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Apart we ride together: The motivations behind users of mixed-reality sports

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ABSTRACT

A new form of sports platforms transfers traditional sports like cycling into a virtual world and lets users socialize, exercise or compete with each other. Despite the increasing public attention, there is no research on motivational factors of this advanced mixed-reality technology allowing virtual-mediated physical interaction. Therefore, we proposed a research model and tested it using structural equation modelling combined with qualitative interviews to investigate the platform's usage. Our results reveal that utilitarian benefits relate to the task-purposes of health consciousness and training, while hedonic benefits relate to training, customizing and socializing. Hedonic benefits are more strongly related to use intention than utilitarian, but subgroup-specific differences are observed. Privacy concerns constitute a risk for all users to continued use of these platforms, while cheating is relevant only for competitive users. Use intention positively relates to actual use behavior in the form of usage time, number of races and followed users.

1. Introduction

Digitalization has significantly changed the way billions of people participate in sports (Statista, 2020). Fitness applications allow us to track our training progress (Campbell, Ngo, & Fogarty, 2008), lose weight (Mateo, Granado-Font, Ferré-Grau, & Montaña-Carreras, 2015) or improve our overall fitness (Higgins, 2016). Corresponding hardware like smartwatches additionally motivates users to take their own preventive health actions (Canhoto & Arp, 2017). Additionally, hedonic motivations play an important role for users of wearable healthcare technologies (Gao, Li, & Luo, 2015). In general, research into fitness applications and wearables has focused on adoption factors (e.g., Canhoto & Arp, 2017), features (Higgins, 2016; Middelweerd, Mollee, van der Wal, Brug, & Te Velde, 2014) or social aspects (e.g., Yang, 2017).

In recent years, a number of sports applications have emerged that pursue a more holistic approach, encompassing health and play, by offering its users a wide range of features (Hamari & Koivisto, 2015b; Neumann et al., 2018; Tu, Hsieh, & Feng, 2019). ZWIFT, an "online cycling game", is an example of such an application, gathering more than 1.6 million users worldwide in early 2020 (for further explanations and depictions, see Delaney & Bromley, 2020). Using a so-called *smart trainer* that is connected to a bike, athletes can measure their performance through sensors attached to their equipment, which is then translated to an avatar within a virtual world (Delaney & Bromley, 2020). Besides training, users can also compete against other athletes in scheduled races. The facts that the reigning Olympic champion and three Tour de France winners participated in the first 'Virtual Tour de France' in July 2020, and that the race was broadcast in over 130 countries shows that virtual cycling platforms have reached the highest level of sport (The New York Times, 2020). During the event, non-professionals also got involved through mass participation races, held on the same virtual courses that professionals ride on (The New York Times, 2020). Another reason why ZWIFT is so popular is the ability of participants to customize the experience by unlocking new bikes or choosing different courses to ride on, which follows a gamification approach. The platform also includes a social component, allowing users to connect to others and build up a social network (Borrill, 2020). As this study was conducted during the COVID-19 pandemic, this form of

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virtual sports turns out to be one of the few opportunities to engage in sports together (Martin & Maxwell, 2020). The emergence of related platforms such as Peloton or Rouvy, both offering partly comparable functionalities, highlights the increasing relevance of this type of application. We decided to focus on ZWIFT for two reasons. First, it covers a wide range of characteristic features for this type of application, as it allows participants to perform the original sport by utilizing mixed-reality (MR) technology (Westmattelmann, Grotenhermen, Sprenger, & Schewe, 2021). Second, it received enormous public attention and is the platform with which most renowned institutions from the traditional sport of cycling cooperate (The New York Times, 2020).

A clear benefit of platforms like ZWIFT is that users can engage in actual sporting activities while their performance is measured through sensors and is visualized in a virtual world, which distinguishes it from other platforms that offer a virtual experience without the physical component. Extended by social interaction and customization possibilities, these platforms go beyond the definition of traditional fitness applications and offer utilitarian *and* hedonic benefits. But there are also potential drawbacks, as user-generated data might be subject to privacy risks, an often-mentioned problem in fitness applications (e.g., Sutanto, Palme, Tan, & Phang, 2013). Further, as ZWIFT is also used competitively, cheating is a potential problem, and has frequently been described as a drawback of fitness apps (e.g., Campbell et al., 2008; Van Mierlo, Hyatt, Ching, Fournier, & Dembo, 2016).

This study is, in particular, motivated by identified research gaps in the areas of virtual reality (VR) sport applications and MR. A systematic literature review of VR sport applications research showed that different physiological and psychological factors have been investigated by conducting experiments on the use of these applications (Neumann et al., 2018). However, how different task purposes, like training, competition or socializing, influence the perceived benefits has not yet been examined. Moreover, it is unclear whether perceived benefits and risks affect actual behavior outside of laboratory environments. Previous research has focused on novice participants, while experienced users and elite athletes have not been considered. In addition, applications that enable physical interaction in a virtual world have been studied, but mainly due to a lack of both public interest and of institutionalization, these applications do not meet the widely accepted definition of sport (Guttmann 1978; Jenny, Manning, Keiper, & Olrich, 2017; Suits, 2007). In the area of MR technologies, it has been shown that the technologies investigated can differ vastly in their design as well as in terms of perception (Flavián, Ibáñez-Sánchez, & Orús, 2019; Speicher, Hall, & Nebeling, 2019). Flavián et al. (2019) identify a strong demand for research into the emotional, behavioral and social responses of users. They also report a focus on positive effects of use, while negative aspects were rarely considered. In order to address these research gaps, we begin by presenting relevant systematic approaches from the areas of MR and VR sport and classify ZWIFT therein. We then address our research questions, which focus on a detailed analysis of factors influencing the motivation to use MR sport platforms and how that helps create demand among its users:

RQ1: How does the performance of sports platform-specific tasks affect the expected benefits of these platforms in terms of utilitarian and hedonic motivation?

RQ2: What influence do expected utilitarian and hedonic benefits as well as perceived risks (privacy concerns and cheating) have on the continued use intention of MR sports platforms?

RQ3: How does continued use intention of MR sports platforms affect the usage behavior of these platforms, in terms of overall usage time, social network size, and race participation?

We follow a multi-method approach and test our proposed research model by performing structural equation modeling, using survey data linked to the respective usage data. We find that the use of sports platforms like ZWIFT is strongly utilitarian as well as hedonically motivated. The individual use purposes, e.g., in the form of health consciousness, training, customizing and socializing, increase the two types of motivation differently. Sub-group analyses reveal differences between users based on their competition frequency. Furthermore, privacy concerns appear to be a general risk, while cheating is relevant only for competitive users. Finally, we examine the impact on general use, competition participation and socializing behavior on the sports platform. To gain a more profound understanding of the relationships considered, we conducted interviews with professional and non-professional users to identify comprehensive theoretical and managerial implications for sports platforms in general.

2. Theoretical background

2.1. Introducing mixed-reality frameworks

The reality-virtuality continuum developed by Milgram and Kishino (1994) serves as a starting point to understand different degrees of virtuality endorsed in applications that enable virtual sports. The two poles of the continuum depict the *Real Environment* (consisting exclusively of real objects), which is observed in person or through hardware like displays, and a purely *Virtual Environment* (consisting entirely of virtual objects; Milgram & Kishino, 1994; Flavián et al., 2019). *Augmented Reality* (AR) and *Augmented Virtuality* (AV) are located between these poles, whereby the level of computer-generated objects is higher for AV technologies (Milgram & Kishino, 1994). According to this taxonomy, *Mixed Reality* is an umbrella term for AR and AV that mainly considers the visual display (Milgram & Kishino, 1994). Reviewing the reality-virtuality continuum, we conclude that, due to its unilateral focus on visual aspects, it is insufficient to grasp the context of virtual sports applications, which is shaped by virtually-mediated physical interactions between multiple users (Westmattelmann et al., 2021). This conclusion also applies for related taxonomies (e.g., Flavián et al., 2019). Moreover, considering recent technological advancements, scholars have been arguing that specifically the notion of MR needs to be differentiated more clearly (e.g., Speicher et al., 2019). Thus, we refer to the framework of Speicher et al. (2019), which emphasizes the *number of environments* required and the *degree of interaction* enabled by a MR application. Further, it also considers that interactions could take place between a possibly high *number of users* as well as the multifacetedness regarding *input* and *output*, which might comprise motions and haptics. The audio-visually focused reality-virtuality continuum is represented by the dimension *level of virtuality* and accompanied by the *level of immersion,* which mirrors users' perceptions of what is presented to them. By combining an application's manifestations of these seven dimensions, a context-specific understanding of MR (e.g., as the alignment of environments or as a form of collaboration) can be established (Speicher et al., 2019).

