Me vs. Super(wo)man: Effects of Customization and Identification in a VR Exergame

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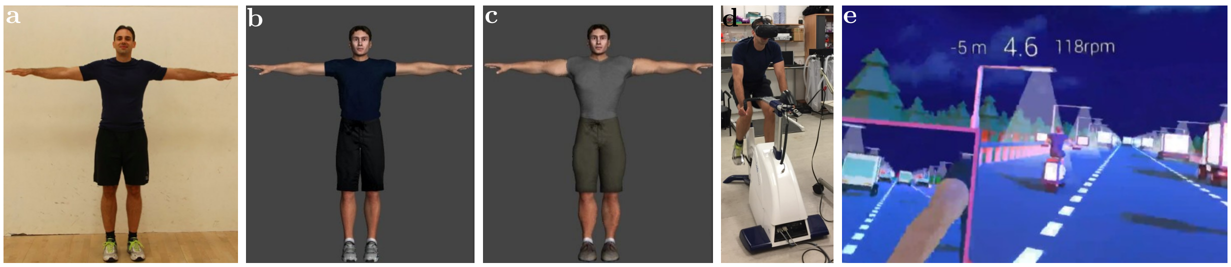

Figure 1. For each player (a) we created a realistic avatar (b) and an idealised avatar (c). Using an exercycle (d), players embodied and competed against either a generic, their realistic, or their idealised avatar in a VR racing game (e).

ABSTRACT

Customised avatars are a powerful tool to increase identification, engagement and intrinsic motivation in digital games. We investigated the effects of customisation in a self-competitive VR exergame by modelling players and their previous performance in the game with customised avatars. In a first study we found that, similar to non-exertion games, customisation significantly increased identification and intrinsic motivation, as well as physical performance in the exergame. In a second study we identified a more complex relationship with the customisation style: idealised avatars increased wishful identification but decreased exergame performance compared to realistic avatars. In a third study, we found that 'enhancing' realistic avatars with idealised characteristics increased wishful identification, but did not have any adverse effects. We discuss the findings based on feedforward and self-determination theory, proposing notions of *intrinsic identification* (fostering a sense of self) and *extrinsic identification* (drawing away from the self) to explain the results.

Author Keywords

Avatar customisation, identification, virtual reality, exergaming, feedforward

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INTRODUCTION

Many people struggle to meet the recommended levels of physical activity [49], with 40-65% of those who begin exercise regimes dropping out within 3-6 months [5]. Introducing digital game elements into exercise contexts to create *exergames* is a promising approach that aims to combat the failure to meet these recommendations and the related rise in global obesity levels [122, 119]. Combining exergames with virtual reality (VR) has revolutionised the possibilities for health interventions, creating an immersive experience with possible attentional distraction from physical exertion [54, 137, 73]. These virtual interventions can increase intrinsic motivation and participation across a range of demographic populations, including adults, children and people with disabilities [10, 56, 137, 22].

A player's encounter with VR exergaming can be an immersive and embodied experience, and at its core lies the player's identity [108]. With recent advancements in VR technology, the player experience of virtual worlds can be more immersive than ever before, blurring the boundaries to reality and making it easier for players to develop virtual identities [85]. At the heart of the immersed sense of identity is the player avatar: a unique character customised by the player with traits and physiognomies that resemble the player, or in some cases are idealised [124]. In non-exertion games, identification with an avatar has been found to increase intrinsic motivation, flow state, self-presence and self-esteem, and motivate the player to improve their game performance [14, 17, 84, 127, 73, 116, 131, 18, 73, 33]. There is also some evidence that avatars in non-VR, low-to-medium-intensity exergames have similar benefits for the player experience [56, 100] and can improve exercise intention [71, 66], in particular with idealised avatars able to lower social physique anxiety [115], increase perceived interactivity [58] and motivate exercise [96, 95, 72]. However, it is not known how customised avatars affect the player experience in *immersive VR exergames*, and in particular, how they affect a player's *physical performance* in exergames designed to challenge the player with a *high physical intensity* [57]. Furthermore, it is unknown how *realistic vs. idealised avatar styles* affect player experience and performance in such exergames.

In this paper we address these gaps in the literature by studying the effects of avatar customisation and identification on the player experience and physical performance in a high-intensity VR exergame. We shed light on whether avatar customisation in such exergames can provide similar benefits as in non-exertion and non-VR low-to-medium exertion games, and consider also, for the first time, how different styles of customisation affect identification and the resulting exergaming experience. We address the following research questions:

RQ1 How does avatar customisation in a VR exergame affect the player experience?
RQ2 Can player-avatar identification improve physical performance in an exergame?
RQ3 Do different styles of customisation affect player experience and performance differently?

To answer these questions, we conducted three studies where participants customised different types of avatars and then used them in a self-competitive exercycle-based VR exergame. To address RQ3, each study investigated the effects of a particular avatar style on player experience (RQ1) and physical performance in terms of power output (RQ2): Study 1 compared generic avatars with customised, realistic avatars; Study 2 compared the same realistic avatars with idealised avatars representing players' desired appearances; and Study 3 compared realistic avatars with avatars that were enhanced in a hypothetical but realistic manner, based on a player's exercise goals. We make the following contributions:

1. Empirical evidence that avatar customisation can improve identification, player experience and physical performance in a high-intensity VR exergame.
2. Results showing how different styles of avatars, from realistic to idealised, can affect player experience and physical performance in different ways.

RELATED WORK

Identification: The process of identification allows a person to replace their identity with that of a character, causing the individual to lose their usual sense of self-awareness and temporarily become the character [26, 50]. The driving factor for identification is commonly attributed to similarity, which assists individuals in imagining themselves as the character portrayed [26, 127, 131, 73]. This similarity extends beyond simple demographics and also includes attitudes, beliefs, experiences and behaviour [26, 127, 116]. In the context of virtual worlds such as games, the player is represented as an avatar, which acts as a virtual embodiment of the player's identity and visually represents the player's interactions [80]. Such presenting of oneself to others is regarded as an essential human interaction [45] and an integral part of the human experience [132]. During play the virtual body of the avatar can become an extension of the real body to create an embodied experience [74]. In order to facilitate identification through similarity and enable players to develop a stronger cyber-identity, modern virtual worlds allow players to create customised avatars [124, 108, 85]. The means used to create and personalise these avatars differ greatly across virtual worlds, which results in a high degree of avatar variability depending on the system and context in which it is created [33]. Players customise visible and easily recognisable body features such as hair style and eye colouring. Clothing is also an important feature of customisation as it is intrinsically linked to identity and the way we present ourselves to others [93]. Clothing can enhance self-perception and influence behaviour as it is representational of one's personality [62], with many people spending real money on virtual clothing and accessories in games such as Second Life [24, 16].

