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# Virtual game Changers: how avatars and virtual coaches influence exergame outcomes through enactive and vicarious learning

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**ABSTRACT**
Exergames offer both enactive and vicarious learning through the graphical representations of the self and virtual coach. This study established and tested a model of exergame motivation with Social Cognitive Theory as the foundation. A 2 (User Avatar: Absent versus Present) × 2 (Virtual Coach: Absent versus Present) between-subjects experiment was conducted with 137 high school students. Results supported a model in which the user avatar led to identification, with the relationship mediated by self-presence. Playing with a virtual coach increased social presence. Both identification and social presence were significantly related to future exercise intention, with the relationships mediated by in-game competence. These findings suggest notable theoretical and practical implications of using self-presence with avatars and social presence with virtual agents to enhance exergame outcomes through enactive and vicarious learning.

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Exergames; enactive learning; vicarious learning; social cognitive theory; avatars

Physically immersive video games (or *exergames*) are unique because they combine the fun of playing video games with the ability to obtain a physical workout simultaneously. The health benefits of exergaming have been supported empirically (Huang et al. 2017; Lwin and Malik 2014; Street, Lacey, and Langdon 2017), while other studies have explored potential facilitating variables such as player enthusiasm (Huang et al. 2019), health consciousness and perceived need for exercise (Pham et al. 2020). However, the psychosocial mechanisms that allow exergames to act as conduits of attitudinal and behavioural change have received less attention. To address this gap, we turn to social cognitive theory (SCT; Bandura 1989). According to SCT, individuals learn through two processes: enactive and vicarious learning. Interestingly, exergames appear to offer the potential for both forms of learning through the graphical representations of the self (i.e. the avatar) and of others, such as AI-controlled agents that guide and support the player (i.e. virtual coaches).

To our knowledge, a small number of studies have employed SCT in examining the impact of exergames as a health intervention. These studies, however, use the SCT model to predict outcomes in competitive versus cooperative conditions (Marker and Staiano 2015; Staiano, Abraham, and Calvert 2013). Based on the enactive and vicarious learning processes of SCT, this article aims to establish and test a model of exergame motivation that will facilitate a better understanding of the psychosocial processes that determine the effectiveness of exergames. By examining the impact of virtual selves (avatars) and virtual others (e.g. agents, coaches) together in exergames, the present research extends the field, which has generally focused on these elements in isolation. The study's findings help elucidate the relative extent to which avatars and virtual coaches motivate actual exercise behaviour after playing exergames, offering both theoretical insights into the psychological effects of these game elements and practical insights about how they should be designed into exergames.

## 1. The influence of avatars and virtual coaches

People's perceptions of their graphical self-representations (or *avatars*) in virtual worlds potentially influence their self-perception, thereby leading to changes in attitudes and behaviours that align with the avatars' characteristics (Yee and Bailenson 2007). For example, one study found that an avatar's body size influenced exercise motivation and behaviours for overweight

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children (B. Li, Lwin, and Jung 2014). When assigned normal-body-size avatars (compared to overweight-body-size avatars), overweight children exhibited better performance and more exercise motivation. K. Li et al. (2018) found that individuals' perceptions of avatar appearance, attractiveness and height were significantly related to perceived avatar friendliness. These studies suggest that avatar characteristics in virtual environments, particularly in exergames, may influence individual attitudes and behaviours in powerful ways.

Apart from the influence of the user's avatar, the presence of others in the virtual environment may also influence the player. These include other human players and non-playable characters (NPCs) who may serve as competition, or more interestingly, may collaborate with or otherwise support the player. One study demonstrated that the body size of opponent avatars might influence participants' physical activity in an exergame, with normal body size opponent avatars resulting in more physical activity and overweight body size avatars resulting in less physical activity (Peña and Kim 2014). The role of virtual coaches – agents that guide players through exergames – has received scant attention in exergame research. Such AI-controlled virtual coaches or trainers are a distinct feature in recent exergames. The virtual coach is likened to an expert companion and functions as an encouragement and motivation element to help players experience greater determination or perceived competence in the exergame. This is similar to the increased motivation and self-efficacy experienced by individuals who attend gym classes conducted by an experienced trainer (Shields and Brawley 2006).

## 2. Enactive and vicarious learning in exergames

SCT defines learning as a change in behavioural intention as a result of intervening experiences and suggests that learning occurs through either enactive or vicarious processes (Bandura 1997). An individual experiences enactive learning after performing a behaviour and then directly experiencing the behaviour's consequences. On the other hand, vicarious learning occurs when an individual observes other people's actions and indirectly experiences the consequences of their behaviour (Bandura 1997).

While research on SCT has often examined the two learning approaches in isolation, exergames present a unique domain where both enactive and vicarious learning can occur simultaneously. In exergames, players are graphically represented by avatars that reflect the player's decisions and actions. The avatar and player experience the consequences of the actions together. Put another way, the individual engages in a 'mediated enactive experience' (Peng 2008, 649) through the avatar during exergaming.

In addition, exergames encourage players to learn and execute exercise moves through vicarious learning. Players are able to learn from others, such as virtual coaches, within the exergame. Virtual coaches and other types of virtual companions (e.g. virtual pets) have been found to motivate positive behaviours across a wide range of domains, from healthy eating to increased exercise to quitting smoking to medical therapy adherence (Ahn et al. 2015, 2016; Grolleman et al. 2006; Heylen, Krenn, and Payr 2010; Johnsen et al. 2014; Radovick et al. 2018; Ratan 2017). Thus, it is no surprise that many exergames (e.g. *Wii Fit, Kinect Training*) present players with virtual coaches who demonstrate exercise activities and act as a model for the player to follow. By observing and mimicking the exercise activity, the player executes the exercise behaviour and engages in vicarious learning.