2.2. Sports digitalization

In sport, digital technologies are primarily applied to measure, analyze or broadcast athletes' performances delivered within the real world (Xiao et al., 2017). In this regard, sophisticated MR technologies resemble a substantial advancement, as they allow the transfer of actual athletic performance into a virtual world, so that activities can be practiced simultaneously together and independently of location (Westmattelmann et al., 2021). Different related research streams are concerned with understanding and designing the interplay of virtualization and physical activity, which is why it is essential to define the term "sport" to differentiate it from related concepts like exercise games or active video games (Mueller et al., 2011; Neumann et al., 2018).

An activity can be considered to be sport if it meets the following criteria: 1) includes play that is voluntary, 2) is organized and governed by rules, 3) includes competition, 4) comprises skills, 5) includes physical skills, 6) has a broad following that goes beyond a local attraction, and 7) has achieved institutional stability where social institutions have regulating rules to stabilize it as an important social practice (Guttmann 1978; Jenny et al., 2017; Suits, 2007). This definition reveals that related concepts such as exergames or active video games (e.g., Xbox Fitness or Wii Fit U) and eSports (e.g., FIFA, Madden or League of Legends) do not meet one or more of those criteria and therefore are not considered as sports in the narrower sense (Cunningham et al., 2018). In their systematic literature review, Neumann et al. (2018) highlight "the use of computer-generated sport-relevant content and a means for the athlete to interact with the virtual environment" (p. 183) as key elements for interactive VR sport applications. They had to apply a broader definition of sport by applying only criteria 1) to 5), since virtual sport is a strongly growing phenomenon, but only reached a broad following and institutionalization with the first Virtual Tour de France held on ZWIFT, which was hosted by the organizer of the real-world Tour de France 'ASO' in 2020 (The New York Times, 2020).

Five components that are relevant to VR sport platforms were synthesized in the literature review (Neumann et al., 2018). *Task factors* can refer to specific sports (currently mainly cycling, running and rowing) or can be summarized across sports under health orientation, training and competition. We propose that the level of *virtuality of the environment* into which sporting performance is transferred via an exertion interface (e.g., ergometer, treadmill) can be classified using the taxonomy established by Speicher et al. (2019). It appears particularly appropriate in the context of sports, since physical aspects that go beyond the audio-visual display are crucial in these cases. *User factors* cover physical (e.g., age, gender, fitness level) and psychological (e.g., individual preferences) characteristics as well as expertise and experience. *Non-VR factors* relate to the real-world environment and involve physical (e.g., temperature or time) and social aspects (e.g., presence of other persons). Finally, *outcomes* of VR sport application usage can be subdivided into performance (e.g., distance, in-task persistence), physiological (e.g., heart rate, muscle fatigue) and psychological (e.g., behavioral intention, motivation) outcomes.

2.3. Benefits of sport platforms and sport applications

The previous section illustrated that VR and MR sports applications allow tasks like health-orientation, training, competition and socializing to be performed, which can lead to various benefits. Specifically, focusing on exploring perceptions of ZWIFT as a MR sport platform for conducting professional bike races during the COVID-19 pandemic, Westmattelmann et al. (2021) underline that athletes using ZWIFT perceive many of these aspects positively. For example, they consider ZWIFT as a suitable substitute for real-world training and even competitive races, which were shown to require comparable performances to real-world races. Beyond that, users stated they enjoyed the possibilities for social interaction with other users and virtually-mediated spectators. Since the benefits of VR and MR sports applications still need further investigation, the following section considers related and established research streams that generally address the intersections of sports, gaming and health.

A large body of work focuses on *health* applications, i.e., services like exercise games (Hamari & Koivisto, 2015a) and smartphone apps that provide the possibility of increased user health and fitness (e.g., Higgins, 2016). Mateo et al. (2015) find that systematic use of relevant mobile phone applications resulted in a significant loss of body weight. Other research focuses on mobile apps as a means to establish a regular fitness routine (Tu et al., 2019; Warburton et al., 2007). VR systems lead to higher enjoyment during exercise and a more persistent fitness routine, which resulted in an overall healthier lifestyle (Banos et al., 2016).

Sport applications are also considered an effective *training* tool to improve physical performance (Warburton et al., 2007). This shows that the process of advancing as an athlete (e.g., Pelletier et al., 1995), is also a benefit that motivates users of sport applications. While the mechanisms may be comparable to those concerning health-related benefits, the purpose for exercising is to optimize performance ability. In that context, users enjoy sport applications that allow them to customize their training based on their preferences (Higgins, 2016). Another motivation is the desire to achieve specific goals in the app (Middelweerd et al., 2014; Rabin & Bock, 2011). VR applications might be especially effective in the training context, as they allow users to "get feedback on performance and to practice specific skills" (Neumann et al., 2018).

Customizing functionalities enable users to incorporate their preferences by allowing them to decide on certain aspects of the application (Teng, 2010; Turkay & Adinolf, 2015). Individual interest in the ability to change the in-game avatar appearance and the equipment, which affects performance can be related to the motivation of using video games (Billieux et al., 2013; Teng, 2010; Yee, 2006). Especially in the context of sports applications, which create a strong relationship between virtual applications and physical activity, the ability to represent their body and equipment in the virtual world might delight some users (Teng, 2010).

Besides that advantage, the *social component* as a benefit of sport applications is an important topic. Tu et al. (2019) find that fitness applications with an integrated social component are perceived positively by users and that users of "social fitness apps" tend to develop a more persistent fitness routine. Studies emphasize the benefits of social components and their effect on application usage (e.g., Yang, 2017), while others note that recognition through social reward systems often represents a major benefit for users (e.g., Chung, Skinner, Hasty, & Perrin, 2017; Hamari & Koivisto, 2015b). Further, social interaction is facilitated in VR environments, as different individuals can be present simultaneously, even if their actual physical location is different, which leads to a stronger task persistence (Neumann et al., 2018; Irwin, Scorniaenchi, Kerr, Eisenmann, & Feltz, 2012).

Tightly connected to social interaction is the possibility for *competition*, to allow athletes to compare their own athletic performance to others. Song, Kim, and Cho (2018) name social comparison as a major factor influencing the continued use of sport applications. Other studies identify specific gamification elements that foster continued application use. For instance, Allam, Kostova, Nakamoto, and Schulz (2015) find that competition elements like rankings are a hugely popular strategy with the potential to change user's behavior. For example, the use of VR sports applications improves race strategy performance in rowing (Hoffmann, Filippeschi, Ruffaldi, & Bardy, 2014).

2.4. Risks of sport platforms and sport applications

Besides the potential benefits of sport applications there also exist certain risks. A common perceived problem is uncertainty regarding *data privacy* in smartphone applications (e.g., Sutanto et al., 2013; Tam et al., 2015). A recent study on professional cyclists' perceptions of ZWIFT found that data transparency and public availability of individual performance data were perceived positively, as they prevent manipulation and allow for accurate performance measurement and improvement (Westmattelmann et al., 2021). However, the growing number of fitness applications that are connected to social media sites in combination with sensitive user-generated health data poses a security threat. Studies suggest that users perceive the problem as severe and are more likely to pay for applications that collect fewer personal data (Egelman et al., 2013). Felt, Egelman, and Wagner (2012) find that unsolicited sharing of personal information by an application is classified as a major concern by users.