Measurement: Avatar identification is an elusive concept and measures of it are usually dependent on a particular context, e.g. MMORPGs. The first widely accepted measurement scale was the Player-Identification Scale (PIS) [131] by Van Looy et al., which defines avatar identification as a second order factor consisting of similarity identification, wishful identification and embodied presence. Van Looy et al. applied the PIS in a MMORPG community and reported a positive association between avatar identification and role play, customisation and escapism. The Player-Avatar Identity Scale (PAIS) by Li et al. [73] comprises four main factors: feelings during play, absorption during play, positive attitudes toward the avatar, and importance of the avatar to one's self-identity. It was created by adapting a scale for the identification of audiences with media characters by Cohen [26] to the context of video games. The Player-Avatar Interaction (PAX) scale by Banks and Bowman [9] includes four factors – emotional investment, anthropomorphic autonomy, suspensions of disbelief and sense of player control – to define the perceived social and functional association between player and avatar. It merges theoretically divergent approaches – character attachment [70] and player-avatar sociality [8] – to measure dimensions of player-avatar relationships.

Idealised Avatars: Similarity is not the only factor when creating and identifying with an avatar. The mirror hypothesis [23] claims that people relate favourably to characters who are either like themselves (the "mirror"), or who represent their ideal self (the "magic mirror"). The magic mirror concept, or wishful identification, conflicts with claims that identification occurs only through true player-avatar similarity [127, 134, 17, 116] but has received support in recent literature [121, 65, 131]. The proposal is that players who customise and fantasise about their avatar so that it more closely fits their ideal self-image should also identify with it more strongly. Ducheneaut et al. [33] investigated the personal attachment users have to their online identity and revealed a tendency for users to embody aspects of their enhanced or ideal self into their avatar. There was a bias of avatar creation toward Western ideals, and older players, those with a higher body mass index, and players with lower psychological well-being were more likely to represent themselves in an idealised way [33, 14], which reduced avatar diversity.

Effects of Customised Avatars: Avatar-based customisation has been shown to positively affect avatar identification [127, 133, 17, 139] and user experience [127, 128, 116, 17]. While a player's characteristics are typically reflected in her avatar, researchers have also observed influences of the avatar on the player: the Proteus effect describes changes in player behaviour that conform with a player's avatar [136]. For example, individuals whose avatars engaged in healthy behaviours were found to be more likely to engage in physical activities in the real world [28], and watching one's realistic avatar lose weight as a reward for activity, or gain weight as a punishment for inactivity, led participants to exercise more [39]. Avatar customisation can enhance learning in virtual environments [90] and can help to personalise risk messages and transform attitude into behavioural change [94]. Players' avatars can elicit stereotypical or compensatory in-game behaviours [7, 97, 130] and influence their satisfaction with online relationships and their offline appearance and health [13, 68]. Furthermore, avatars can motivate non-exertion game players to improve engagement and performance [17, 127, 18].

Effects of Idealised Avatars: Players who created idealised avatars were consequently more satisfied and more attached to their avatars [33] and felt greater avatar-self connection [60]. 'Superhero' avatars were shown to motivate pro-social behaviour [102, 138] in the real world, 'creative' avatars increased creativity [46], and avatars perceived as more appropriate for a musical task led to increased musical performance [64]. Despite all these positive results, idealised avatars also bear potential risks. Self-discrepancy theory states that comparisons with your ideal self can lead to feelings of uneasiness and dissatisfaction with your actual self [51]. Negative self-perception of our bodies has been associated with depression, mental health disorders and inactivity [4], e.g. a video game emphasising an unrealistic male body ideal was found to have a negative impact on body satisfaction [123]. Women are more likely to encounter body dissatisfaction than men [21], particularly with the prevalence of celebrity culture and social sites such as Instagram depicting idealised and sexualised images of women. High exposure to such media can lead to decreased motivation and negative emotional states [62].

Exergames: Avatars in exergames have been used to investigate the role of self-construal on exercise intentions and self-presence [59]. Customised exergame avatars elicited more psychophysiological reponses compared to generic avatars [100]. Avatars improved identification, presence, enjoyment, activity and exercise intention [71, 66], and lowered social physique anxiety for people with body image dissatisfaction [115]. Customising idealised avatars was found to increase perceived interactivity and affect immersion in different ways depending on previous priming [58]. Exergame players with a normal-weight avatar were more physically active and more motivated to exercise than those using an obese avatar [96, 95, 72]. Giving an avatar idealised capabilities by augmenting an avatar's running speed and jumping height in a VR exergame also led to increased intrinsic motivation and perceived competence [56].

STUDY 1: GENERIC VS. REALISTIC AVATARS

We investigated the effect of customised, realistic avatars on player experience (RQ1) and performance (RQ2) in a VR exergame by comparing them with generic, 'Lego-like' avatars. Avatars are hardly visible if seen only from the typical first-person perspective of a VR exergame [19, 114]; therefore, we chose a self-competitive VR exergame [10] where the player would race against their recorded previous gameplay performance, represented by their avatar in a third-person perspective, in addition to embodying their avatar directly from the typical first-person perspective. This design was chosen to allow participants to fully see their avatar during gameplay as a 'ghost' of their own previous performance, making the player's avatar a more natural and immersive part of the exergame, as a third-person perspective has been shown to elicit more pronounced effects of custom avatars compared to a first-person perspective [75]. We used a within-participants design to investigate the effects of the independent variable *avatar type* with levels: baseline (B), generic avatar (G), and realistic avatar (R). All participants started with the baseline B, where they embodied the generic avatar and no 'ghost' avatar was shown; this served to create a 'self-model' of their gameplay performance to be used in the following conditions. Then, participants competed against their self-model twice: once represented with a generic avatar (G) and once with their realistic avatar (R). In each condition, the respective avatar was also used to embody the player from the first-person perspective. The order of G and R was counterbalanced.

