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Virtual Humans in Virtual Reality Mental Health Research: Systematic Review

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Table of Contents

Original Manuscript 4
Supplementary Files 49
Figures 50
Figure 1 51
Figure 2 52

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Abstract

Background: Virtual humans (VHs) have shown increasing promises in the use of assessing, understanding and treating mental health difficulties in virtual reality (VR). However, their design and impact have rarely been the primary focus of mental health research.

Objective: We provide a systematic review of the use of VHs in immersive VR in applications for mental health, focusing on their roles, interaction types, and the human characteristics being tested.

Methods: We developed a taxonomy to categorize VHs and conducted a systematic review of 79 studies following PRISMA guidelines.

Results: VHs were most frequently applied in studies on social anxiety (n = 18), eating disorders (n = 18), and psychosis (n = 15). They were primarily used as active social interaction partners (n = 40), virtual crowds (n = 16), and virtual bodies (n = 23). Explicit interactions dominated active partner studies, while implicit and passive/no interactions were prevalent in crowd and body studies. Over half of the studies (n = 44) manipulated VH characteristics, with body size and gender being the most common variables, and personality explored in fewer studies. Only a limited number of studies provided detailed descriptions of VH appearance and behaviour, with some including still images and videos.

Conclusions: VHs are versatile and play an important role in mental health VR, but systematic examinations are needed to better understand how their design impacts the outcomes in mental health research. The research community would also benefit from standardized reporting frameworks for VH to enhance reproducibility in future research. Clinical Trial: PROSPERO CRD42021244748

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Original Manuscript

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Virtual Humans in Virtual Reality Mental Health Research: Systematic Review

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Background: Virtual humans (VHs) have shown increasing promises in the use of assessing, understanding and treating mental health difficulties in virtual reality (VR). However, their design and impact have rarely been the primary focus of mental health research.

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Trial Registration: PROSPERO CRD42021244748; https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=244748

Keywords: virtual reality; virtual human; agent; avatar; mental health

Introduction

Virtual humans (VHs) have been part of VR mental health applications since the late 1990s. The pioneering work by Riva & Melis [1] used images of a female silhouette in VR to represent the participant's body, marking one of the earliest uses of VH in mental health research. Other early studies showed that virtual audiences could effectively induce anxiety in participants [2,3]. Since approximately 2013, advancements in VR technology and reductions in cost have significantly improved accessibility, enabling the use of VHs in research areas such as understanding paranoia [4,5], treating autism [6,7] and improving symptoms from post-traumatic stress disorder (PTSD) [8]. Some recent applications have integrated virtual coaches to guide patients and automate treatments [9,10], as well as body swapping experiences that allow participants to switch between different entities to experience perspective changes [11–13].

VHs enable researchers to simulate social interactions commonly encountered in daily life [14,15] or under special circumstances such as conflict or danger [16,17]. They can also serve as the self-representations of participants through the sense of embodiment and creating the illusion that the virtual body the see and control is their own body [18]. Compared to experimental setups with trained real actors, VHs provide greater experimental control and repeatability, preserving ecological validity[19].

Despite their growing use and potential, VHs have not been studied thoroughly in mental health research. This gap is partly due to the inherently multidisciplinary nature of the field, which requires expertise in psychology, immersive technologies, and 3D design to build VHs that are clinically suitable and technically feasible. Furthermore, conducting full-scale clinical trials to evaluate VH design within patient populations is often impractical. In contrast, the computer science community has explored VHs to optimise their visual and animation quality [20–22], develop realistic and adaptive behaviours [23–25], and create open-source character libraries [26–28]. These efforts highlight the value of VHs in other research areas, for example in mental health.

Understanding the role and impact of VHs in mental health research is essential for optimising current implementations and discovering future applications. As VR and character creation software tools improve, VHs have potential to play even a more important role in mental health, offering customised therapeutic experiences with fine-tuned emotional attributes design specifically to each patient. We present a systematic review of research studies in mental health VR featuring VHs, from the early development of VR until November 2024. This review proposes a taxonomy based on the most important aspects to consider in VHs for mental health applications, and classifies the studies found in this domain. The systematic review addresses the following questions:

- What roles and functions have VHs played in VR mental health research?
- What have been the chosen agencies for VHs in VR mental health research?
- What characteristics of VHs have been examined in VR mental health research?