There is also a high risk that performances and achievements displayed within these applications might not actually represent reality. *Cheating*, in this context defined as seeking illegitimate advantages by violating the agreed rules of the game and deceiving competitors (Lee, Whitehead, & Ntoumanis, 2007), represents a substantial risk related to health, sport and fitness applications (Hopia & Raitio, 2016; Van Mierlo et al., 2016). Cheating issues and data manipulation were also identified as severe issues among professional cyclists using ZWIFT (Westmattelmann et al., 2021). Campbell et al. (2008) note that users of running applications could easily alter the output data; thus, cheating might be easier in online applications than in real-life (Gal-Oz & Zuckerman, 2015). Schmidt-Kraepelin et al. (2019) observe that cheating in applications dedicated to developing a healthier routine in life might demoralize other users.

2.5. ZWIFT as an exemplary mixed-reality sports application

The analysis in this paper is based on the example of ZWIFT, as it is currently the MR sports application with one of the highest user numbers and also has a comparatively high range of functions, large public interest and a significant degree of institutionalization. In order to allow the transfer of results to other sports applications, ZWIFT will be classified in the following into the described frameworks from the domains VR sports and MR, using the framework by Neumann et al. (2018) as an overarching systematization. Regarding *tasks*, ZWIFT allows its users to cycle or run in a virtual world (Delaney & Bromley, 2020; see Supplementary material A: Screenshot ZWIFT). ZWIFT enables joint group rides (training) as well as competing with other users and allows for extensive monitoring of relevant health data related to these activities. Furthermore, ZWIFT offers various customizing options by allowing the appearance of the avatar to be changed and equipment from original real-world manufacturers to be chosen. Additionally, commonly used means of communication, such as a chat function and "Likes", here called "Ride-on", can be used. The app also includes a strong social component, allowing users to connect to other users and build up a social network within the platform (Borrill, 2020). Regarding the *VR respectively MR environment* and in accordance with Westmattelmann et al. (2021), ZWIFT is classified here following the MR taxonomy of Speicher et al. (2019), since this taxonomy allows for a more rigorous and up-to-date categorization than does Neumann et al. (2018). While ZWIFT combines a joint *virtual environment* and the *real world* (i.e. individual users' homes/training facilities), most features of the platform engage *multiple users* (Delaney & Bromley, 2020). Regarding the *level of virtuality*, users see a purely virtual world via a stationary or portable display, while their movements on the smart trainer (e.g., cadence) are translated to an avatar in the virtual world. Further, we assume the *level of immersion* to be high due to the required focus and physical activity (Westmattelmann et al., 2021). The *level of interaction* is high due to functionalities for interacting with other users (e.g. chat functions, joint group rides, racing, simulated slipstream effects) and the environment (e.g., using "speed boost" power ups, changing environment and gradient; Borrill, 2020; Delaney & Bromley, 2020). These mechanisms increase the perceived enactive realism, which resembles the user's perception that "he or she is actually [..] acting out in the mediated environment" (Lin & Peng, 2015, p. 5). Finally, using a so-called 'smart trainer' that is connected to a real bike, athletes can measure their performance through sensors attached to the equipment, and thus, translate their own athletic performance (*input* measured in watt per kilogram) into the virtual world while receiving audio-visual and physical feedback from it (*output*; Delaney & Bromley, 2020). In terms of the framework of Neumann et al. (2018), the smart trainer with an attached bike resembles the exertion interface. Specifically, the functionality to provide real-time haptic feedback resembling activities in the virtual world via this hardware is a key feature of ZWIFT. In conclusion, ZWIFT can be categorized as virtual environment respectively reality according to the frameworks of Milgram and Kishino (1994) and Neumann et al. (2018), which focus on the audio-visual dimension. Since other dimensions (especially physical aspects) are important in the context of sports, we follow Speicher et al. (2019) and categorize ZWIFT as a (MR) sport application. Here, ZWIFT represents a form of *collaboration*, which enables an interaction between users that are physically separated (Speicher et al., 2019; Westmattelmann et al., 2021). Concerning the *user factors*, the different features and executable tasks allow usage according to individual preferences and motivation. Depending on the fitness level and individual goals, users can choose the appropriate training programs or participate in races, so that the users range from recreational to world-class athletes (Westmattelmann et al., 2021). The *non-VR factors* are manifold, meaning that ZWIFT can be used in all places where electricity and internet connection is available. It can be used alone in social distance or even for mass events in stadiums, as frequently seen in an (e)sports context. Finally, ZWIFT generates various *outcomes*. By using a smart trainer and additional sensors, the performance can be measured, shared with other people and systematically analyzed based on different physical parameters such as training duration, power output, heart rate, and cadence (Westmattelmann et al., 2021). The fitness level and the training progress can be monitored over time by means of corresponding tools. On the psychological side, MR sport can affect motivation, use intention and lead to new social contacts (Westmattelmann et al., 2021). Beyond that, ZWIFT can be considered as a multi-sided platform, which are defined as intermediaries that enable two or more user groups to have interactions that they perceive as beneficial (Evans, 2003).

3. Model and hypotheses development

3.1. Overview

To derive our research model, we draw on core mechanisms of the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2; Venkatesh, Thong, & Xu, 2012) and extend the model to improve its context-specificity according to the multi-level framework proposed by Venkatesh, Thong, and Xu (2016). In this regard, we emphasize the task factors *health orientation, training, competition* (Neumann et al., 2018) as well as *customization* and *socializing*, which all represent individual-level context factors relating to the task characteristics (Venkatesh et al., 2016). By adding novel exogenous mechanisms, we examine whether they relate to the UTAUT2 model's concepts of performance expectancy (=Expected Utilitarian Benefits) and hedonic motivation (=Expected Hedonic Benefits). In this context, we define Expected Utilitarian Benefits as the user's perception of the degree to which the use of MR sports platforms is efficient for achieving their goals (Venkatesh et al., 2012; Venkatesh, Morris, Davis, & Davis, 2003). Hedonic Benefits on the other hand refer to the user perception of the degree to which the use of MR sports platforms brings them fun and enjoyment (Rauschnabel, He, & Ro, 2018; Venkatesh et al., 2012). Since the perceptions as to whether a specific task is utilitarian or hedonic might differ, depending on individual user preferences and attitudes (Neumann et al., 2018; Venkatesh et al., 2016), we will hypothesize for both types of Expected Benefits in the following. Beyond that, we extend the model by endogenous mechanisms, which directly relate to use intention. In this regard, we focus on risk perceptions opposing the benefit perceptions, as e.g. Rauschnabel et al. (2018) conceptualized it. Privacy concerns refer to the individual-level sphere of technology attributes, while the unacceptance of cheating concerns a higher-level organizational factor affecting continued use intention (Venkatesh et al., 2016). Finally, we consider new conceptualizations of technology use, respectively outcomes of sport application usage (Neumann et al., 2018), as we measure Use Behaviour via three forms of objective platform data (Venkatesh et al., 2016).

3.2. Task purpose

Various studies deal with the concepts of exergames and "serious games", whereby the overall goal or outcome of these games is to combine utilitarian and hedonic benefits (Baptista & Oliveira, 2019; Hamari & Keronen, 2017; Mueller et al., 2011). Several studies identify overall better health as an expected utilitarian benefit of (virtual) sports or exercise apps (Higgins, 2016; Mateo et al., 2015; Tu et al., 2019; Neumann et al., 2018). Other studies also note that hedonic motivation plays an important role for fitness applications' users (Canhoto & Arp, 2017; Gao et al., 2015; Hamari & Koivisto, 2015b). Thus, we hypothesize that:

H1: *Health Consciousness positively relates to **a)** Utilitarian Benefits and **b)** Hedonic Benefits.*

Athletes using ZWIFT stated that they perceive the application as suitable for training purposes (Westmattelmann et al., 2021). In this regard, improved physical performance abilities are considered to be a utilitarian benefit of exercise gaming applications (Hamari & Koivisto, 2015b; Tu et al., 2019; Warburton et al., 2007). This is supplemented by hedonic benefits, e.g. through individual goal-setting or other gamification elements (Middelweerd et al., 2014; Rabin & Bock, 2011). Therefore, we hypothesize that:

H2: *Training positively relates to **a)** Utilitarian Benefits and **b)** Hedonic Benefits.*