Avatar Customisation

An off-the-shelf software tool for video game character design, Autodesk Character Generator, was used to create each avatar. The tool provides an interface for the design of avatars based on blendshapes, i.e. pre-defined body shapes that can be combined to adjust face and body design (Fig. 2). Participants were given guidance on how to customise a base character to make an avatar in their own likeness by choosing the character sex (male or female), face shape (by blending two faces together), facial features including eye, mouth and nose shape, body shape (by blending two body shapes together), skin

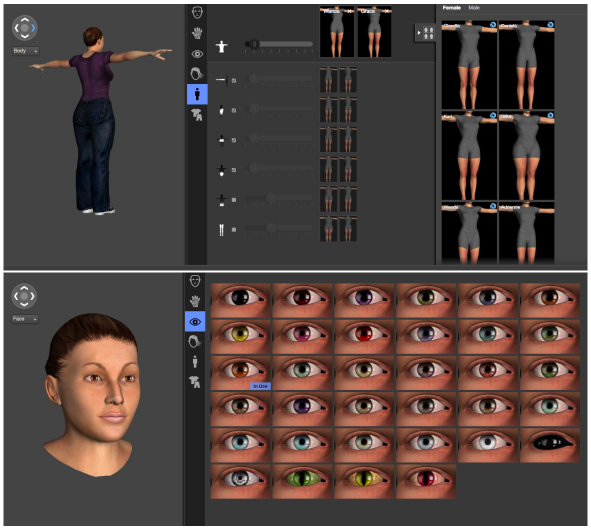

Figure 2. Customising body shape and eye colour.

tone, hairstyle, hair colour and eye colour. Finally, participants were given a choice of garments for the top half and lower half, plus a choice of shoes. Following the guidelines from Ducheneaut et al. [33], particular emphasis was given to more visible and recognisable features, such as hair, clothing and body shape, in order to facilitate identification. Although the session was intended as an individual task, several participants sought advice from the researcher about elements of their appearance and were comfortable discussing different aspects of their bodies. In order to mitigate bias [1, 86] we took care to engage with participants in a friendly, non-judgemental atmosphere, emphasising anonymity and that authentic answers would be most helpful. Each avatar design session took 30-60 minutes, enabling the participants to engage effectively in the customisation process.

Exergame

The exergame was played by riding a Lode Excalibur Sport stationary exercycle while wearing an HTC Vive head-mounted display (HMD) (Fig. 1d & 1e). The game was very similar in appearance and functionality to the game used by Barathi et al. [10]: players raced along a straight road, with speed controlled by the exercycle and lateral movements controlled by head tilt. To make the gameplay more interesting, trucks moved slowly on the road, which the player could avoid, although collisions did not have any consequence. The game implemented a 5-minute high-intensity interval training (HIIT) protocol with two high-intensity sprints: 60 sec warm-up, 30 sec sprint, 90 sec recovery, 30 sec sprint, 90 sec cool-down. The protocol was based on ACSM guidelines for exercise [89] and was also used by Barathi et al. [10]. We chose HIIT because of its benefits in reducing exercise time [42], motivating participants [126, 11] and delivering health outcomes [69, 87, 43]. During warm-up, recovery and cool-down, a daytime scene was shown, with bright colours to evoke a relaxing atmosphere. During the sprints, a nighttime scene was shown with cars following the player, evoking a sense of urgency. For the warm-up, recovery and cool-down phases, we instructed participants to cycle at a low cadence, between 65 and 70 RPM, using a fixed low resistance of 12 Nm. Following HIIT protocols [55, 10], resistance during sprints was initially set to 0.4 Nm kg^{-1} based on body mass. It was then adjusted, if necessary, in a familiarisation phase to enable participants to perform at a "very hard" rate of perceived exertion (RPE) during sprints while avoiding uncontrolled movements due to high cadence. The exergame was designed to record a player's gameplay in the baseline condition B, thereby creating a 'self-model' of the player, and playing it back during the other conditions in the form of a third-person 'ghost' avatar. In order to make the gameplay physically challenging and elucidate performance differences in the avatar conditions, the exercycle resistance was increased during sprints by 20% in G and R, compared to baseline B. The player and the 'ghost' avatars started each sprint beside each other to ensure fair self-competition.

Outcome Variables

Player-avatar identification was measured by combining validated subscales that were suitable for use in a VR exergame from the aforementioned Player-Identification Scale (PIS) [131], Player-Avatar Identification Scale (PAIS) [73] and Player-Avatar Interaction Scale (PAX) [9] identification scales. The resulting new questionnaire, which we refer to in the following as Player-Avatar Identification for Exergaming (PAIE), combines the similarity identification (our main measure of identification), wishful identification and embodied presence subscales from PIS, the absorption during play and importance to identity subscales from PAIS, and the emotional investment and sense of control subscales from PAX. The other subscales are geared towards MMORPGs and are not suitable for our exergame. Heart rate (HR) was recorded in each condition as a measure of exertion using a Polar A300 fitness monitor. We estimated maximum HR based on ACSM guidelines [89], calculated as 220 minus age. We then calculated Peak HR% as the average of the peak HR of the two sprints, as percentage of maximum HR. Performance for each of the three experimental conditions was quantified using average power output in Watts (W) over both sprints measured by the exercycle. In order to compensate for individual differences in performance, we considered ΔPower, which is a participant's difference in average power output from any of the other conditions to their baseline B. We used the Intrinsic Motivation Inventory (IMI) [104], which has been used and validated in sport and exercise studies [78, 25], to measure intrinsic motivation with the central Interest/Enjoyment subscale as our main measure of intrinsic motivation. We included also the secondary Effort/Importance, Perceived Competence, and Pressure/Tension subscales. Flow was measured using the Positive Psychology Lab's Flow State Questionnaire (FSQ) [76], with both its subscales: Balance of Challenges and Skills, and Absorption in the Task.