The combination of enactive and vicarious learning in the exergame environment is a unique proposition. It is likely that when playing an exergame, an individual engages in enactive learning by experiencing and acting out the exercise activity; concurrently, the individual engages in vicarious learning by observing a virtual coach and modelling the exercise behaviour. Together, both mechanisms may help facilitate the individual to learn and carry out domain-specific behaviours (Biddle and Mutrie 2007). In the context of our study, players can express learning outcomes in the form of self-assessed competence in the exergame and intention to exercise in the future.

## 3. Conceptual framework and hypotheses

SCT provides an important overarching theoretical foundation on the enactive and vicarious learning processes that may be present in an exergame. In addition, considering that exergames occur within virtual environments, we utilise a series of theoretical concepts that are particularly relevant to virtual experiences. These concepts guide the application of the SCT framework in the present research.

### *3.1. Self-presence*

Self-presence refers to the extent to which an individual experiences the avatar as an extension of the self (Biocca 1997). When virtual environment users lose awareness of their avatars' virtuality and treat these avatars as actual selves, they experience self-presence (Lee 2004).

Studies have examined self-presence as a multi-level conception of self extension into an avatar (body, emotion, and identity; Ratan and Hasler 2010) bodily movement of an avatar (Jin and Park 2009), or experiences of the undefined 'you' in a virtual space (Behm-Morawitz 2013). In order to avoid this complexity, the present research treats body-schema as the fundamental construct of the self (Damasio 2006) which can potentially be altered or extended through tool use (Maravita and Iriki 2004). Higher levels of self-awareness, such as self-identity, are built on top of this core conception of self (e.g. through autobiographical memories of interactions between the body and the environment; Damasio 2006), but their relationship with avatars is better understood through other concepts of relationships with media besides self-presence (e.g. identification). Therefore, self-presence is treated here as the extension of body schema into the virtual environment through avatar use, akin to the concept of embodiment as described in other literature (Banks and Bowman 2016; Van Looy et al. 2012). In other words, the more someone feels that their body, arms or legs are extended or integrated into the virtual environment through the avatar, the more self-presence they are experiencing. In an exergame, seeing your own avatar and controlling it can lead to higher self-presence. Hence, we propose the following hypothesis:

**H1** The presence of a player's avatar is positively associated with self-presence.

*Social presence* is the extent to which individuals feel they are sharing the mediated space with another person (Biocca, Harms, and Burgoon 2003). There are multiple types of awareness of another, including co-presence, psychological involvement, and behavioural engagement. The present research considers each of these to be factors of social presence, as researchers have previously suggested (Biocca, Harms, and Burgoon 2003). Studies that consider social presence across these types of awareness have proven fruitful, for example illustrating that social presence mediates social attraction to, intelligence perception of, and enjoyment of interaction with a social agent (Lee et al. 2006). In mediated communication, people experience more social presence (e.g. they pay more attention, feel more co-located) when the communication partner exhibits more behavioural realism (Astrid et al. 2010) or is represented by an anthropomorphic figure in comparison to simply text or audio alone (Bente et al. 2008, 2004). In an exergame, embodied others can include other players or virtual coaches who communicate with the player. Such communication influences social presence and thus the outcomes of the exergame. Hence, we propose the following:

**H2** The presence of a virtual coach is positively associated with social presence.

Based on the above explication, we suggest that self-presence is at the origin of the enactive route of learning, while social-presence is at the origin of the vicarious route. However, although self-presence and social presence are distinct constructs, they are also potentially interrelated. Self-presence has been understood from its conception to have a social component, given that the self is socially constructed (Biocca 1997; Lee 2004). In other words, people reflect on and present themselves in relation to others (Goffman 1959) and so the feeling of self-presence is intrinsically tied to the experience of other social actors within that environment. Consistent with this, one study found that self-presence significantly correlated with social presence (.62) for students who used avatars to participate in an online course (Ratan and Hasler 2010).

Here, we extend that reasoning and posit a directional relationship, namely, that self-presence facilitates social presence. This expectation is based on the understanding that in order to experience a sense of mutual attention, involvement, and co-location with a virtual other, you must feel as though your body schema is at least somewhat extended into the same space as that virtual other. Of course, social presence can be experienced even when self-presence is minimal given other factors that contribute to social presence, such as the social characteristics of the interactant. Such contributors have been examined in previous studies (e.g. Bente et al. 2008; Nowak and Biocca 2003), but no studies of which we are aware have examined self-presence as a direct contributor to social presence. Thus, we predict the following:

**H3** The experience of self-presence is positively associated with social presence.

### 3.2. Identification

Identification with traditional media characters has often been conceived of as a psychological connection between an audience member and a distinct social other (Cohen 2001), while identification with avatars is somewhat different, given that avatars are self-representations, by definition (Nowak and Fox 2018). The former reflects a dyadic relationship ('I identify with her') while the latter a monadic relationship ('My identity is merged with the character's identity') in which self-concept is temporarily altered to include the perceived characteristics of the avatar (Klimmt et al. 2010). Clearly, identification with an avatar represents a different concept from identification in a traditional-media sense, but the conception and operationalisation of sub-constructs have been hotly debated (Bowman, Downs, and Banks 2020; Downs, Bowman, and Banks 2019; McDade-Montez and Dore 2020). Here, we accept the conceptual approach to identification as a merger of the self and the avatar, but operationally we focus on the user's perceived similarity to the avatar, which has been confirmed empirically as a key element of avatar identification (Trepte and Reinecke 2010; Van Looy et al. 2012; Waltemate et al. 2018). Namely, when people feel that their avatar appears similar to themselves, they feel a sense of identification with that avatar. This approach is consistent with the notion that identification is a self-avatar merger. If the user perceives the avatar as possessing similar elements of identity, then the user and avatar share an identity to some extent, reducing the distinction between (i.e. merging) the user's perception of the avatar and the user's self-concept. This is in line with Bandura's (1997) proposition that people consider self-schemata in making efficacy judgments. Pre-existing self-knowledge structures help individuals interpret and organise efficacy information. A perceived similarity with the avatar activates these self-schemata and enhances self-efficacy beliefs. Consistent with this reasoning, programmes based on entertainment-education increase the level of identification by offering characters that resemble the audience through body-related and behavioural features (Brown and Fraser 2003).

It is important to note here the difference between self-expressiveness and identification. The former refers to the degree that an individual perceives that a media content consistently represents their self-concept (Sharma et al., 2020). There are two distinct points that sets it apart from identity. First, self-expressiveness focuses on the media type and content, such as a video game or a movie. Identification on the other hand refers to the relationship between the individual and their character or avatar. Second, self-expressiveness requires the media content facilitates the user to be acknowledged publicly. Identification, however, does not require public endorsement of the self-avatar affinity.

With regard to the antecedents of avatar identification, studies have identified a few factors, including perceived avatar attractiveness and avatar image (Liao, Cheng, and Teng 2019; Teng 2019). We propose that the experience of self-presence is another source. Identification as defined here (perceived self-avatar similarity) and self-presence as defined here (perceived body-schema extension into the avatar) are similar concepts in the sense that both focus on a close connection between the avatar and the user in some aspect of self. However, identification focuses on identity-related aspects of self, while self-presence focuses on body-schema. Identity and body schema are differentiated in important ways, namely the body provides a 'core consciousness' focused on experience in the moment while identity is an outcome of an 'extended consciousness' that is built on 'autobiographical' memories over time (Damasio 2006). Further, core-consciousness – which is related to perceptions of the body (i.e. like self-presence) – provides the foundation extended consciousness, which is related to meta-cognitions about the self (i.e. like identification). In this regard, self-presence in a more fundamental process that potentially gives rise to identification. Consistent with this line of reasoning, these concepts have been found to similarly reflect a psychological connection to the avatar but also represent two distinct concepts (i.e. body-level and identity-level connections to avatars), supporting both convergent and discriminant validity (Ratan and Sah 2014). Hence, we posit that identification and self-presence are positively related as part of the enactive route:

**H4** The experience of self-presence is positively associated with avatar identification.

### 3.3. In-game competence

Ryan, Rigby, and Przybylski (2006) found that players who reported greater in-game competence were more engaged and immersed in the game experience, and these effects were positively related to game motivation, self-esteem, and preference for future game play. Przybylski, Rigby, and Ryan (2010) concluded that 'psychologically satisfying experiences of play were a robust predictor of motivation and well-being across individuals and across the varied game contents and narratives' (157). Need satisfaction of competence in video games is fulfilled when players demonstrate their capability to perform required actions and achieve the goals set by the game (Ryan, Rigby, and Przybylski 2006), and this experience can lead to positive affect such as feelings of confidence (Bandura 1997).

The presence of a virtual coach can help guide the player to meet game challenges and hence fulfil the need satisfaction of competence. A virtual coach is able to enhance the player's feeling of competence through socially engaging interactions with the player, just as physical coaches increase athletes' perceived competence and motivation through responsive communication during training (Black and Weiss 1992). The coach is not simply a source of information, but is also a model who explains how to achieve such vicarious or social learning. According to Bandura (1997), a proficient model motivates individuals by raising their self-esteem. As they achieve progress toward aspirational standards provided by a proficient model, they gain greater personal confidence in themselves and in enacting the modelled behaviour. This is similar to the perceived in-game competence one feels when learning socially through an aspirational model such as the virtual coach.

Thus, if a virtual coach is not perceived as a social entity, then we would expect the potential for vicarious learning – and resulting in-game competence – from the virtual coach to be minimised. Conversely, the more a virtual coach is perceived as a social entity, the greater the potential for vicarious learning and thus in-game competence. Therefore, we posit H5 (below) as part of the vicarious route.

In-game competence should also be influenced by an element of the enactive path, namely, identification. Given that identification is a psychological merger between the user's and avatar's identity (Klimmt et al. 2010), the more the user identifies with the avatar, the more the user should identify with the game environment within which the avatar is being used. Consistent with this logic, one study found that identification with game characters increased play enjoyment (Hefner, Klimmt, and Vorderer 2007) and mediated the relationship of play modality in a diet-promotion game and post-game eating self-efficacy (Peng 2008). This implies that in-game competence should also be positively influenced by identification, which we hypothesise in H6.