The ability to customize the user experience and specifically the avatar appearance according to personal preferences is deemed an important factor for motivating gamers to continue playing (Billieux et al., 2013; Teng, 2010; Turkay & Adinolf, 2015; Yee, 2006). Related studies find support for effects of utilitarian and hedonic factors related to gamification (Baptista & Oliveira, 2019; Hamari & Koivisto, 2015a, 2015b). In a sports-related context, studies suggest that fitness application users perceive customization elements positively (e.g., Higgins, 2016; Middelweerd et al., 2014). Regarding ZWIFT, professional cyclists also mentioned the topics of in-game equipment and power-ups (Westmattelmann et al., 2021). Customization elements like the ability to purchase new and better bikes might represent a utilitarian value for some users, as they lead to competitive advantages and can be classified as functional aspects of customizing (Turkay & Adinolf, 2015). We hypothesize:

H3: *Customizing positively relates to **a)** Utilitarian Benefits and **b)** Hedonic Benefits.*

The existence of competitions has been frequently mentioned as a major benefit and important building block of traditional sports (Pelletier et al., 1995) and virtual sports applications (Neumann et al., 2018). Moreover, ZWIFT's applicability for competitive purposes has recently been proven (Westmattelmann et al., 2021). The concept has also been proven to be an important motivational driver in an eSports context (Cunningham et al., 2018; Seo & Jung, 2016), or in a gaming context (Billieux et al., 2013; Yee, 2006). The concept is also addressed in fitness applications, where social comparison is identified as a major influencing factor that fosters continued service use (e.g., Allam et al., 2015; Lister, West, Cannon, Sax, & Brodegard, 2014; Song et al., 2018). To further analyze the benefits of competitions we hypothesize:

H4: *Competition positively relates to **a)** Utilitarian Benefits and **b)** Hedonic Benefits.*

The importance of social components as providing hedonic benefit within gaming or information systems in general is extensively discussed in research (Chung et al., 2017; Hamari & Koivisto, 2015b; Park, Baek, Ohm, & Chang, 2014; Shin & Shin, 2011; Zhang, 2008). However, in a more sports-specific context, the utilitarian benefit of social components to develop a more consistent fitness routine is also frequently emphasized (Tu et al., 2019; Yang, 2017). ZWIFT users expressed positive attitudes towards interaction possibilities with other riders, spectators, and the public (Westmattelmann et al., 2021). In order to further investigate the influence of social factors as an expected benefit we hypothesize that:

H5: *Socializing positively relates to **a)** Utilitarian Benefits and **b)** Hedonic Benefits.*

3.3. Expected Benefits

The influence of Expected Utilitarian Benefits on Use Intention is a consistently proven concept within technology adoption literature (for an overview see Venkatesh et al., 2016), as initially suggested by Venkatesh et al. (2003) and Davis (1989). Hedonic aspects of usage have frequently been discussed as a predictor for technology use as well (e.g., Rauschnabel, 2018; Venkatesh et al., 2012). As both conceptualizations were confirmed regarding related adoption scenarios, such as MR applications (e.g., Rauschnabel et al., 2018), gaming (e.g., Hamari & Keronen, 2017) and social media (e.g., Ngai, Tao, & Moon, 2015), we hypothesize:

H6: ***a)*** *Expected Utilitarian Benefits and **b)** Expected Hedonic Benefits positively relate to Use Intention.*

3.4. Perceived risks

With sport activities taking place within the virtual sphere, novel vulnerabilities arise. Perceived risks can relate to privacy concerns, mirroring the user's fears of misuse or lack of control over collected personal information, which reduces the intention to use a technology (Malhotra, Kim, & Agarwal, 2004). Perceived risk and information security were identified as important factors during the adoption process of mobile gaming (Kleijnen, De Ruyter, & Wetzels, 2004), social media (Kwon, Park, & Kim, 2014) and social network game adoption (Shin & Shin, 2011). The negative effect of security issues on user adoption is also mentioned in the context of fitness applications (Egelman et al., 2013; Felt et al., 2012; Tam et al., 2015). Moreover, issues related to cheating might also be perceived as risks. Cheating and corruption are described as potentially relevant in the context of eSports (Seo & Jung, 2016). The issue is relevant especially in the context of sports-related smartphone applications, as results could more easily be altered than in real life, which might demoralize other honest users (Campbell et al., 2008; Hopia & Raitio, 2016; Schmidt-Kraepelin et al., 2019; Van Mierlo et al., 2016). In the context of ZWIFT, a related study found that possibilities of cheating and data manipulation concern users and correspondingly highlighted suspicious patterns (power output and weight) in provided user data (Westmattelmann et al., 2021). Thus, we hypothesize that:

H7: *Perceived Risks, namely **a)** Privacy Concerns and **b)** Unacceptance of Cheating negatively relate to the Use Intention.*

3.5. Use behavior

The relation between Use Intention and Use Behavior is one of the key concepts in technology acceptance literature (e.g., Davis, 1989; Venkatesh et al., 2003; Venkatesh et al., 2012, 2016) which has been applied and proven rather consistently. In line with that, we assume that Use Behavior is positively affected by Continuous Use Intention. We collected actual usage through publicly available data and distinguish Use Behavior between (i) the amount of time respective respondents spent on ZWIFT, (ii) the number of races each respondent participated in, and (iii) the number of social contacts a user has on the platform. This allows us to very specifically identify different motivations for using ZWIFT. We hypothesize:

H8: *The Use Intention positively relates to the Use Behavior, specifically **a)** Social Network Size, **b)** Time used in 30 days and **c)** Number of Races in 30 days.*

4. Methodology

4.1. Research design

To illuminate the postulated relationships, we followed a mixed-methods approach. To test the hypotheses, we collected quantitative data, which we supplemented with qualitative data by conducting semi-structured interviews with different users to obtain a more profound understanding of the identified relationships (Myers, 2010; Schultze & Avital, 2011). The quantitative part of the study is based on survey data collected in March 2020 and actual use data obtained from the platform in April 2020 (30 days after online survey completion), which we matched to the individual survey responses. The online survey was sent to (potential) users via so-called ZWIFT communities. 876 athletes clicked on the link to the survey of, whom 536 completed it. A data cleansing process was conducted as follows: 17 participants did not pass the integrated attention check, 140 participants could not be assigned a ZWIFT account, another 86 had a private ZWIFT profile and the completion time of nine participants deviated by more than two standard deviations from the arithmetic mean. Thus, the final sample consists of 284 respondents we determined to be actual users of the application. The average age is 39.84 years (SD = 11.15; Min = 16; Max = 71) and 85.21% are male. On average users had 19.10 months (SD = 14.31; Min = 1; Max = 64) experience with the application before taking the survey and the average usage time was 174.61 h (SD = 179.61; Min = 0, Max = 1,486).

We then set up the empirical model to test our hypotheses. Confirmatory factor analyses and covariance-based structural equation modelling (SEM) were conducted with the R-based *lavaan* package (Rosseel, 2012). Complementary to the overall model, where we treated all 284 respondents as a homogeneous group, we additionally analyzed two subgroup models to get a deeper understanding and to compare the relationships among users. In subgroup model 1, we distinguish between users who took part in races more than once in the last 30 days (racers; Subgroup A) and users who only participated in at most one race in this period (others; Subgroup B). For subgroup model 2, we differentiate between users (racers), who participate in at least four races in the last 30 days (Subgroup C) and those who only competed up to three times (Subgroup D). The number of races conducted in the last 30 days is not included as a dependent variable in the sub-models, as it was used to distinguish between racers and non-racers.

The subsequent qualitative study was conducted on the basis of semi-structured interviews in order to investigate the identified relationships more comprehensively (Schultze & Avital, 2011). The underlying interview matrix was derived from the theoretical foundation of the proposed research model, but also allowed the interviewer to deviate from the structure to capture further aspects that are relevant for this study. All participants were informed about the handling of the interview data, data protection and measures to ensure privacy.

Qualitative data was gathered by performing semi-structured interviews with eight professional and six non-professional cyclists that use the platform. Professional riders are defined as regularly competing riders in a professional team registered with the International Cycling Union UCI, while non-professionals are recreational or amateur cyclists. The interviews lasted between 16 and 56 min, were recorded after gaining permission from the interviewees and were transcribed afterwards. Of the professional participants, two (25%) are female and of the non-professional cyclists three are female (50%). The total annual distance that the interviewed riders rode on their bikes averages 17,443 km (professional: m = 23,750, SD = 3,845; non-professional: m = 9,033, SD = 3,691), of which 1,905 km per year were ridden on the platform (professional: m = 1,759, SD = 992; non-professional: m = 2,100, SD = 1,999). Among the professional respondents, we interviewed a Tour de France stage winner, Olympic participants and winners of internationally recognized races.

