust in VR sports use, such as the mismatch of the visual and audio background. For example, one user indicated that “The easy level will promote mild nausea, not due to motion sickness, but sadly the combination of world design, music, and sound effects (What is going on in the background here?? I get it’s supposed to be a chocolate river, but it looks and sounds like a local sewage treatment plant has suffered a catastrophic failure and is in the process of exploding in slow motion!)”. In addition, some bad behaviors, such as toxic words in social interaction among multiplayer could induce users’ disgust in VR sports use as these behaviors could have side effects on the youth generation or the teenagers who join in VR sports. A list of the factors triggering users’ disgust is presented in Table 7.

Words	Views	Specific factors	Review samples
toxic weird mess crap garage backward gutter ugly greedy nausea	Technological features	Manipulation - Position in space (a) - Lag, disorientation in space (b) - Quick flip among scenes (c) - System: Jerky frame rate (d) - System: Camera rotation (e) - Low simulation of real moves (f) - Mismatch of virtual and real moves (g)	<ul style="list-style-type: none"> <li>I also noticed that resting the Oculus position mid-game will also mess up the detection (a).</li> <li>I've started experiencing lag issues which are causing me to miss or end my streak. I didn't have these problems before the update. The issue is also happening on my quest 1. I also am experiencing lag that causes the screen to get stuck which gets disorienting causing minor nausea (b).</li> <li>In fact, 2D images instead of 3D models; are not a problem, but sometimes it won't know what image to show and quickly flip between two images, which is distracting at best and caused nausea for me sometimes (c).</li> <li>I noticed an increasingly jerky frame rate. At times it felt a bit of a mess and I started to feel a little nausea just because of the jerky motion (d).</li> <li>The camera automatically rotates when grabbing some holds. Super annoying and can't disable this. Causes nausea, it's surprising, beak immersion causes head bonks and falls (e).</li> <li>If I go uphill, it should feel slower, but if I'm cruising downhill then it should speed up, but it just goes one constant speed that's way too slow...It just felt weird that what we physically were doing didn't match in vr (f).</li> <li>When rowing you are having the opposite movement you would have in the boat. I have gotten motion sickness when trying to row in this app (g).</li> </ul>
		Multiple senses: visual & audio (Mismatch with visual and audio)	<ul style="list-style-type: none"> <li>The easy level will promote mild nausea, not due to motion sickness, but sadly the combination of world design, music, and sound effects (I mean - what is going on in the background here?? I get it's supposed to be a chocolate river, but it looks and sounds like a local sewage treatment plant has suffered a catastrophic failure and is in the process of exploding in slow motion!)</li> </ul>
		Avatar (Moves)	<ul style="list-style-type: none"> <li>The AI movement in this game is super weird and wonky and barely resembles an actual football player.</li> </ul>
	Social interaction	Multiplayers' behaviors in the community	<ul style="list-style-type: none"> <li>These players not only make other players feel bad, but they are influencing younger age kids to be toxic and learn cuss words.</li> </ul>
<b>Table 7. Factors Related to Disgust in VR Sports Use</b>			

## Discussion

This study identified the factors associated with six different emotions in VR sports use, including joy, surprise, anger, sadness, fear, and disgust, through a combined approach of text-mining and content analysis with online reviews. The factors associated with the six different emotions can be mapped to content, VR technological features, and social interaction views.

Different factors related to VR technological features were found to associate with joy, surprise, anger, sadness, fear, and disgust. These findings are partly consistent with some prior literature that highlighted the importance of VR technological features in triggering users' different emotions in various VR applications, such as multiple sensory cues (Kothgassner et al., 2017; Duong et al., 2022). However, in our research, we found different reasons for the two positive emotions (e.g., joy and surprise) from the multiple senses view. Specifically, we found that visual smoothness induces joy, while super aesthetic scenes generate surprise. It seems that VR sports users feel that the visual design is important for their joyful experience of VR sports use and high-quality aesthetic visual design could enhance their positive feeling and lead to high intensity of positive feelings, such as surprise. Compared with prior research mainly

examining multiple senses cues in VR environment on emotional responses (Serrano et al., 2016; Kothgassner et al., 2017; Mousas et al., 2018; Duong et al., 2022), the manipulation-related factors such as the accuracy of control and realistic moves are unique technological factors identified in VR sports use to induce different emotions. When there is high-level accuracy of control and realistic moves, positive emotions including joy and surprise are induced, and negative emotions otherwise. Among the two factors regarding manipulation, it is interesting to find that the high level of the two factors induces fear though fear is defined as a negative emotion (Myrick, 2017; Bender & Sung, 2021). In addition, avatar design is also a vital aspect to trigger users' joy. When users find that the avatar is friendly and appears to be with a good personality, users could think that the avatar is more like a human and makes them feel that they are interacting with a real human, which is consistent with the prior research verifying that interaction with affiliate avatars could generate joy among users (Wrzesien et al., 2015; Harjunen et al., 2018). But too close a distance with the avatar could be cautious to produce a sense of fear due to the uncanny value effect caused by the avatar.