Procedure

Participants were screened using the Physical Activity Readiness Questionnaire (PAR-Q) [125]. If there were no health concerns, participants were then asked to complete a demographics questionnaire and the International Physical Activity Questionnaire (IPAQ) [48], which estimates general physical activity. Afterwards participants created their own avatars in a guided customisation session, as previously described. The customisation process was led by the participant and aimed to create an avatar that was a realistic representation of their true appearance. Once the avatar was created, pictures of the avatar were emailed to the participant in conjunction with the PAIE indentification questionnaire to complete.

In the following exergaming session, participants were informed about the VR exergame, that they would compete against the recorded self-model of their baseline performance, and that the sprint resistance would change. Participants performed a familiarisation phase to experience the gameplay, understand the exercise and adjust the sprint resistance to the appropriate level. Participants then played the game in the baseline condition (B), with instructions to work 'very hard' during the sprint phases. In the following conditions, participants played the exergame again with the generic (G) and realistic (R) avatars as self-competitors, with sprint resistance increased by 20% so that players had to work harder to keep up with their recorded baseline performance.

At the beginning of each condition, participants were shown a full 3D view of the avatar that would embody both their 'ghost' and themselves in order to mitigate the impact of the partially obscured seating position on identification during gameplay. At the end of each condition participants were asked to complete the PAIE, IMI and FSQ questionnaires and provide qualitative comments regarding their experience with that avatar. Participants had a rest of 15 minutes between conditions to mitigate fatigue. The entire experiment (avatar creation to exercise completion) took approximately 120-150 minutes.

Hypotheses

Based on related work on avatars [71, 66] and pilot trials, we posed the following a-priori hypotheses:

H1 Players identify more with realistic avatars (R) compared to the baseline (B) without third-person avatar.
H2 Players identify more with their customised avatar (R) than the generic avatar (G).
H3 Intrinsic motivation is higher with a realistic avatar (R) compared to the generic avatar (G).
H4 Performance is higher with a realistic avatar (R) compared to the generic avatar (G).

Participants

We recruited 15 participants (9 male, 6 female, age 20-46) through personal communication and mailing lists. The participants were mostly students and staff of the University of Bath. The IPAQ classified 10 as *HEPA Active*, 4 as *Minimally Active*, and one as *Inactive*.

Figure 3. Realistic (left) and idealised (right) avatars.

Qualitative Results

Examples of the realistic avatars are shown on the left of Fig. 3. During the customisation process, we found that five of the female participants wanted to discuss aspects of their avatar's characteristics, speaking aloud as they were designing. The women were highly expressive about the aspects of their own physical body they would like to change (*"my thighs are much larger than that", "my nose is more prominent"*). Five of the six female participants made their avatars noticeably larger than they were in reality. By contrast, the male participants appeared more confident describing their physicality, and especially highlighted features that they liked about themselves, e.g. one participant spent well over 10 minutes trying to get the right eye colour match (*"I like my blue eyes, they are a strong feature, in my family the blue eyes are dominant"*). The male participants also stated more frequently that their customised avatar was more authentic to their actual body image, with many giving positive statements about their physique (*"I have been working out lately and my body has changed, so I need to find an avatar build slightly muscular, I am happy with how I look now"*). Participants spent considerable time choosing the right wardrobe and described this as one of the most important customisable features, as it brought the avatar to life and expressed an important part of their individuality. All participants preferred their custom avatar compared to the generic one. After playing the exergame, all participants noted an increase in enjoyment between the baseline and the avatar conditions. Enjoyment was further increased with greater avatar similarity (*"Better to look at and improved the gaming experience knowing I created it myself"*). The increased similarity also motivated them to try harder (*"It felt like I had more of an incentive to succeed as my avatar's achievements were reflective of my own. Also, it made the game more immersive and made me more competitive to beat my previous time"*).

Table 1. Summary of demographics and results for each study (mean ± std. dev., * p ≤.05, ** p ≤.01).

Study	n	Demographics	Variable	Avatar (within-participants)			
				None (N)	Generic (G)	Realistic (R)	Idealised (I)
1	15	m=9, f=6 age=26±6	Power	292.50±73.40	341.41±92.75	*352.01±89.67	
			ΔPower		48.92±28.85	*59.51±28.70	
			PIS Similarity ID	1.49±0.49	1.78±0.83	**3.41±0.89	
			PIS Wishful ID	1.43±0.56	1.45±0.62	*1.89±0.83	
			IMI Interest	5.21±0.71	4.95±1.03	5.38±0.91	
			FSQ Balance	3.73±0.66	3.55±1.08	3.64±0.94	
			FSQ Absorption	3.67±0.53	3.66±0.66	**4.00±0.54	
2	16	m=11, f=5 age=32±18	Power	295.34±82.08		361.61±112.80	*351.20±94.454
			ΔPower			66.27±30.72	*55.86±12.38
			PIS Similarity ID	1.84±0.84		3.34±0.97	3.13±0.99
			PIS Wishful ID	1.60±0.83		2.64±0.77	*3.58±1.13
			IMI Interest	5.48±0.69		5.49±0.85	5.47±0.94
			FSQ Balance	3.92±0.66		4.01±0.53	3.89±0.63
			FSQ Absorption	3.84±0.51		3.89±0.73	4.06±0.71
					Realistic (R)	3 Months (E3)	6 Months (E6)
3	17	m=11, f=6 age=21±1	Power	86.6±8.91	410.88±103.82	403.37±93.46	413.17±101.75
			ΔPower		69.24±24.91	61.73±14.55	71.52±22.84
			PIS Similarity	2.37±1.33	3.71±0.55	3.57±0.42	3.56±0.57
			PIS Wishful	1.88±0.97	2.99±0.62	3.17±0.70	*3.75±0.78
			IMI Interest	5.61±1.09	5.75±0.98	5.61±0.88	5.68±0.97
			FSQ Balance	4.15±0.67	3.94±0.59	3.97±0.67	4.04±0.74
			FSQ Absorption	3.95±0.45	4.04±0.58	4.01±0.51	3.92±0.61