4.2. Measures

Measures were adapted from relevant literature in English, translated to German (since the study participants spoke German) and translated back to check validity. Moreover, a pretest was conducted, and the survey was carefully modified. We decided to maintain the original item scales per construct, so we measured them on 5-point and 7-point Likert scales and standardized the values subsequently (see supplementary material B). *Competition* and *Socializing* were operationalized by four items each and *Customizing* was represented by three items, all measured on 5-point Likert scales based on Yee (2006). *Health Consciousness/Consideration* was adapted from Gould (1988) and measured by three items on a 7-point Likert scale. A construct consisting of four items from Ribbens, Malliet, van Eck, and Larkin (2016) operationalized *Training* with a 5-point Likert scale. *Utilitarian* and *Hedonic Benefits* as well as the *Continued Intention to Use* were measured by four, three respectively three items on 7-point Likert scales from Venkatesh et al. (2012). Five items measured on a 7-point Likert scale operationalize *Privacy Concerns* (Malhotra et al., 2004) while three items measured on a 5-point Likert scale operationalize the *Attitude Towards Cheating* (Lee et al., 2007). The latter was inverted for analysis to measure Unacceptance of cheating, so high expressions of the construct resemble rejection of cheating.

Use Behavior was measured by three outcomes, which were collected directly from the platform a month after the survey was finished: The overall time spent on the platform in the last 30 days (*Use Time 30 Days*), the number of races entered in the last 30 days (*Races 30 Days*) and the overall number of connections a user has made (*Social Network Size*). Thus, the objective outcomes represent general and competitive usage in the last 30 days as well as the social network size. Since number of races conducted in the last 30 days was used to separate the racers from non-racers, it is only included as an outcome variable in the overall model.

All constructs reach sufficient internal reliability, as the values for Cronbach's Alpha and Composite Reliability were all above 0.7 (Cronbach, 1951; Henseler et al., 2009). Convergent reliability can be assumed, as the Average Variance Extracted (AVE) is above 0.5 for all constructs (Fornell & Larcker, 1981). Moreover, the Fornell-Larcker criterion is fulfilled, as the square root of each construct's AVE is greater than any of their correlations, supporting sufficient discriminant validity (Fornell & Larcker, 1981).

5. Results

Means, standard deviations (SD), and correlations of all latent variables are shown in Table 1.

The fit of the overall model is good, as the comparative fit index (CFI), incremental fit index (IFI) and the Tucker-Lewis index (TLI) exceed the threshold of 0.9 and the root mean square error of approximation (RMSEA) as well as the standardized root mean square residual (SRMR) vary below 0.08 (see Fig. 1). Finally, the χ^2 per degree of freedom ratio is below 2 (Hooper, Coughlan, & Mullen, 2008; Tabachnick, Fidell, & Ullman, 2019).

In Table 2 the subgroup models 1 and 2 show lower, but still sufficient, model fits. Only the TLI slightly misses the threshold of 0.9 in subgroup model 1 (0.897) and subgroup model 2 (0.888). We attribute this to the sensitivity of the TLI for smaller sample sizes (Hooper et al., 2008; Tabachnick et al., 2019) and the fact that the "racers" (Subgroup A and C) in the sub models are comparatively small, especially in subgroup model 2. Summarizing, the overall model specifications are supported by all fit indices, while the TLI of the sub models is marginally deviating. To maintain comparability with the main model, we will not adjust the sub models.

Regarding *Health Consciousness*, we find mixed evidence. H1a is supported, as there is a positive relation towards *Utilitarian Benefits* in the overall sample ($ß = 0.159$; $p < .05$) and in Subgroups B and D (<2 respectively < 4 races). The analysis of the interviews demonstrates that

Table 1
Zero-order correlations and descriptive statistics.

Construct	Mean (SD)	1	2	3	4	5	6	7	8	9	10	11	12
1 Health	5.609 (0.862)	—											
2 Training	2.707 (0.907)	0.016	—										
3 Competition	3.218 (0.886)	0.152	0.099	—									
4 Socializing	3.221 (0.861)	0.084	0.26	0.366	—								
5 Customizing	3.02 (0.757)	0.205	0.097	0.317	0.231	—							
6 Utilitarian	5.72 (0.9)	0.188	0.344	0.162	0.198	0.139	—						
7 Hedonic	6.098 (0.867)	−0.008	0.219	0.15	0.321	0.195	0.359	—					
8 Privacy	2.98 (1.012)	0.011	−0.038	−0.024	−0.066	−0.111	−0.171	−0.208	—				
9 Cheating	4.812 (0.428)	0.045	0.009	−0.08	0.067	−0.061	0.105	0.022	−0.086	—			
10 Intention	5.763 (1.024)	0.079	0.263	0.125	0.231	0.147	0.525	0.576	−0.244	0.006	—		
11 Time spent 30 days	11.6 (13.506)	−0.054	0.173	−0.012	0.173	−0.009	0.119	0.175	−0.019	0.083	0.219	—	
12 Following	61.645 (96.9)	0.066	0.154	0.251	0.195	0.115	0.185	0.138	0.005	−0.044	0.184	0.102	—
13 Races 30 days	3.046 (4.372)	−0.036	0.087	0.065	0.100	0.106	0.197	0.128	0.017	−0.063	0.231	0.085	0.505

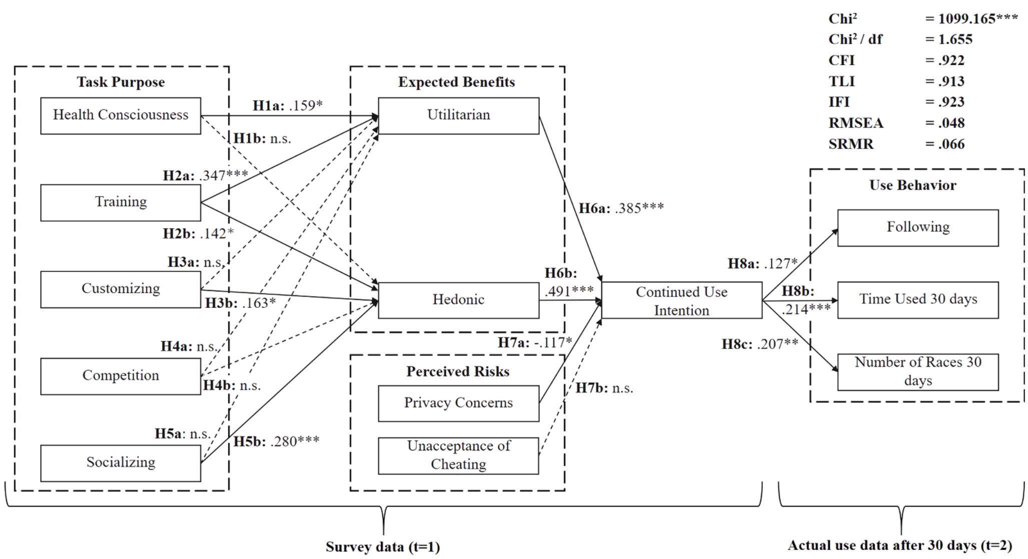

Fig. 1. Results of the overall structural equation model. *Note*. Significance levels: +p < .1, *p < .05, **p < .01, ***p < .001.

the expected health-related benefits resulting from the use of MR sports platforms can be manifold. As reasons for use it was stated "I do it only for myself and my body and my mind" (Non-Pro1). Other users expect an improved weight regulation: "I have […] some weight problems and I get them cured a little bit, which means that I also burn energy" (Non-Pro2). In view of the increasing traffic in many regions, the aspect of road safety is also of particular importance: "I think […] it's a safety factor […], who wants to ride outside […] when it's dark?" (Pro1). We find no evidence for a relation to *Hedonic Benefits* either in the overall sample ($p = .439$) or in any subgroup, which means that H1b is not supported.