**H5** Feelings of social presence with a virtual coach are positively associated with in-game competence.

**H6** Avatar identification is positively associated with in-game competence.

### 3.4. Behavioural intention

If players feel that they are competent in exergame performance – as a result of enactive and vicarious learning while playing the game – they may also feel more capable and interested in exercising in the future, even without an exergame. Consistent with this expectation, previous studies have found that playing exergames leads to increases in exercise intention, behaviour and interest (Lwin and Malik 2014; Nguyen et al. 2016; Song, Peng, and Lee 2011), but mechanisms related to enactive and vicarious learning and in-game competence have not been tested. Because enactive and vicarious learning facilitate domain-related behaviours (Biddle and Mutrie 2007) and are expected to increase in-game competence, then we would expect that in-game competence in an exergame is associated with an increased intention to exercise in the future. Hence, we propose the following hypothesis:

**H7** In-game competence positively relates to exercise intention.

In sum, this article suggests that playing exergames facilitates two routes of learning: enactive and vicarious. Self-presence – the feeling that the player's body schema is represented in the virtual environment – is a key factor in the enactive route given than according to SCT, individuals learn through this route when they experience a stimulus directly (Bandura 1997). Social presence – the feeling of mutual attention, involvement, and collocation with a virtual other – is a key factor in the vicarious route because in order to learn vicariously through others, an individual must experience some level of social connection to them (Bandura 1997). Although self-presence is expected to facilitate and thus be correlated with social presence, the two routes are also expected to operate independently. A player experiences enactive learning by seeing his avatar within the exergame and acting out the behaviour, which increases his perceived self-presence (H1). In this route, the exergame player's sense of self-presence in the avatar is expected to be correlated with the avatar identification (H4). In parallel, an individual experiences vicarious learning by observing a virtual coach that is present and mimicking the behaviour modelled by a virtual coach. In this route, the accompaniment of a virtual coach allows them to feel a sense of social presence (H2), which is also facilitated through a sense of self presence in the exergame (H3). The extent of perceived in-game competence is expected to be influenced by feelings of both social presence (H5) and identification (H6). Finally, perception of in-game competence is expected to relate to future exercise intention (H7). Figure 1 presents this full conceptual model and the proposed hypotheses. A study had previously examined and found support for the enactive route of a similar model (Li and Lwin 2016). However, that inquiry was based on cross-sectional self-report data from participants' experience of a single exergame condition, limiting the validity of causal inferences. For example, self-presence is developed through the process of exergame playing and thus should be measured as a result of exergame experiences. The present research addresses this need, offering a more robust and expanded examination of the model of exergame effects. Manipulating the presence or absence of the player avatar and virtual coach to elicit self- and social presence, respectively, is a more accurate way to test the enactive and vicarious routes to learning in an exergame context.

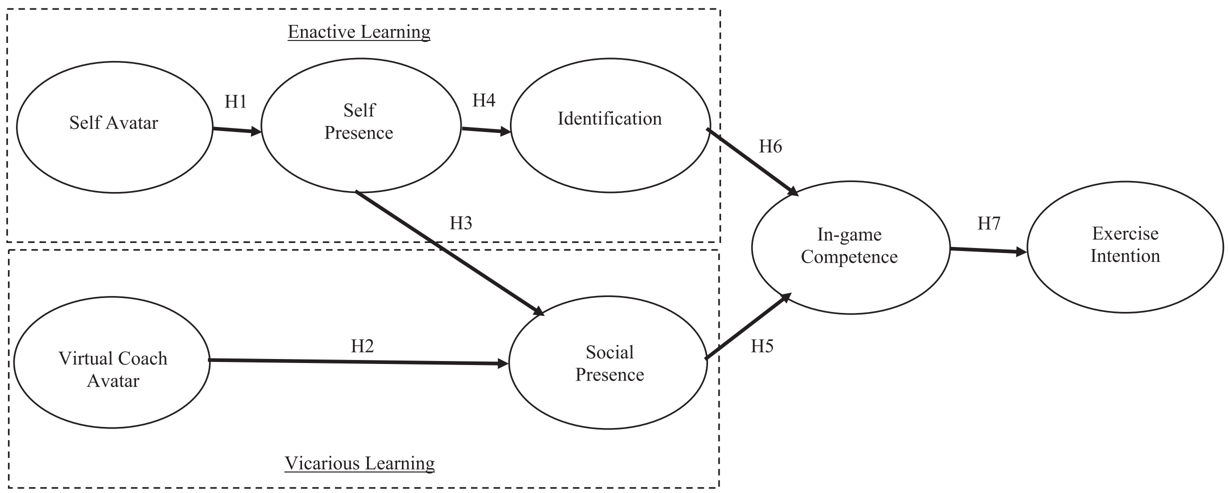


**Figure 1.** Conceptual model and proposed hypotheses.

## 4. Method

### 4.1. Sample and design

The study consists of a 2 (Player Avatar: Absent versus Present) × 2 (Virtual Coach: Absent versus Present) between-subjects experiment. We followed recommendations by Anderson and Gerbing (1984) and Ding, Velicer, and Harlow (1995), who suggest that 100–150 participants is the minimum recommended minimum sample size for structural equation modelling (SEM). After accounting for dropouts, a total of 139 participants took part in the study, with 81 (58.3%) males. Participants, recruited from a high school in Singapore, were between 13 and 18 years of age ($M = 14.9$, $SD = .82$) and randomly assigned to experimental conditions.

### 4.2. Manipulations and procedure

The exergame employed for the study was *Your Shape: Fitness Evolved 2012* on the *Xbox Kinect*. Two games which were part of the kickboxing training set were used. The games consisted of either a kickboxing trainer session where the player had to follow the moves of a virtual coach, or a kickboxing workout where players enacted moves based on objects that appeared on screen. The trainer session game was used for the virtual coach-present conditions, while the kickboxing workout was used for the virtual coach-absent conditions. In the player avatar-present/virtual coach-present condition, participants engaged in the kickboxing trainer session, which involved a sequence of pre-set kickboxing activities for 15 min. A virtual coach demonstrated each activity, and the player was required to mimic the behaviour of the virtual coach to successfully complete the workout. The participant's avatar was displayed alongside that of the virtual coach, and the player was able to see in real-time whether the player's actions corresponded with that of the coach.