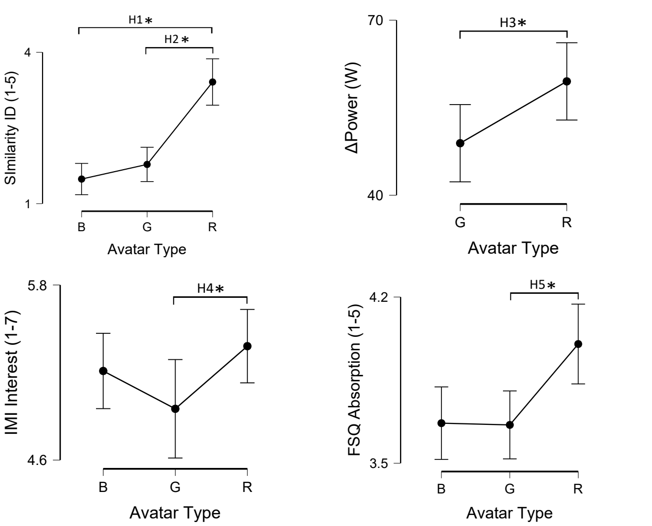

Figure 4. Similarity Identification (top left), ΔPower (top right), IMI Interest/Enjoyment (bottom left) and FSQ Absorption (bottom right) for baseline (B), generic (G) and realistic (R) avatars.

Quantitative Results

Results are shown in the upper section of Table 1 and in Figure 4. All graphs show means with 95% confidence intervals. We used paired t-tests – two-tailed if there was no directed hypothesis and one-tailed if there was. According to a power analysis, the latter were able to detect medium-sized effects (Cohen's d=0.68) between conditions at $\alpha = 0.05$ with a power of 0.8.

PAIE questionnaire analysis only considered responses taken after each test condition in order to closely reflect the identification players felt during gameplay. Similarity Identification (Fig. 4 top left), Wishful Identification, Importance to Identify and Emotional Investment were all significantly higher with realistic avatars (R) compared to the baseline (B) without third-person avatar ($t(15) \geq 2.133, p \leq .026$), so we accept H1. The differences in these identification measures between baseline (B) and generic avatar (G) were not significant ($t(15) \leq 1.658, p \geq .120$). Similarity Identification, Wishful Identification, Importance to Identify and Emotional Investment were all significantly higher for the realistic avatars (R) compared to the generic avatars (G) ($t(15) \geq 2.348, p \leq .017$), therefore we accept H2. Interest/Enjoyment was significantly higher (Fig. 4 bottom left) for the realistic avatars (R) compared to the generic avatars (G) ($t(15) = 2.102, p = .027$), with a 'medium' effect size (Cohen's $d = 0.543$), so we accept H3. FSQ Absorption was significantly higher (Fig. 4 bottom right) for the realistic avatars (R) compared to the generic avatars (G) ($t(15) = 3.287, p = .003$), with a 'large' effect size (Cohen's $d = 0.849$). FSQ Balance was also higher for R compared to G, but the difference was not significant ($t(15) = 0.737, p = .237$). Peak HR% was on average above 80 in all conditions, which indicates that participants were exercising to the required intensity for HIIT [89]. ΔPower was significantly higher (Fig. 4 top right) for realistic (R) compared to generic avatars (G) ($t(15) = 2.428, p = .015$), with a 'medium' effect size (Cohen's $d = 0.627$), so we accept H4.

STUDY 2: REALISTIC VS. IDEALISED AVATARS

Our second study followed on from our first to investigate how different styles of customisation affect identification, user experience and performance (RQ3). Participants created a realistic and an idealised avatar of themselves. Similar to Study 1, we used a within-participants design for the independent variable *avatar type* with levels: baseline (B), realistic avatar (R) and idealised avatar (I). We compared the effects of a realistic avatar style (R) vs. an idealised avatar style (I). The procedure for Study 2 was identical to that for Study 1, with the key difference that two avatars were created during the avatar design session and that, during the exercise session, the generic avatar condition (G) was replaced by the idealised avatar condition (I). We asked participants to create a character that embodied their idealised view of themselves, taking their realistic avatar as a basis. Participants were encouraged to create an avatar that "should reflect not the reality, but your dreams and wishes of how you would like to look – even if it is just for a day." The process of creating an idealised avatar based on an existing realistic avatar took 15-20 minutes.

Hypotheses

Based on pilot study results and identification theory [131, 73, 51], we posed the following hypotheses:

H5 Wishful identification will be higher for idealised avatars (I) than realistic avatars (R).

H6 Performance will be lower for idealised avatars (I) than realistic avatars (R).

Participants

We recruited 16 participants (11 male, 5 female, age 21-75) similar to Study 1. Eight of them also participated in Study 1. The IPAQ classified 13 as *HEPA Active*, one as *Minimally Active*, and one as *Inactive*.

Qualitative Results

Female participants tended to give their idealised character a slimmer build while male participants tended toward a more muscular avatar physique. Around half of the participants changed eye and skin colour, while all participants changed hairstyles. All participants modified their realistic avatar toward Western ideals, which is consistent with related work [33]. By these standards, participants preferred to make avatars that look more attractive and fitter and stand out more. Despite a reduction in similarity, twelve participants noted a preference for their ideal avatar (*"I liked that I could be a superhero in the game"*). Notably, our two oldest participants (both in their 70s, one female), who were not familiar with computer games and VR, commented that both their avatars appeared "lifeless" and had an "unfamiliar, creepy" impression on them, similar to the uncanny valley effect [81].

Quantitative Results

Results are shown in the middle section of Table 1 and in Figure 5. According to a power analysis, the one-tailed paired t-tests used to test the hypotheses were able to detect medium-sized effects (Cohen's d=0.65) between conditions at $\alpha = 0.05$ with a power of 0.8. PIS Wishful Identification significantly increased (Fig. 5 left) from condition R to condition I ($t(15) = 3.373, p = .002$) with a 'large' effect size (Cohen's $d = 0.843$), so we accept H5. None of the other identification subscales showed significant differences between R and I ($|t(15)| \leq 1.286, p \geq .218$). No significant differences were found for any of the IMI and FSQ measures between R and I ($|t(15)| \leq 1.461, p \geq .165$). There was a significant decrease in average power output (Fig. 5 right) for I compared to R ($t(15) = 1.779, p = .048$) with a 'medium' effect size (Cohen's $d = 0.445$), so we accept H6.