H2a regarding the purpose of *Training* can be supported, as it positively relates to *Utilitarian Benefits* ($ß = 0.347$; $p < .001$) in the main model and all subgroups. Training is also positively associated with *Hedonic Benefits* in the main model ($ß = 0.142$; $p < .05$), thus supporting H2b, and in Subgroups A and D (≥2 races and < 4 races). The interviews indicate that "You can gain great benefit from it, even in training." (Pro2). Additionally, a benefit is a higher training motivation and satisfaction of the need for playfulness: "If someone is riding in front and you think […] I can still catch him […] then you do a sprint that you would not do on the road." (Pro3). MR sports platforms also offer opportunities to discover real-world courses: "You can't fly to every race or every course in advance and inspect them, and if it offers such opportunities, I'm happy to use it […] I rode live in London, and it [ZWIFT] reflects that very well." (Pro3).

Customizing is not related to *Utilitarian Benefits* in the overall model or in any of the subgroups, so H3a is not supported. However, we found that some competitive riders spend time to customize their virtual bike to the virtual course in order to gain a competitive advantage: "I used to take my aero bike for the flat races and […] there's also a climbers' bike for the mountain races. […] I always took the time to choose it." (Pro4). On the contrary, H3b) can be supported, since *Customizing* is positively related towards *Hedonic Benefits* in the overall model ($ß = 0.163$; $p < .05$) and in Subgroups A and C (≥2 and ≥ 4 races). The interviews reveal that users are motivated by customization: "I like this gamification aspect. […] I'm someone who tortures himself for a virtual jersey." (Non-Pro2).

H4a and H4b have to be rejected, as *Competition* does not relate to *Utilitarian* ($p = .609$) or *Hedonic Benefits* ($p = .822$) in the overall sample or in any subgroup. During the interview study, users mentioned that the constant comparison of performance can evoke negative consequences: "Yes, of course this competitive thing. It puts me under pressure." (Pro5).

H5a is rejected as *Socializing* is not related towards *Utilitarian Benefits* in the overall sample ($p = .194$) or in any subgroup. This result can be attributed to a lack of constructive feedback from the community: "I'm not really that keen on socializing […] it doesn't help me when others comment on my rides". (Pro2). In contrast, H5b is supported since *Socializing* positively relates towards *Hedonic Benefits* within the overall sample ($ß = 0.280$; $p < .001$) and each subgroup. The importance of social interaction is also reflected in the interviews and can include social comparison ("I think many famous riders also use ZWIFT - of course you can compare yourself with them." - Non-Pro3) or can focus on mutual activities: "You wait for the slower one; everyone is taken

Table 2
Subgroup-specific SEM results and model fit indices.

Independent	Dependent	Subgroup Model 1		Subgroup Model 2	
		Subgroup A ≥ 2 races	Subgroup B < 2 races	Subgroup C ≥ 4 races	Subgroup D < 4 races
Health	Utilitarian	0.102 (0.064)	0.236** (0.069)	0.157 (0.064)	0.187* (0.063)
Training	Utilitarian	0.392*** (0.066)	0.328*** (0.102)	0.338*** (0.076)	0.333*** (0.08)
Customizing	Utilitarian	0.125 (0.121)	0.037 (0.129)	0.167 (0.097)	0.032 (0.128)
Competition	Utilitarian	−0.141 (0.098)	0.112 (0.088)	−0.146 (0.113)	0.05 (0.071)
Socializing	Utilitarian	0.095 (0.056)	0.124 (0.094)	0.177 (0.069)	0.087 (0.071)
Health	Hedonic	0.027 (0.091)	−0.104 (0.067)	0.062 (0.108)	−0.09 (0.062)
Training	Hedonic	0.191* (0.086)	0.087 (0.09)	0.084 (0.118)	0.137+ (0.072)
Customizing	Hedonic	0.269* (0.183)	0.059 (0.134)	0.373** (0.179)	0.044 (0.131)
Competition	Hedonic	−0.053 (0.139)	−0.041 (0.088)	−0.091 (0.191)	0.027 (0.073)
Socializing	Hedonic	0.196+ (0.082)	0.409*** (0.103)	0.266* (0.119)	0.326*** (0.075)
Utilitarian	Intention	0.532*** (0.121)	0.322*** (0.085)	0.475*** (0.153)	0.336*** (0.079)
Hedonic	Intention	0.358*** (0.065)	0.556*** (0.081)	0.487*** (0.074)	0.512*** (0.073)
Cheating	Intention	−0.078 (0.064)	−0.041 (0.155)	−0.214* (0.201)	−0.025 (0.112)
Privacy	Intention	−0.126 (0.051)	−0.098 (0.053)	−0.115 (0.056)	−0.108 (0.048)
Intention	Following	0.215** (0.15)	0.061 (0.144)	0.244* (0.126)	0.201*** (0.142)
Intention	Hours 30 days	0.294** (0.148)	0.122 (0.135)	0.265* (0.172)	0.114 (0.121)
n		129	155	93	191
Chi^2		1,839.596		1,881.543	
Chi^2 / df		1.385		1.417	
CFI		0.908		0.900	
TLI		0.897		0.888	
IFI		0.910		0.902	
RMSEA		0.052		0.054	
SRMR		0.077		0.078	

Note. Significance levels: +p < .1, *p < .05, **p < .01, ***p < .001. Standardized beta coefficients (standard error in brackets).

across the finish line.” (Non-Pro3). Thus, MR sports platforms can not only help users maintain existing relationships, but also to expand their social network: “ZWIFT ultimately enables me to expand my network of friends and contacts. […] I will be going to events to meet people I met through ZWIFT.” (Non-Pro2).

Utilitarian (ß = 0.385; p < .001) and *Hedonic Benefits* (ß = 0.491; p < .001) are both positively related towards the *Continued Use Intention* in the overall sample and in all subgroups, clearly supporting H6a and H6b. The utilitarian benefit in particular results from the wide range of options to perform different tasks offered by the platform: “For me [ZWIFT] is a useful complement to all the outdoor training.” (Non-Pro4). Accordingly, these platforms allow activities to be integrated more flexibly into everyday life: “I use ZWIFT so that I have the opportunity to pursue this otherwise time-consuming sport of cycling after a stressful day.” (Non-Pro1). The survey data reveals that the impact of hedonic benefits on the use intention is more pronounced than that of utilitarian benefits, which is also reflected in the interviews and can in particular be attributed to the immersion created: “[Indoor training] was deadly boring. And ZWIFT simply tempts you to join in; you forget about the time and have fun.” (Non-Pro2).

Regarding risk perceptions, we find support for H7a regarding the impact of *Privacy Concerns* towards *Continued Use Intention* in the overall sample (ß = −0.117; p < .05). In contrast, this effect does not persist among subgroups. The interviews clarify why privacy concerns have a negative effect on the intention to use: “Data has become extremely valuable. […] It could be determined how many watts per kilo I ride on a mountain. […] These are interesting data and I prefer to keep them private. I don’t get any money for it and actually give people something they would probably pay for.” (Pro6). H7b is partially supported, since *Unacceptance of Cheating* only negatively relates to the *Continued Use Intention* in Subgroup C (≥4 races), while no relation is observed in the overall sample (p = .288) respectively in the other three subgroups. In line with this, we faced divergent reactions to the issue of cheating, which seems to be specifically relevant in the context of competitive use: “But if I would race there, of course, then I would be very upset to not know if the others are truly racing or […] if they have faked their numbers.” (Pro4). Another professional rider added “that would completely demotivate me” (Pro7). Other users see it as an opportunity rather than a problem: ”I even like it sometimes […], because it’s sometimes annoying for me if I can’t participate in certain rides because I simply can’t bring the performance over the time. […] I can understand if someone […] would simply adjust this parameter [his/her weight].” (Non-Pro2).