In the player avatar-absent/virtual coach-present condition, participants were asked to view a recording of the same 15-minute kickboxing trainer session and enact the kickboxing actions. In this recording, only the virtual coach was present to demonstrate the activities. The player was unable to see an avatar on the screen. The recording was loaded on a DVD that was played on the *Xbox Kinect* system to simulate a real exergame.

In the player avatar-present/virtual coach-absent condition, participants engaged in a kickboxing workout. However, in place of following the movements of a virtual coach, they were required to punch and kick virtual blocks that appeared in front of their avatar on the screen. No virtual coach was present or required during gameplay. The entire workout lasted 15 min.

In the player avatar-absent/virtual coach-absent condition, participants engaged in the kickboxing workout but were unable to see their avatars on the screen. Their responses to the virtual blocks appearing on the screen through actual punches and kicks were still captured. To achieve this, participants were required to stand at a prescribed distance from the *Xbox Kinect* console. This predetermined distance was sufficiently close for the participants' movements to be detected, but far enough such that the console was not able to detect the player's silhouette to display on screen as an avatar. Pretests with the game stimuli suggest that playing in this condition (without seeing an avatar) did not hinder the ability to succeed in the game task (i.e. knocking down blocks). Examples and screenshots of all four conditions are presented in Figures 2 and 3.


**Figure 2.** Screenshots of kickboxing game for virtual coach present condition.

### *4.3. Manipulation Check*

To test for the effectiveness of the player and virtual coach avatar manipulations, participants were asked to rate their responses to the statements 'I had a sense of being in the exergame' and 'I felt as if I was accompanied by a fitness coach' respectively. Independent samples t-test revealed that the player avatar manipulation was successful ($t(135) = -2.64$, $p < 0.01$, Cohen's $d = 0.46$). Participants in the player avatar-present condition reported a higher score ($M = 5.52$, $SD = 1.23$) as compared with those in the player avatar-absent condition ($M = 4.90$, $SD = 1.47$). Results also showed that the coach manipulation was successful ($t(135) = -2.22$, $p < .05$, Cohen's $d = 0.39$). Participants in the virtual coach-present condition reported a higher score ($M = 5.28$, $SD = 1.51$) compared with those in the coach-absent condition ($M = 4.75$, $SD = 1.24$).

### 4.4. Measures

The measures employed in this study were mainly adapted from previous versions of validated scales in presence, serious games, and exergame research. The item descriptions of the measures and reliability coefficients are presented in Table 1.

## 5. Results

We analyzed the data using covariance-based SEM. SEM was used as the analytic method because of its ability to analyze the relationships between latent and observed variables. Random errors are also modelled in the observed variables which allows for more precise measurements. The standard two-step approach was employed: In the first step, we first estimated a measurement model which included all latent variables, also known as a confirmatory factor analysis (CFA) model. The CFA model allows us to understand how well the observed indicators measure the latent variables. The second stage consists of testing the suggested structural model, through a specification of the proposed relationships among the exogenous and endogenous variables.

The skewness and kurtosis of the 17 measurement items were first examined for potential anomalies. While skewness may affect tests of means, kurtosis may influence tests of variances and covariances, which are the foundation of SEM (Byrne 2010). Skewness indices for the measurement items ranged between −.58 and −.04, while kurtosis indices ranged between −.69 to .51. These small numbers are well within the recommended levels of |3| for skewness and |10| for kurtosis (Kline 2015).

Results from confirmatory factor analysis showed a good model fit ($\chi^2$ ($df$) = 227.60(133); $\chi^2/df = 1.71$; CFI = 0.95; TLI = 0.94; RMSEA = 0.07). The measurement model was further analyzed for the convergent and discriminant validity of the constructs. Convergent validity is examined by comparing the factor loadings of the items, with a recommended cutoff value of .60 (Chin, Gopal, and Salisbury 1997). As shown in Table 1, the factor loadings in our measurement items ranged from .79 to .95, which demonstrated substantial convergent validity. We examined the correlations of the constructs to assess discriminant validity (see Table 2). Multicollinearity may be an issue for constructs that exhibit correlations of .90 or higher (Hair et al. 2010). The correlations between the constructs in the model range between .52 and .68, which suggests the absence of multicollinearity and therefore establishing discriminant validity. We further examined the average variance extracted (AVE) to strengthen support for convergent and discriminant validity. The AVE of the constructs should be higher than .50 to show convergent validity (Hair et al. 2010). For discriminant validity, the AVE of the construct should be greater than the square of the correlations with other constructs (Fornell and Larcker 1981). The AVE values in our measurement model fulfilled these requirements as shown in Table 2.

Next, SEM was run to test the hypothesised exergame motivation model. The results showed a good fit for the hypothesised model [$\chi^2 = 246.30$, $df = 146$; $\chi^2/df = 1.69$; CFI = 0.95; TLI = 0.94; RMSEA = 0.07] based on recommendations by Browne and Cudeck (1992) and Hu and Bentler (1999). All hypothesised paths were significant. Figure 4 shows the final model with the standardised regression weights.

## 6. Discussion

While recent literature has explored the effects of variables such as player enthusiasm, optimism, health consciousness, and perceived need for exercise on the efficacy of exergames (Huang et al. 2019; Nguyen et al. 2018; Pham et al. 2020), the present research proposes an exergame behavioural change mechanism through the conceptualisation and testing of a theoretical model based on SCT. Results provided a fitting model for explaining exergame processes and outcomes, and offer theoretical implications about utilising SCT when considering learning and other behavioural effects in virtual environments. Further, this research provides practical implications about how to design exergames in ways that harness the potential behavioural influence of avatars and virtual coaches.