Content-related factors were found to induce joy, surprise, anger, and sadness among VR sports users, including products and the elements of a task or campaign. Optimal kits/series provide users with autonomy which generates joy while sadness is incurred when there is a lack of options. The reason might be that VR sports users take different options of sports content necessary for VR sports. Various options will make them happy, and they might feel bored and feel sad about VR sports when various sport options are not available. In addition, the elements of a task or campaign such as competition, sports duration, challenge feature, and complexity of content could trigger joy, surprise, anger, and sadness. Joy and surprise are more likely to be aroused by a challenge task/campaign, while surprise is prone to be induced by accident factors such as occasional events. But sadness is incurred when users feel impossible to achieve tasks encountering super challenging ones. According to Kothgassner et al. (2017), users may lose control when they challenge themselves in super-challenge sports. Following the normal psychological process, when users feel the loss of control and failure in tasks in VR sports, they could feel sadness, which is the same as in real sports. And anger is more likely to associate with the complexity of content because too much or finicky content designed in VR sports could confuse users and impede users' appropriate use of VR in sports. When users are not clear about what to do in VR sports, they will get angry.

Some factors related to social interaction in VR sports are linked with joy and anger. Real personal interaction such as with friends in a virtual world could excite users' joy experience which is consistent with the research finding of Ang et al. (2015). When users could interact with their friends in VR sports, they will get a feeling of connection with friends as in real sports, inducing a joy experience. However, when users could not control or avoid annoying and rude multi-players in virtual communities of VR sports, anger is triggered because users feel low self-control in the social interaction process, which is also identified as an interpersonal provocation by prior research around social VR communities (Divine et al., 2020).

## **Contributions**

This study could make contributions to the literature in several ways. First, this study enriches the VR sports literature by identifying the factors related to six discrete emotions (e.g., joy, surprise, fear, anger, sadness, and disgust) in VR sports and by synthesizing the factors to the perspectives of content, technological features of VR, and social interaction. It provides a comprehensive understanding of the reasons beyond users' positive and negative emotions for VR sports use. Second, this study provides new insights into the reasons for users' discrete emotions in VR sports by detecting content as one important dimension in understanding users' discrete emotions. Previous studies have highlighted the importance of VR technological features and social interaction in triggering users' positive emotions and enhancing user experience in VR use (Cadet & Chainay, 2020; Duong et al., 2022). The findings on the role of content to trigger users' emotions in VR sports use extend the understanding of users' discrete emotions from the technological and social interaction view to the content view.

In addition, the findings of this study could provide some practical guidelines for VR sports developers. The findings on the factors related to the content, technological features, and social interaction triggering users' six different emotions could provide practitioners with some practical guidelines on how to make the technological design enhance users' positive emotions such as joy and surprise and reduce negative emotions among users. Such as, developers could improve the precision of navigation, provide more realistic moves, and design smooth visual backgrounds enhanced with audio cues such as voice

introductions to incur joy among users. Meanwhile, those factors incurring negative emotions are mainly from the manipulation of VR and uncomfortable systems in the virtual world. Thus, developers should improve the accuracy of control, tracking, and instructions to avoid users to get angry in their VR sports use. Developers could also improve the comfortable system by eliminating disorientation in space and frequent camera tracking and rotation to reduce disgust. The developers could focus on the replica of realistic movements in VR sports to incur joy and surprise and reduce anger and disgust. Lastly, an affiliative avatar could enhance joy but the proximity interaction with a scary avatar causes fear. Thus, the developer should take cautious in avatar design to avoid the uncanny valley effect on users. But the developer should also consider the VR sports content development and social interaction in VR sports.

## Limitation and Future Work

The current study is not without limitations. First, this study explored the factors related to the six discrete emotions from the perspectives of content, VR technological features, and social interaction. Future studies could consider examining the relative importance of these identified factors in explaining the six discrete emotions at different stages of their VR sports use. Second, this study only examined the different reasons for the six different emotions but ignored how these negative and positive emotions could lead to users' evaluation of VR sports as well as their behaviors. Future research could investigate how different emotions could affect user satisfaction, the ranking of the app, and users' continuance or switching behavior, especially the negative emotions. Third, this study was conducted in the VR sports context. Cautions should be taken when generalizing the findings in other VR application contexts.

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