Methods

Categorising VHs in Mental Health VR

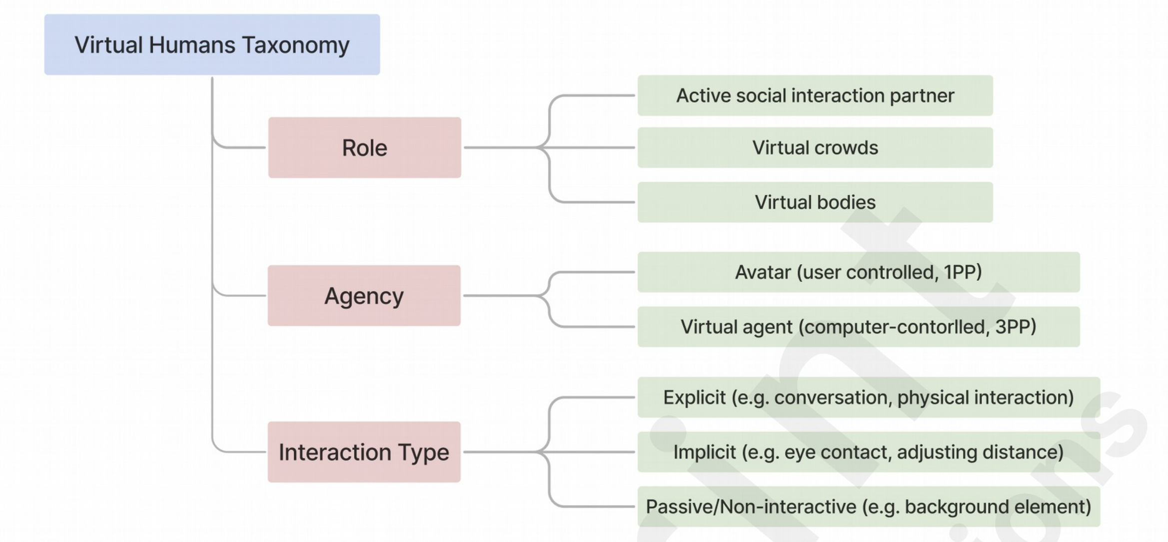

Figure 1. Virtual human taxonomy based on existing mental health VR studies.

We present a taxonomy of VHs in mental health VR (Figure 1), categorising their features into three main aspects: *role*, *agency*, and *interaction type*. These features were selected because they represent the critical dimensions influencing how VHs are designed, implemented, and experienced in mental health VR. Role defines the primary function of the VH within the virtual environment, agency determines the level of control and autonomy the VH exhibits, and interaction type describes the nature and depth of engagement between the VH and the participant. Together, these features provide a comprehensive framework for understanding the diverse ways VHs are utilised in mental health research, enabling researchers to systematically evaluate their design and impact.

Role

The role of VHs can be divided into three categories: *active social interaction partner*, *virtual crowds* and *virtual bodies*. These categories were chosen to reflect the distinct ways VHs are utilised in VR mental health research across diverse applications.
Active social interaction partners engage with participants to simulate interactions through verbal and non-verbal communication. A virtual coach is an example of active interaction partner that focuses on providing guidance or feedback to facilitate psychological treatment [9].
Virtual crowds, unlike active social interaction partners, have limited contact with participants or normally interact passively with implicit interaction such as making eye contact [29]. It is common for virtual crowds to be part of the stimuli in the virtual world [30].
Virtual bodies focus on body representation, either by depicting a range of body types or serving as the user's avatar for embodiment experiences [31].

Agency - Avatars and agents

Agency refers to the state or entity of taking action or exerting control [32], and can be categorised as *avatars* and *virtual agents*.

An avatar is a digital representation controlled by a user, serving as their own body in a different medium, for example in a virtual environment [32]. Typically viewed from a first-person perspective (1PP), avatars are co-located with the user’s real body. The real body is usually concealed thus overriding them and creating the illusion that the body they see is their own body. The term ‘avatar’ has often been misused in VR studies to describe any virtual human, even those who do not represent any user and are controlled by a computer.

A virtual agent (VA) is a computer-generated character designed to simulate human interaction autonomously, moving and responding without being controlled by a real person [33]. VAs are mainly controlled by computers and typically viewed from a third-person perspective (3PP). They can exhibit varying degrees of autonomy, with semi-autonomous agents combining computer automation with operator intervention. This approach is referred as the Wizard of Oz technique [34] (a hidden operator simulates autonomous system behaviour), and allows researchers to make VAs respond in real-time based on participant responses while still being computer animated [19].