A study by Ho et al. (2017) found that level of presence users experienced in exergames was a key factor in predicting their attitudes towards exergames. However, the presence scale used in that study was measuring a general sense of presence within the virtual environment. Presence comprises of many sub-dimensions and understanding their individual impact beyond a general notion of presence is crucial (Lee 2004). Findings from our study show that the levels of self-presence and social presence experienced by individuals are important determinants of their exergame outcomes.

The relationship found between self-presence and social presence is consistent with the argument that the former facilitates the latter. In order to feel like you are there in a shared space with a virtual other, you must feel as though you – your body – is there as well, at least to some extent. Only one other study of which we are aware has provided empirical

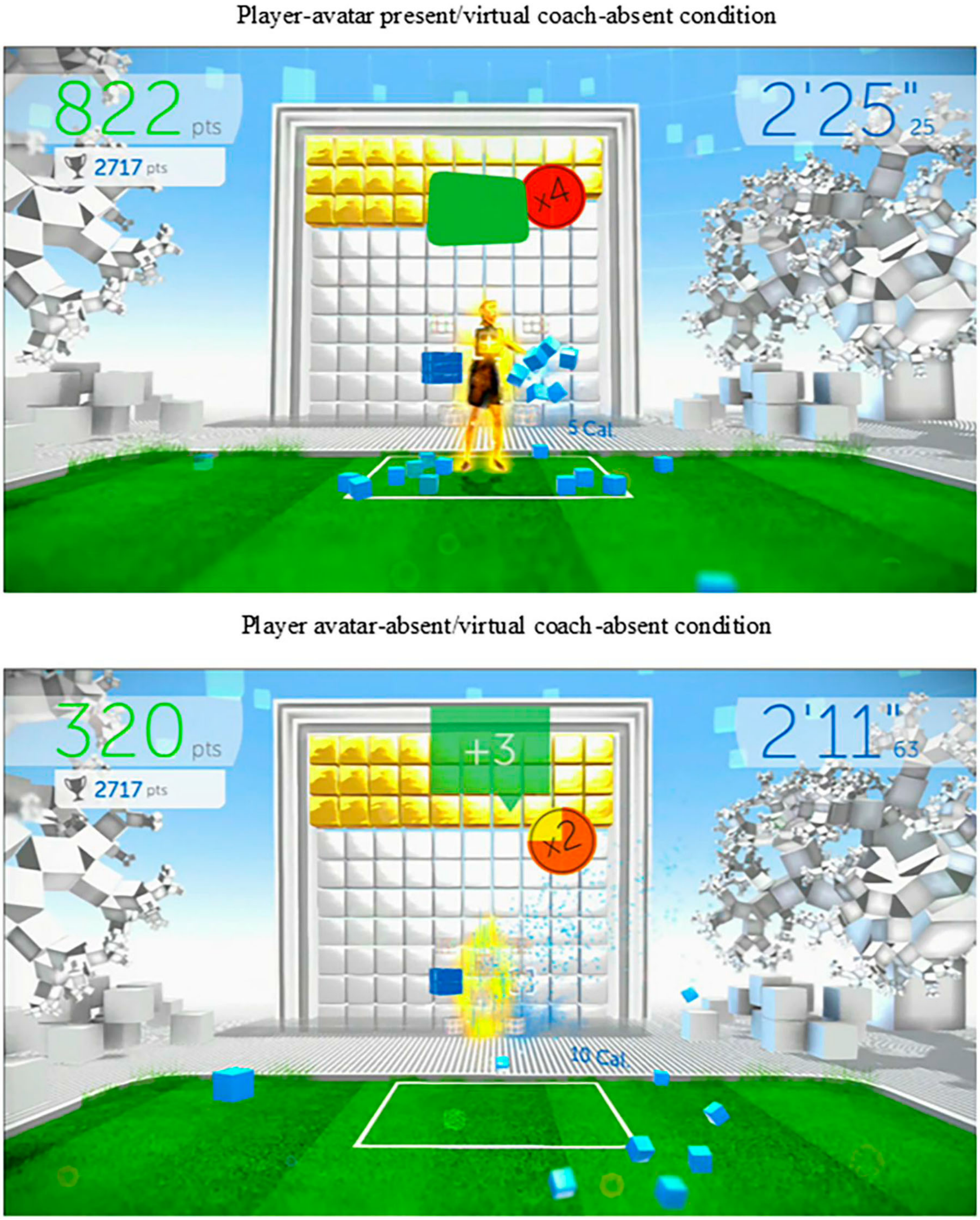


**Figure 3.** Screenshots of kickboxing game for virtual coach absent condition.

support for this claim (Ratan and Hasler 2010), so the present study improves our confidence in this understanding of the relationship between these two constructs.