Finally, *Continued Use Intention* positively relates to *Use Behavior*, as measured by *Use Time 30 Days* (ß = 0.214; p < .001) and *Races 30 Days* (ß = 0.207; p < .01) as well as the *Social Network Size* (ß = 0.127; p < .05) in the overall model, supporting H8a, H8b and H8c. The effects towards *Use Time 30 Days* also occur in Subgroups A and C, while the relation towards *Social Network Size* was confirmed in Subgroups A, C and D. The interviews reveal that the different use modes allow a wide variety of use patterns: “I start ZWIFT, get on the bike and then just do an endurance ride. Or, if you say, […] ‘I’m really going to blow it today’, then you just go deep with racing.” (Non-Pro1). Others are increasingly using the platform to get some variety via racing: “I wanted to do training 2–3 times a week […] then mostly in the evening and I’m also looking for races.” (Non-Pro5). Many users value the social connections they developed on the platform and are interested in peers’ activities: “Well, I find it very interesting to see how other people ride. Mainly with those I am following.” (Non-Pro6).

6. Discussion

6.1. General discussion

MR sports platforms such as ZWIFT represent a way to practice physical sports with or against other participants in a virtual world by exhibiting virtually-mediated physical interaction and represent one of the first widespread and publicly noticed consumer applications of MR technology besides Pokémon Go (Flavián et al., 2019; Rauschnabel, Rossmann, & tom Dieck, M. C. , 2017). Focusing on ZWIFT allows us to address the research gap regarding the motivations for using similar mixed-reality sports applications in everyday life. This gap exists because these platforms require complex devices and consequently were mainly studied in experimental laboratory settings in prior research (Neumann et al., 2018). Our study is able to go beyond the laboratory to explore a large population of users in natural settings.

RQ1 aims at understanding which platform-specific sports tasks create motivation. Regarding the use purpose of *Health-consciousness*, recreational users perceive the opportunity to be physically active and thereby strengthen their health as a utilitarian benefit. Beyond that, practicing MR sports minimizes the risk of having accidents on the road or catching a virus through social exposure, which might be specifically relevant for health-concerned users. Accordingly, a reduced risk of getting injured and increased physical safety were identified as benefits of exercising games (Mueller et al., 2011) and the AR gaming application ‘Pokémon Go’ (Rauschnabel et al., 2017). Thus, while keeping the character of the original sport, virtual exercise mitigates common risks associated with physical exercise in the real world.

We find that *Training* can serve as a strong motivator on its own that provides utilitarian and hedonic value. From a sport psychology perspective, this result corresponds to the Sport Motivation Scale, which links sporting activity itself to different forms of extrinsic and intrinsic motivation, such as the willingness to accomplish better performance for individual realization (Pelletier et al., 1995). The literature on exercise gaming also highlights that training and performance improvement are major motives for use (Neumann et al., 2018), especially tailored training schedules and features for gathering and analyzing performance data enable advanced training management (Westmattelmann et al., 2021). The literature further proposes that social factors and gamification elements are suitable to combine training with hedonic aspects following the mantra "productivity through fun" (Hamari & Koivisto, 2015b).

Customizing relates only towards perceptions of hedonic benefit. In this regard, we refer to gamification literature, which highlights the effectiveness of reward systems to nudge players to continue playing games (Wang & Sun, 2011). Remarkably, this effect is sustained among the competitively-oriented race mode users. This may be because certain rewards or items are only available to users who have successfully completed certain challenges, so that the use of these items can foster social recognition among other users (Hamari & Koivisto, 2015b).

Other than hypothesized, the purpose of *Competition* does not relate towards the perceived benefits of the platform, not even among competitive users. This is remarkable, as the ability to compete in a virtually-mediated physical sport is a major novelty of MR applications such as ZWIFT, which even allow for virtual competition on a professional level (Westmattelmann et al., 2021). A reason no relationship between competition and utilitarian respectively hedonic motivation was identified could be that the sporting relevance of virtual competitions might currently still be considered as being low. Moreover, the perceived realism and fairness of the competitions might be perceived as low, as they require different skills compared to traditional competitions (e.g., use of power-ups; Westmattelmann et al., 2021).

In line with previous research on serious gaming, exercise gaming and MR gaming, we find that *Social* factors serve as major determinants of hedonic motivation and continued use of MR sports platforms (Chen, Rong, Ma, Qu, & Xiong, 2017; Rauschnabel et al., 2017; Tu et al., 2019). Beyond that, our interview results specifically indicate that social interaction has a value in itself. This corresponds to findings from the literature on social network game adoption, which underlines that game design can specifically incentivize players to establish and enhance relationships within the game environment (Kwon et al., 2014; Park et al., 2014; Shin & Shin, 2011). Thus, the search for social interaction is a major task purpose that significantly increases the hedonic value of the platform (Chen et al., 2017).

As we have previously emphasized the determinants of motivation, we now focus on RQ2 and therefore the effect of *Hedonic Motivation, Utilitarian Motivation* and *Risks* on continued *Usage Intention*. This study suggests that the relationship between hedonic benefits and use intention is strongest within the overall model and among users with a non-competitive usage focus. In contrast, the utilitarian facet is the main motivation for competitive users. Regarding results of comparable studies focusing on MR technology use, past research finds that for AR gaming, hedonism (enjoyment) is the major determinant (Rauschnabel et al., 2017). For exergames the situation is rather inconsistent, with some studies showing utilitarian motivation (Kari & Makkonen, 2014) and others hedonic motivation (Lin, Wang, & Chou, 2012) more strongly influencing usage. These differences between studies is likely due to the heterogeneity of the user groups considered. We are able to resolve this conflict in the literature through our subgroup analysis. We find that some users ("casual users") focus on recreational, social and enjoyment-oriented purposes, while other users ("racers") focus on the utilitarian purposes of training to succeed in competition and to gain health improvement. Accordingly, we find the platform to be a multi-purposed information system (Hamari & Keronen, 2017; van der Heijden, 2004), similar to social network services (Ngai et al., 2015).

Regarding *Perceived Risks*, we find that *Privacy Concerns* are negatively related to use intention, which is in line with related research (Egelman et al., 2013; Felt et al., 2012; Tam et al., 2015). While this effect is subgroup-independent, *Unacceptance of Cheating* only affects user groups that regularly participate in competitions. For rarely competing users, cheating has no impact on the platform's value. In contrast, highly competitive users, who might also be endorsed in serious leagues, do perceive cheating as a relevant issue. For them, the comparability of individual skills needs to be ensured, e.g., by institutionalized procedures to avoid cheating (Cunningham et al., 2018; Funk, Pizzo, & Baker, 2018; Seo & Jung, 2016). A related study supports this argumentation, as it highlights cheating concerns among pro-cyclists, who demand measures to prevent cheating and data manipulation (Westmattelmann et al., 2021).

Finally, we examine the relationship between usage intention and different dimensions of *Use Behavior*, as stated in RQ3. The intention to continue use is related to use behavior and thereby affects general use, social use and competitive use, covering different dimensions of use behavior. Comparing the task purpose of competition with the outcome of competitively using the platform, we find that the purpose of competition does not exert any impact on perceived benefit, but we also find that the intention to use does affect the outcome of engaging in competitive races. Thus, we conclude that competing with others does not represent a sufficient use purpose on its own, but rather that specific reasons for using the platform are training (for real-world competition), customizing the avatar to possibly gain advantages and get attention during races, and socializing in the context of participating in competitive rides with peers. In contrast, the purposes of socializing show a significant impact towards perceived hedonic benefits and the outcome of following is related to use intention. These results reveal that findings regarding real-world sports applications and their use in everyday life (e.g. Tu et al., 2019) also apply for MR sports platforms, which, mostly, have been studied in laboratory settings (Neumann et al., 2018) and thus only allowed for limited insights on continued use behavior.

6.2. Theoretical contributions

This study contributes to different literature streams by positioning MR sports applications theoretically, providing a coherent picture of task-related motives for using them and relating motivators, barriers and continued usage intention to actually measured use behavior.

First, the study emphasizes the broad acceptance of an application type that exhibits MR technology and allows joint, virtually-mediated sportive activity to take place in real time (Neumann et al., 2018; Tu et al., 2019). In contrast to existing exercise gaming applications, which do not meet the narrow definition of sport (Guttmann 1978; Jenny et al., 2017; Suits, 2007), we propose that novel MR sports platforms do so due to sufficient institutionalization, broad public following and reliable virtually-mediated physical interaction. Thus, this study focuses on a type of applications that is already used for serious competitive activity and enables virtual performances comparable to real-world performance (Westmattelmann et al., 2021).