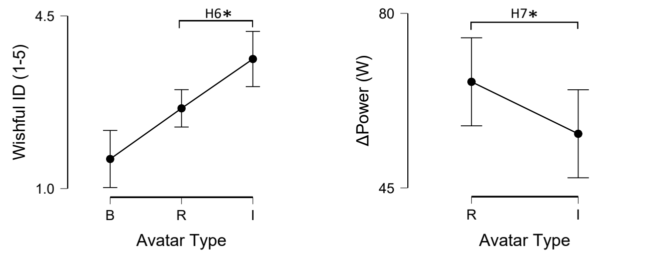

Figure 5. Wishful Identification (left) and ΔPower (right) for baseline (B), realistic (R) and idealised (I) avatars.

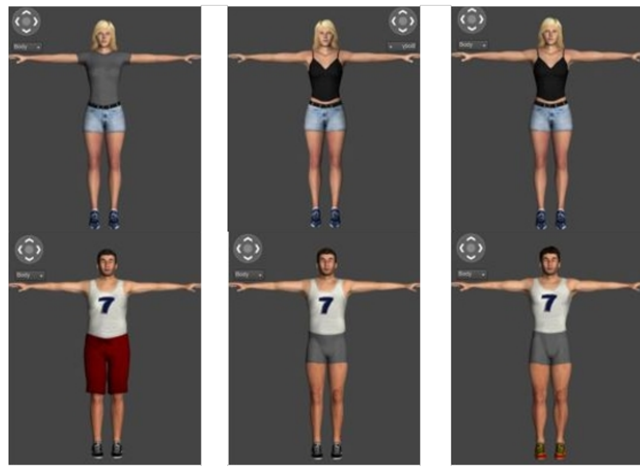

Figure 6. Two examples of progressively idealistic avatars: realistic (R), realistic enhanced over 3 months (E3) and realistic enhanced over 6 months (E6).

STUDY 3: REALISTICALLY ENHANCED AVATARS

The previous studies show that realistic and idealistic avatars are different in their effects on exergame players. A natural question is whether there is a middle ground: what happens if we enhance realistic avatars in a way that makes them more idealistic, but still within the realm of what is realistically achievable? Could this motivate players to try harder? We investigate this in a third study which compares a baseline (B), a realistic avatar (R), and two different realistically enhanced avatars (E1 and E6) using a within-participant design. The enhanced avatars are a progression between the realistic and idealistic avatars of a player (Figure 6). The first enhanced avatar (E1) represents the player after one month assuming they led a healthy lifestyle and completed regular exercise according to their exercise goals. Similarly, the second enhanced avatar (E6) represents the player after 6 months on the same trajectory. The methodology is analogous to that of the two previous studies, with the addition of the enhanced avatars.

Enhanced Avatar Design

The hypothetical points in the future for the enhanced avatars were chosen based on experiences and empirical data about the way a person's body shape typically changes under the influence of healthy diet and exercise. Based on typical weight loss from diet and exercise [135, 103, 118] and muscle development from resistance training [117, 110, 112, 79], body shape changes typically become apparent after one month and are clearly visible after about 6 months [77, 99], with the rate of change decreasing in the longer term. Body shape changes depend on the exercise programme performed, which in turn is typically created based on exercise goals. Therefore we elicited each participant's exercise goals through a questionnaire and when talking to them during the design of their idealistic avatar. Then a researcher designed the enhanced avatars by changing the realistic avatar according these exercise goals and the ideal body shape as shown in the idealistic avatar, based on a documented procedure[1][67]. The enhanced avatars retained the key facial features of the realistic avatar, as opposed to the idealistic facial features, in order to maintain realism and a high level of similarity identification. The body shape and muscles of the avatars were adapted based on estimates of weight loss [135, 103, 118] and muscle gain [117, 110, 112, 79], mapping a realistic journey towards their desired body shape with the aim of increasing wishful identification. In order to keep the adaptations realistic and consistent across participants, they were guided by a simple decision tree. The tree considers the current general body shape of a participant based on their BMI [41] ('underweight', 'healthy' and 'overweight') and their exercise goals in broad categories (weight loss, weight maintenance / increased muscle definition, and increased muscle mass). In month 1 (avatar E1), an 'underweight' or 'healthy weight' participant would mainly develop increased muscle tone, and an 'overweight' participant would mainly lose body fat. By month 6 (avatar E6), visible changes would diverge more depending on the exercise goals, with muscles becoming more defined or increasing in mass. For example, the bottom half of Figure 6) shows the progression of a high-BMI male avatar with weight loss and muscle gain goals. The top half shows a low-BMI female avatar with a goal of increased muscle definition. The example illustrates that some progressions, e.g. weight loss from 'overweight', are more salient than others, e.g. for those who are well-exercised [99]. We made sure that all participants were aware of the changes in their enhanced avatars by asking and explaining them if necessary.

[1]https://doi.org/10.15125/BATH-00757

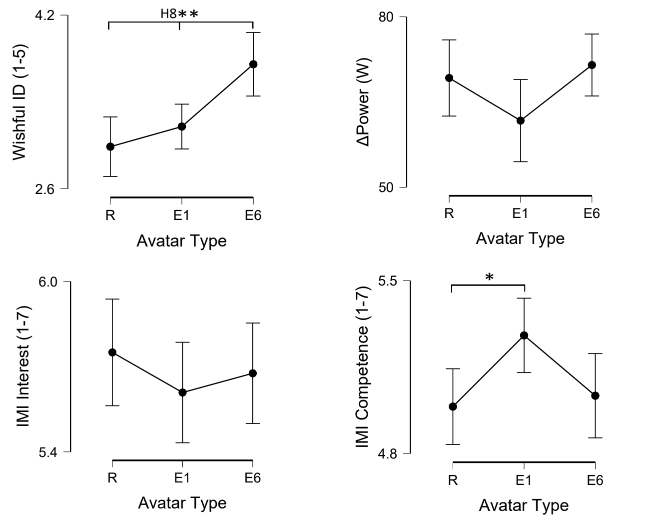

Figure 7. Wishful Identification (top left), ΔPower (top right), IMI Interest/Enjoyment (bottom left) and IMI Perceived Competence (bottom right) for baseline (B), realistic (R) and enhanced avatars (E1 and E6).