The finding that self-presence is associated with avatar identification contributes to a theoretical understanding of how avatars influence user behaviour through virtual enactive experiences. While recent studies have observed user perceptions of avatars such as attractiveness and credibility being antecedents of identification (Liao, Cheng, and Teng 2019; Teng 2019), findings here show that self-presence is a significant predictor. Self-presence implies a connection between the avatar and user's body schema. Conversely, identification implies a connection between the avatar and user's identity. This finding is consistent with the

**Table 1.** Item descriptions, factor loadings and reliability of measures.

| Variables | Item coding | Item descriptions | Factor loading | Cronbach's alpha |
|---|---|---|---|---|
| Self-Presence adapted from Ratan (2013.) | SELFP 1 | I felt my avatar was an extension of my body within the exergame. | .81 | .91 |
| | SELFP 2 | I felt my arms and legs are stretched into the exergame through my avatar. | .79 | |
| | SELFP 3 | I felt my arms and legs are inside the exergame. | .90 | |
| | SELFP 4 | I felt I could reach into the exergame through my avatar. | .91 | |
| Social Presence adapted from Lee et al. (2006) | SOCP 1 | How much attention did you pay to a fitness coach? | .70 | .90 |
| | SOCP 2 | How much did you feel involved with a fitness coach? | .89 | |
| | SOCP 3 | How much did you feel you were in the same room with the fitness coach? | .87 | |
| | SOCP 4 | How much were you able to assess the reactions of the fitness coach to your behaviour? | .87 | |
| Identification from Van Looy et al. (2012) | IDEN 1 | My character resembles me. | .95 | .93 |
| | IDEN 2 | I identify with my character. | .94 | |
| | IDEN 3 | My character is similar to me. | .82 | |
| In-game Competence from Deci et al., (1994) and McAuley et al. (1989) | IGCO 1 | I felt as if I mastered the exercises. | .82 | .86 |
| | IGCO 2 | I felt as if I mastered the exergame. | .83 | |
| | IGCO 3 | I felt capable and competent in my abilities while using this exergame. | .81 | |
| Exercise Intention from Limperos, (2011) | EXINT 1 | The experience I had today made me want to start exercising regularly. | .84 | .91 |
| | EXINT 2 | Based on my experience today, I would consider exercising regularly in the future. | .94 | |
| | EXINT 3 | At the next available opportunity, I intend to participate in some form of exercise. | .87 | |

notion that body schema is a foundational aspect of the self upon which identity is formed (Damasio 2006). In the context of avatar use, this implies that the mechanisms through which the user's body schema connects to the avatar (e.g. through joysticks, motion controllers, buttons, etc.) play an integral role in identification with the avatar. Controlling an avatar facilitates or otherwise influences identification with it, just as interactions between a human's body-schema and external entities gives rise to the higher levels of consciousness that form identity (Damasio 2006). In the exergame context, this suggests that by encouraging the player to experience the avatar as an extension of the player's own body schema (i.e. increased self-presence), the player will identify more with the avatar, which leads to additional benefits (as discussed below).

The finding that social-presence increases perceived own in-game competence contributes to a theoretical understanding of how virtual others influence behaviour through vicarious learning. When the player experiences social presence with the virtual coach, the virtual coach is not perceived simply as a source of information, but is also a model that the player can emulate. The stronger that social perception of the virtual coach (i.e. social presence), the more the player feels capable of such vicarious learning, and thus increases perceived own in-game competence.

The finding that identification increases perceived in-game competence supports the argument that identification facilitates enactive learning through an avatar. The more the user identifies with the avatar, the more the user identifies with the game environment within which the avatar is being used. This is consistent with the notion that identification facilitates enjoyment (Hefner, Klimmt, and Vorderer 2007) and self-efficacy (Peng 2008) in video games.

Finally, in-game competence and exercise intention were positively associated. This demonstrates that the player's perceived skill in mastering the game's objectives may motivate them to exercise in general. While past studies tend to examine the effects of exergaming on exercise motivation, our findings suggest that the impact of exergaming is largely enhanced by the ability of the exergame to provide both enactive and vicarious learning for the player.

### 6.1. Theoretical and practical implications

In this study, enactive and vicarious learning were examined in parallel with self- and social-presence. While these dimensions of presence were studied separately in past exergame research (Jin and Park 2009), this study has examined both concepts together in an exergame that includes player avatars and virtual others. Results support the notion that the influence of exergames depends on the experience of self- and social-presence.

Further, by augmenting the degree of self-presence and thus identification, the game is able to enhance the player's exercise motivation. Exergame developers can consider enhancing the salience of the user's body schema and identity through the avatar. Regarding the

**Table 2.** Descriptive statistics of measures and assessments of discriminant validity.

| | Mean | SD | AVE | Correlations | | | | Square of Correlations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | SELFP | SOCP | IDENT | IGCO | SELFP | SOCP | IDENT | IGCO |
| Self-Presence (SELFP) | 5.13 | 1.24 | .73 | | | | | | | | |
| Social Presence (SOCP) | 4.90 | 1.15 | .70 | .68 | | | | .46 | | | |
| Identification (IDEN) | 4.80 | 1.46 | .82 | .65 | .52 | | | .42 | .27 | | |
| In-game Competence (IGCO) | 4.53 | 1.29 | .68 | .63 | .56 | .56 | | .39 | .31 | .31 | |
| Exercise Intention (EXINT) | 5.05 | 1.31 | .78 | .56 | .53 | .52 | .61 | .31 | .28 | .27 | .37 |

Note: SD = Standard deviation; AVE = Average variance extracted.

former, control mechanisms can be more responsive and intuitively mapped to the player's movements, allowing the player to feel as though their bodies are physically connected to the virtual environment. Regarding the latter, the avatar can be made visually prominent, or customisable in ways that allow the player to represent an ideal or possible self. To facilitate enactive learning, the consequences of the player's actions through the avatar should be immediately depicted within the exergame.