Moreover, no coherent understanding of sports applications' degree of virtuality exists yet (Mueller et al., 2011; Neumann et al., 2018; Westmattelmann et al., 2021). By combining theoretical frameworks focusing on precisely defining MR (Milgram & Kishino, 1994; Flavián et al., 2019; Speicher et al., 2019) and on design factors of virtual exercising applications (Mueller et al., 2011; Neumann et al., 2018), we contribute to clarifying whether applications should be understood as MR or VR. We propose that determining the degree of an application's virtuality by focusing on visual display (Milgram & Kishino, 1994; Neumann et al., 2018), is insufficient, especially in contexts where audio-visual factors are less important to an application's value than incorporating interactions between multiple users and environments. By extending the dimensions considered, as done by Speicher et al. (2019), the understanding of technological artifacts is greatly improved. To transfer this recent advancement in MR literature to the sport context, we introduced the term MR sports application. MR sports applications refer to MR as a form of collaboration, which allow users to interact in a joint virtual world (Speicher et al., 2019; Westmattelmann et al., 2021), while the focal part of interaction takes place at each user's individual real-world location, mediated by specific hardware.

Third, this study proposes an empirical model for understanding the adoption and use of MR sports platforms. Following the approach of Venkatesh et al. (2016), we contextualize our research model by considering different dimensions from the VR exercise framework by Neumann et al. (2018) as exogeneous variables that model the peculiarities of the technological artifact examined. We specifically focus on task factors – which have been largely overlooked as determinants of MR technology adoption (Muetterlein & Hess, 2017; Venkatesh et al., 2016) – as well as user factors and outcomes, while the technological factors shape the context of the application under consideration. Regarding outcomes, this study is the first to analyze continued use intention and consecutive use behavior as measured by application usage data stating past continued use intention. Former studies on exercise applications with different degrees of virtuality (e.g. Kari & Makkonen, 2014; Mueller et al., 2011) did not gather this kind of data, as most were bound to experimental laboratory settings. Thus, this study extends the literature on exercise gaming, as findings might be transferrable, while the number of social connections might serve as a valuable outcome in social network research. Moreover, we acknowledge that there is no one-size-fits-all solution to understanding MR sport application's adoption and underline the relevance of subgroup analyses. A clear distinction of user groups can enable advanced and specific marketing strategies (Mahajan, Muller, & Srivastava, 1990). The research model used here, as also our approach for incorporating specific application contexts, will be useful for research on MR and exercise applications as well as for general technology adoption research.

Fourth, our foundations and findings are relevant for further studies on MR technologies and their adoption, as we empirically identify specific task purposes as determinants of different types of motivation, which in turn relate to usage intention. This allows the researcher to understand what drives user's continued use of information systems, covering both utilitarian and hedonic aspects (van der Heijden, 2004). In this way we contribute to the existing literature by finding that MR sport applications are not hedonic or utilitarian by design, but that the individual task purposes define whether a user primarily perceives them as utilitarian or as hedonic. We further conclude that task factors related to complementary functionalities (i.e. customizing, socializing) relate to perceived enjoyment, while the utilitarian value mainly arises from task purposes related to the applications' core functionalities (i.e. using it for training and/or health improvement). Moreover, this study is among the first to include the actual use behavior in the context of hedonic MR applications (see also Rauschnabel et al., 2017). This allows us to validate the relation between usage intention and three dimensions of context-specific use behaviors as novel outcome phenomena. Thereby, the outcomes partly reflect the task purposes and allow a comparison of usage drivers and actual usage behavior.

Summarizing, we contribute to the research on the digitalization of sport (Xiao et al., 2017). While research so far has focused on technologies to measure and compare real-world athletic performance, such as fitness apps (Mateo et al., 2015), MR sports platforms allow sports in the narrower sense (Guttmann, 1978; Jenny et al., 2017) to be transferred into a virtual world. This also distinguishes them from exergames utilizing different degrees of virtuality (Neumann et al., 2018). Our empirical results highlight the relevance of context-specific, task-related motivators as drivers of continued usage intention, which in turn affects actual use behavior of these multi-purpose systems. These means allow for observation of user group-specific differences.

6.3. Managerial implications

From a practical perspective, we provide a list of guidelines for designing and managing MR sports platforms and for MR technologies in general. First, it is important to consider that there are many different user types driven by different motives. Thus, it is crucial to consider which task factors affect the motivation of the respective groups. Given the group-specific differences identified here, the focus should go beyond competitively-oriented users.

MR sports platform operators could focus on health-related benefits, as functionalities like monitoring and visualization of health data might contribute to a more persistent fitness routine (Tu et al., 2019; Warburton et al., 2007). Furthermore, platform operators could connect with partners that provide content on health-related topics (e.g., nutrition providers), and supplement sensory devices for tracking further types of health data. As training is another major reason for using MR sports platforms, applications should support training success by providing feedback for optimization and offer interfaces to professional training management tools. To ensure the transferability of training success to outdoor sports, the comparability and realism of the simulated performance and the courses are crucial. For both health- and training-oriented users, a major advantage of MR sports platforms is the reduced risk of injuries or, in the context of a pandemic, viral infection, that is associated with real-world sport.

We also advise the consideration of customization elements in MR sports platform design. By allowing users to customize an avatar and to choose specific equipment options, immersion can be improved. Moreover, cooperation with original manufacturers from the real-world sport could enable the provision of original equipment (e.g., bikes, gear), which would further increase perceived realism. A rewards system granting items (such as jerseys) for fulfilling specific tasks and publicly visible achievements can foster enjoyment, social recognition and usage. In many applications, new items can be obtained via in-app purchases. This approach should be questioned for MR sports platforms, as the perceived value for users who have earned the items through sporting achievements could decrease. Moreover, collectible power-ups may improve variety and diversion, which increase hedonic value and continued use. More generally, MR applications should incorporate the ability to customize user-specific characteristics. The ability to adapt aspects of the virtual world, and of the avatar as a virtual reflection of the self, increases the motivation to interact within that world. Functionalities supporting the purpose of socializing range from those related to social recognition (see above) to those for explicit interaction (e.g., chat functions, joint group activities including haptic feedback on virtually-mediated social interaction, such as slipstream effects). Moreover, user communities and social events should be supported. In current public communication, it is mainly the races hosted on ZWIFT that attract attention. In contrast, we propose that future marketing of diverse MR sports platforms should emphasize the social aspects of sporting, watching and comparison with other people. MR's geographical independence enables users to participate in a community more easily, allowing the catchment area to be expanded. Competitive use behavior is particularly prevalent among a specific user group that draws a lot of attention. Fair and comparable circumstances are necessary to keep participants using the platform. The reliability of measurements across different hardware setups is crucial to preventing cheating. Additionally, there must be (institutionalized) mechanisms to identify suspicious data, as there are for other forms of misconduct such as doping (Houlihan, 2014). For MR sports platforms and for MR applications in general, we find that usage seems particularly personal due to the high degree of immersion and the sensitivity of the real-world-related personal data generated, which allow conclusions to be drawn about users' characteristics in the real world, such as health data. Hence, data security is of particular importance for users and privacy settings should enable tailored privacy settings.

6.4. Limitations and future research directions

The validity of this study has certain limitations. First, we only surveyed and interviewed users from Germany, Austria and Switzerland. Thus, cultural and country-specific influences might arise and further studies need to validate our findings. Second, this study analyzed what motivates users to engage in virtualized cycling. Beyond that, other types of tasks/sports like running or rowing might be an interesting study subject. Moreover, the generalizability of our findings to non-sport applications of MR has to be validated. Third, even though we measured actual use behavior along three dimensions, we propose to also monitor use behavior across different points in time to include seasonal effects. This might help understanding of the intention behavior gap in specific subgroups. Fourth, we created subgroups by splitting the sample regarding their competitive use behavior. Further studies could take a more elaborated approach, e.g. cluster users based on demographic and psychographic factors. Finally, we examined the central user group of MR sports platforms, the athletes. Other stakeholders involved in these platforms, like teams, sponsors, spectators or the media, should be considered in follow-up studies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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