Interaction types of VAs

VAs can have different degrees of interaction with the human participants. We categorise them into *explicit*, *implicit*, and *passive or non-interactive*.

Explicit Interactions: These involve direct engagement between a VA and a participant, such as conversations, physical interactions (e.g. shaking hands [35]), or collaborative activities (e.g. playing a sport together [36]). Explicit interactions aim to replicate real-life social experiences, and they can be difficult to implement due to the complexity of managing a large pool of possible outcomes.

Implicit Interactions: These include subtle behaviours, such as acknowledging the participant’s presence by making eye contact or adjusting interpersonal distance, without fully engaging in an explicit interaction. Such interactions are less resource-intensive than explicit ones and still contribute to enhancing the sense of presence [37,38], making participants feel as if they are part of the scene rather than just being spectators.

Passive or non-interactive: These VAs act as background elements in VR environments, unresponsive to participant actions. They are easier to implement due to the scripted nature of

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their animations. They are used for crowd simulations and creating social situations such as populating a virtual restaurant [39] or constructing an office scene [40].

Inclusion and exclusion criteria

Inclusion criteria: Papers were required to: (1) Use VHs; (2) Use immersive VR; (3) Used for assessment or intervention of mental health conditions through empirical tests with human participants.

Exclusion criteria: Papers were excluded if they: (1) Had no quantitative data or case studies (number of participants = 1); (2) Were focused on psychology concepts (e.g. the rubber hand illusion paradigm); (3) Were not available as a full text.

Searching strategy

The literature search was performed on MEDLINE, Embase, PsycINFO, and Ovid, with title and abstract searches for the keyword combinations around (1) virtual reality, (2) VH, and (3) mental health with the search query: [(virtual reality OR immersive virtual reality OR VR) AND (virtual human OR virtual character OR virtual agent OR avatar OR humanoid) AND ((assessment OR treatment OR therapy OR mental health) OR (mood disorders OR depress* OR bipolar OR mania OR paranoia OR psychosis OR psychotic OR schizophren* OR schizotyp* OR delus* OR hallucinat* OR phobias OR obsessive compulsive disorder OR OCD OR anxiety OR post traumatic stress disorder OR PTSD OR trauma OR anorexia nervosa OR bulimia nervosa OR eating disorders OR binge eating OR insomnia OR sleep OR nightmares OR circadian OR panic OR substance OR abuse OR cannabis OR tobacco OR alcohol OR amphetamine OR hallucinogens OR heroin))].

Article screening

The search returned 2596 articles published between 1997 and 2024 (final search performed in November 2024). From these, 231 articles passed the abstract check and 73 fitted the inclusion criteria. Six additional studies were also identified through citation chains, which resulted in 79 studies being included. Figure 2 presents a PRISMA diagram [41] summary of the search process.