With regard to social presence, which was also associated exercise intention via in-game competence, exergames should seek to feature additional characters or virtual companions other than the player with whom the player may experience social connections. In order to increase social presence and thus in-game competence, elements such as a virtual coach can be designed to guide the player through workouts and serve as a model to emulate. Another approach would be to incorporate social elements through the presence of other players, which is a strong motivation for play across video game genres (Kahn et al. 2015; Przybylski, Rigby, and Ryan 2010).

### 6.2. Limitations and future research

The exergame used in this study allowed us to choose a particular genre (kickboxing) while giving us the ability to manipulate whether the player sees their own or their coach's avatar. However, the settings of both games differ from each other. The first consists of a fitness workout in a boxing ring while the other takes place in an outdoor field. While we acknowledge that the participants may respond differently based on the setting they are in, both games emphasise the importance of executing the kickboxing moves accurately through in-game elements such as achievements and point scoring for performing the tasks well. Hence, player engagement and focus on the exergame might supersede the influence of exergame setting. Nonetheless, future studies can explore if the game environment might affect players' sense of presence and other outcomes.

Our final sample size consisted of 137 participants, which fell short of the recommended sample of 150 (Muthén and Muthén 2002). As there were between three and four latent indicators per observed

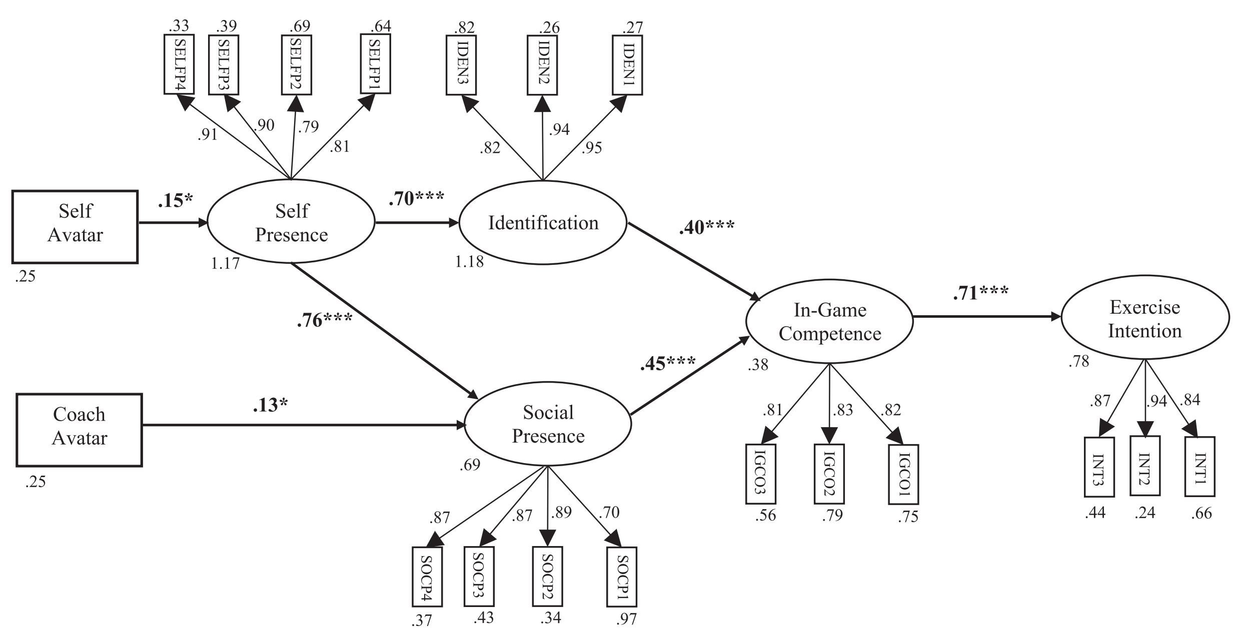


**Figure 4.** Final structural model. *$p < 0.05$; ***$p < 0.001$.

variable, this was considered reasonably sufficient for a proper solution (Anderson and Gerbing 1984). Nonetheless, given the good fit and mostly substantial effect sizes found in the present study, we would not expect a larger sample to contradict our results. In spite of the general challenge in recruiting participants in experimental studies, future studies should recruit more participants to establish more conclusive support for the model. Also, participants in our study consisted of students who tend to be more agile and eager to engage in video games as compared to the average adult. Additional studies are needed with different target groups in order for the results from this study to be extrapolated to a general population.

Another limitation of the present research is the single-message design given the potential for elements of the specific games used here – besides the theoretical constructs of interest – to have influenced participants. Although we believe that this study sufficiently isolated those factors in order to support the internal validity of the findings, future research should include multiple-message designs to bolster the confidence in the inferences drawn.

Further, we examined social presence in the form of a virtual coach. Although findings show that the virtual coach had a significant influence, exergames feature other kinds of NPCs. These can exist in the form of virtual supporters that cheer the player on or virtual opponents with whom players compete. Future studies could examine the potential influence of such NPCs. Moreover, real-world players can provide social presence. Many exergames now enable cooperative and competitive gameplay through additional players engaging in the same exergame experience. Future studies can examine the influence of social presence through real-world players, or examine their impact vis-à-vis virtual NPCs.

This study sought to conceptualise a model of exergame learning using both enactive and vicarious routes. While findings provide support for the model, the separate effects of each route were not examined here. Future studies could examine whether enactive or vicarious learning is more effective in the exergame context, or explore their relative impact on different groups. While Bandura (1989) states that enactive learning is more effective than vicarious learning in increasing self-efficacy, studies have shown that some population groups respond better to vicarious learning than the former (Elliot and Dweck 2013). It is essential to ascertain the differential influence of both routes in developing more effective exergames and interventions.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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