Hypotheses

Based on our previous studies and theory [73, 131, 30, 51], we posed the following a-priori hypotheses:

H7 Enhancing avatars (from R to E1 and E6) increases Wishful Identification.

H8 Enhancing avatars (from R to E1 and E6) changes performance.

Participants

We recruited 17 participants (11 male, 5 female, age 20-22) similar to Study 2. Three of them also participated in Study 2. The IPAQ classified 13 as *HEPA Active*, three as *Minimally Active*, and one as *Inactive*.

Qualitative Results

Fourteen participants expressed that they liked their enhanced avatars and that they would like to achieve the exercise results they represented. Ten participants, especially those who desired an increase in muscle mass, noted the six-month enhanced avatars' (E6) changes within the exergame. Six participants, especially female ones with comparatively more subtle goals such as weight loss and muscle toning, noted that the changes in the 1-month enhanced avatar (E1) were hard to notice (*"This avatar is very similar to my realistic avatar"*), and some similar but less frequent comments were made for the 6-month enhanced avatar. In particular, male participants expressed a sense of delight when beating any of the avatars and noted it was motivating beating the enhanced versions of themselves.

Quantitative Results

Results are shown in the bottom section of Table 1 and in Figure 7. According to a power analysis, the one-way repeated measures ANOVAs used to test the effects of avatar type were able to detect small-to-medium effects (Cohen's f=0.19) between conditions at $\alpha = 0.05$ with a power of 0.8. The effect of avatar type (R, E1, E6) on Wishful Identification (Fig. 7 top left) was significant ($F(2, 32) = 10.38, p < .001$), with a 'large' effect size ($\omega^2 = 0.161$), therefore we accept H7. Post-hoc tests with Holm correction showed that Wishful identification for E6 was significantly higher compared to R ($t(16) = 3.730, p = .005$) and E1 ($t(16) = 3.499, p = .006$). However, the difference between R and E1 is not significant ($t(16) = 1.242, p = .232$). The effects of avatar type on all other identification subscales were not significant ($F(2, 32) \leq 1.229, p \geq .306$). The effect of avatar type on Perceived Competence (Fig. 7 bottom right) was significant ($F(2, 32) = 4.321, p = .022$), with a 'small' effect size ($\omega^2 = 0.012$). Post-hoc paired t-tests with Holm correction showed that Perceived Competence for E1 was significantly higher compared to R ($t(16) = 2.976, p = .027$), with (Cohen's $d = 0.722$). However, the difference between R and E6 ($t(16) = 0.399, p = .695$), and E1 and E6 ($t(16) = 2.242, p = .079$) were not significant. The effect of avatar type on all other IMI subscales, including Interest/Enjoyment (Fig. 7 bottom left), was not significant ($F(2, 32) \leq 1.692, p \geq .200$). One-way repeated measures ANOVAs showed that the effect of avatar type on FSQ Absorption ($F(2, 32) = 0.836, p \geq .443$) and Balance ($F(2, 32) = 0.692, p = .508$) were not significant. A one-way repeated measures ANOVA showed that the effect of avatar type (R, E1, E6) on ΔPower (Fig. 7 top right) was not significant ($F(2, 32) = 2.788, p < .077$), with a 'small' effect size ($\omega^2 \geq 0.012$), so we reject H8.

DISCUSSION

There is some evidence that avatars in non-VR, low-to-medium-intensity exergames have benefits for the player experience [56, 100] and can improve exercise intention [71, 66], in particular with idealised avatars able to lower social physique anxiety [115], increase perceived interactivity [58] and motivate exercise [71, 66, 96, 95]. However, it is not known how customised avatars affect the player experience in *immersive VR exergames*, and in particular, how they affect a player's *physical performance* in exergames designed to challenge the player with a *high physical intensity*. Previous studies have mainly shown an increase in avatar identification through customisation in games where the user assumes a definite role or controls a distinct character [129, 14, 17, 73, 33]. These studies typically focused on MMORPGs and other non-exertion game genres where avatars are used over an extensive period of time. Our results provide more evidence that avatar customisation can increase identification (H1, H2) even for a brief exposure to the customised avatar [71, 66], and that this is relevant in high-intensity VR exergames. Physical feature selection can generate custom avatars capable of improving similarity identification, wishful identification, importance to identity and emotional investment compared to a generic avatar (H2). Furthermore, we showed that this identification can be intrinsically motivating in high-intensity exergames (H3), and not just in non-VR, non-exertion [17, 127, 116, 18, 33] and low-to-medium exertion games [71, 66, 96, 95, 72], and that it can also lead to performance gains in terms of physical power output (H4).

A possible explanation for these positive effects is feedforward [10, 120, 30, 31], a psychological training technique that achieves performance and motivation gains through identification with an improved self-model. For example, feedforward users watch a video of themselves edited to show only their best performance [32]. Similarly, self-competing with an avatar in VR, similar to our exergame [10], or creating the illusion of a better performance in VR [56] can elicit feedforward effects. Feedforward is theorised to rely on mirror neurons, which are activated when a user identifies with an improved self-model [30]. Using a customised avatar, compared to a generic avatar, is likely to increase identification and hence the feedforward effect. In line with this, social cognitive theory predicts that similarity identification with a model leads to more learning and imitation of modelled behaviours [39]. Alternatively, self-determination theory [106] can explain the positive results by arguing that realistic avatars better fulfill the three main psychological needs that facilitate self-motivation: *relatedness*, through increased identification; *competence* because players see themselves performing well in the form of their avatar; and *autonomy* because a realistic avatar frames their efforts as self-competition independent of others [10]. This is congruent with findings for non-exertion games that preference for an avatar can lead to greater invested effort [17].