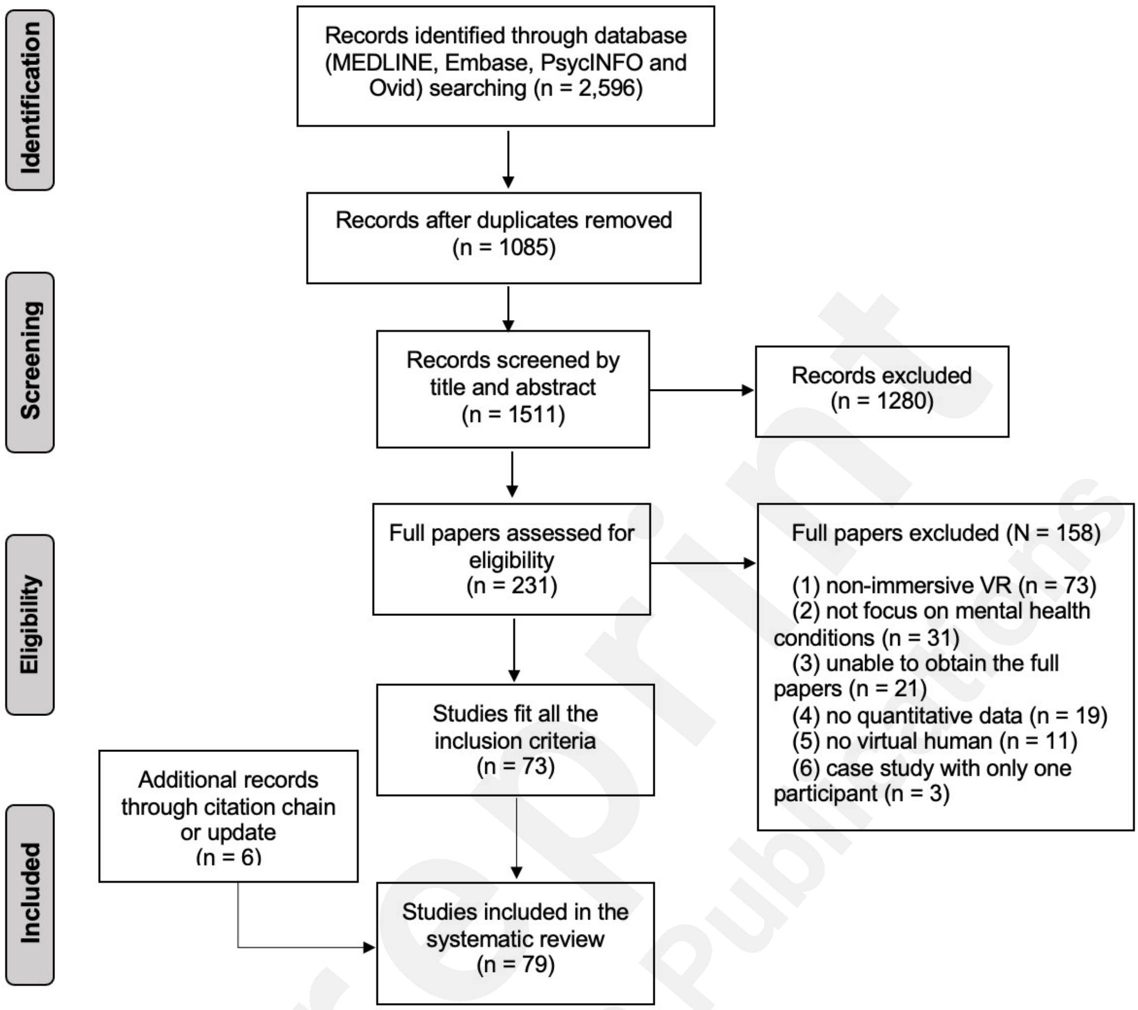

Figure 2. PRISMA flow diagram. Study screening flowchart of the systematic review.

Results

A total of 79 studies meeting the inclusion criteria were found. Error: Reference source not found- provide a list of these studies along with a brief summary for each.

Table 1. Studies primarily used VHs as active social interaction partners.

Citation	Role	Agency	Virtual Agent Interaction Type	Parameters for manipulation	Condition	N	Participant characteristics	Comment on findings
Lee et al. (2004)	Active interaction partner	Agent	Implicit Interaction	-	Substance abuse	16	Males who smoked at least 10 cigarettes a day	VHs in cue exposure therapy exerted stronger impact compared to seductive objects.
Park et al. (2009)	Active interaction partner	Agent	Explicit Interaction	Gender; Emotional facial expression	Psychosis	54	Patients diagnosed with schizophrenia and non-clinical general population	VHs with emotional facial expression successfully triggered emotional and biological response.
Wieser et al. (2010)	Active interaction partner	Agent	Implicit Interaction	Gender; Gaze pattern; Interpersonal distance	Social anxiety	39	Females with social anxiety	Women paid more attention to the weight gained areas on VH than men.
Kwon, Powell and Chalmers (2013)	Active interaction partner	Agent	Explicit Interaction	-	Social anxiety	20	Students with social anxiety	VHs provoked both stronger anxiety and presence than those in non-immersive display.
Powers et al. (2013)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	-	Social anxiety	26	Female undergraduate	Encountering VHs could trigger strong anxiety and fear.