The aforementioned theories also help to explain the negative impact of idealised avatars on physical performance (H6). The concept of wishful identification involves a desire to be more like the avatar [131] and is strongly related to self-discrepancy [51]. Although the player may wish to be similar to the avatar in certain regards, they are actually not, which is also reflected in a small but consistent reduction of similarity identification observed for the idealised avatar in Study 2 and the enhanced avatars in Study 3. Reduced similarity identification, in turn, reduces the feedforward effect due to reduced self-recognition and mirror neuron activity [120, 30, 31]. Similarly, less similarity identification leads to less learning and imitation of modelled behaviours according to social cognitive theory [39], and it also leads less self-motivation due to reduced relatedness, less apparent self-competence and less apparent autonomy according to self-determination theory [106]. The wishful identification with the idealised avatar can also be interpreted as self-discrepancy on a deeper psychological level, in the form of a conflict between the Jungian 'Self' and the ego [63]. Our inner 'Self' is perceived by us through the distorted lens of our ego, which identifies with superficial personas such as the desired looks of our idealised avatar. In line with this, self-determination theory defines two different types of motivation: *intrinsic motivation*, which relates to the Self and the deeper enjoyment of an activity, and *extrinsic motivation*, which relates to external control or introjected self-regulation

[105]. Intrinsically motivated goals have been found to positively influence self-determined motivation, physical self-worth, wellbeing and exercise behaviour, whereas extrinsically motivated goals relating to the body – similar to our idealised avatars – had a negative effect [44, 111]. In order to describe the influence of identification on motivation and performance, we propose the notions of *intrinsic identification*, which is based on a recognition of one's true Self and fostering a sense of oneness with the Self, and *extrinsic identification*, which is based on personas projected by the ego and drawing the attention away from the Self. In accordance with this, the distinction between "Koerper" – the material body – and "Leib" – the animate body inhabited by the Self – has been proposed to guide the holistic design of exergames [82]: while an idealised avatar focuses on the material body we do not have and the corresponding persona projected by our ego, the realistic avatar respects our body and ourselves for what we are.

We could not find related work demonstrating clear negative effects of idealised custom avatars, such as the negative impact on physical performance (H6) observed in Study 2. In related works both realistic [127, 134, 17, 116] and idealised [121, 65, 60, 56] custom avatars were found beneficial for identification, game enjoyment and flow, and avatars were found to become more important to participants when they project more aspects of their ideal self [33, 27, 9]. Notably, Jin discussed the potential for self-discrepancy of idealised vs. realistic avatars in exergames [58], but her empirical results were mixed and mainly favoured idealised avatars. A possible explanation for this is that unlike typical non-exertion or low-to-medium exertion games, our high-intensity exergame was affected by *ego depletion*, the phenomenon that intense physical and emotional exertion reduces willpower and motivation [12, 61]. Thus, the motivational and performance benefits gained from feedforward and self-determined, intrinsic motivation may have had a greater effect on maintaining performance in these situations [109, 47]. Furthermore, Study 3 about enhanced avatars indicates that a small degree of idealisation may not have a negative effect. The enhanced avatars (E1 and E6), especially the 6-months enhanced avatar (E6), managed to increase wishful identification (H7) at a relatively small cost of similarity identification and no other notable disadvantages. Qualitative comments of studies 2 and 3 indicate that despite their potential disadvantages, idealisation of avatars can be an entertaining game element.

Limitations

We used only one avatar creation tool and one VR exergame, so it is unclear how well the results can be generalised without further work. However, the exergame and the avatar creation tool contained many elements typical for such systems. Similarly, our participants were mainly young university students. It would be interesting to consider the effect of different demographics, such as older participants with higher BMIs, as well as longer-term effects of avatars in future work. The sample sizes were relatively small; however, the power analyses confirmed that they were large enough to detect the hypothesised effects and, except for Study 3, they did detect them. Study 3 was sufficiently powered to detect small-to-medium effects, and the observed effects were very small ($\omega^2 < 0.01$, with $\omega^2 = 0.1$ commonly regarded as 'small' [91]), making it unlikely more participants, without other changes, would lead to meaningful differences. The changes in the enhanced avatars may not have been very salient during the exergame, and the complex interaction between *intrinsic* and *extrinsic* identification should be further investigated in future work; however, the changes were salient enough to lead to a significant increase in wishful identification.

Impact on Exergame Design

Improving intrinsic motivation with customised avatars (H2) is important for exergames aimed at helping people to be physically active as intrinsic motivation is an important predictor of adherence to an exercise program [3, 107, 40]. Health guidelines recommend regular exercise of moderate or vigorous intensity [89], but intense exercise generally decreases intrinsic motivation [105, 34]. While it is known that good exergame design enhances intrinsic motivation [37, 101, 35, 113], our results demonstrate that, even with increased exercise intensity, intrinsic motivation can be improved specifically through customised avatars. By motivating players with avatar customisation (H2), exergame designers may be able to mitigate the large dropout rates observed for people starting an exercise programme [5, 6, 29, 36]. Furthermore, it is a challenge to motivate people to exercise at sufficient intensity [38, 92] and maintain high-intensity exercise [88, 20], also in exergames [98, 15, 10]. To address this, exergame designers could offer avatar customisation as a tool to elicit an increased player performance (H4). Avatars that are more realistic than idealistic are likely to be beneficial (H6). Designers could avoid the pitfalls of extrinsic identification and self-discrepancy by offering suitable customisation functions that do not encourage or facilitate overly idealised avatars, to foster intrinsic identification and positively affect the way players relate to their own body [83], e.g. by focusing on avatar realism or automating the avatar customisation process [52, 53, 2]. Interestingly, this is in contrast to some previous recommendations that "exergame developers should consider designing avatars that are slim and toned" [72].

CONCLUSIONS

We conducted three studies investigating the effects of avatar customisation in a VR exergame, concluding that:

1. Exergame designers should consider using realistic avatar customisation to improve player experience and performance in exergames.
2. Idealised avatars can increase wishful identification but may impact physical performance negatively.
3. 'Enhancing' a realistic avatar with some idealised characteristics may provide a suitable interface to support progression with an exercise regime.

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