Han et al. (2014)	Active interaction partner	Agent	Explicit Interaction	Attitude (positive, negative dialog)	Psychosis	45	Patients with schizophrenia and non-clinical general population	Patients with schizophrenia had active avoidance of eye contact with VHs compared to the healthy controls.
Hartanto et al. (2014)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	Attitude (positive, negative dialog)	Social anxiety	24	General population	Positive dialogue feedback from VH resulted in less anxiety, lower heart rate, and longer answers.
Pan, Gillies and Slater (2015)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	Personality (confident, shy)	Social anxiety	24	Male participants	VH with a shy personality can be perceived as more friendly.
Fornells-Ambrojo et al. (2016)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	Responsiveness in social interaction	Psychosis	61	Male participants	Highly contingent VH were perceived more trustworthy for extremely paranoid individuals.
Ryan and Griffin (2016)	Active interaction partner	Agent	Implicit Interaction	-	Social anxiety	27	Students	VR exposure to a VH could successfully triggered social anxiety.
Falconer et al. (2016)	Active interaction partner	Agent and/or avatar	Explicit Interaction	-	Depression	15	Patients with depression	Changing the viewer perspective in a virtual social interaction could decrease self-criticism and increase

								self-compassion.
Robitaille et al. (2017)	Active interaction partner	Agent and/or avatar	Explicit Interaction	Responsiveness in social interaction	PTSD	12	Non-clinical military members and military members with mild traumatic brain injury	Participants with PTSD displayed a lack of navigational behaviour during a VH interaction.
Amaral et al. (2018)	Active interaction partner	Agent	Implicit Interaction	-	Autism	15	Patients with high-functioning ASD	VH affected social attentions among patients with autism.
Du Sert et al. (2018)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	-	Psychosis	15	Patients diagnosed with schizophrenia	VR therapy with VH could improve auditory verbal hallucinations and depressive symptoms.
Freeman et al. (2018)	Active interaction partner (virtual coach)	Agent	Explicit Interaction	-	Phobias	100	Individuals with fear of height	A virtual therapist could help automate the VR therapy.
Shin et al. (2018)	Active interaction partner	Agent	Explicit Interaction	Different levels of social pressure	Others	64	General population and patients with internet gaming disorder	VHs elicited cravings in gaming in gaming addiction exposure.
Kothgassner et al. (2019)	Active interaction partner	Agent and/or avatar	Explicit Interaction	Perceived agency (avatar VS agent)	Social anxiety	56	Students	Virtual social support from a VH human could be effective when the recipient thought it was from a human.

Quintana et al. (2019)	Active interaction partner	Agent	Explicit Interaction	-	Social anxiety	53	Female adults	Perception towards the VH could be affected by odorants manipulation.
Reichenberger et al. (2019)	Active interaction partner	Agent	Explicit Interaction	Gender; Interaction pattern (with or without aversive behaviour)	Social anxiety	60	General population	VH could be used to learn about social fear, and women reported higher fear compared to men.
Slater et al. (2019)	Active interaction partner (virtual coach)	Agent and/or avatar	Explicit Interaction	Dialogue contents (self-dialogue VS scripted dialogue)	Depression	58	General population	Self-dialogue VR coaching had better results than the scripted VR counselling.
Seo et al. (2019)	Active interaction partner	Agent	Explicit Interaction	Interaction pattern (combination of gaze and pointing)	Social anxiety	33	General population	VHs with non-verbal behaviour could be used to measure and promote joint attention.
Miloff et al. (2020)	Active interaction partner (virtual coach)	Agent	Explicit Interaction	-	Phobias	70	Patients with fear of spider	Alliance toward a virtual therapist is a significant predictor of treatment outcome in VR.
Nijman et al. (2020)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	Facial expression	Psychosis	22	Patients with psychotic disorder	VHs’ facial expressions can be utilised to train participants’ social cognition.

Kim et al. (2020)	Active interaction partner	Agent	Explicit Interaction	-	Others	36	Non-clinical male volunteers	VHs could be used for assessment and intervention to promote subjective well-being.
Lee et al. (2021)	Active interaction partner	Agent and/or avatar	Explicit Interaction	-	Psychosis	48	Patients diagnosed with schizophrenia and non-clinical general population	The social context created by VHs impacted the difference in peri-personal space recognition.
Kothgassner et al. (2021)	Active interaction partner	Agent and/or avatar	Explicit Interaction	Perceived agency (avatar VS agent)	Social anxiety	84	Females	Social interaction experience with VHs was comparable to real-life experience of cyberbullying.
Brander et al. (2021)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	Visual and behaviour traits of the virtual character through customization	Psychosis	10 9	Psychiatric hospital staff (psychotherapists, nursing staff, and administrators)	The function to customise VH for VR treatment was highly valued by clinical staff.
Guldager et al. (2022)	Active interaction partner	Agent	Explicit Interaction	-	Substance abuse	37 2	Students aged 15-18	VR party simulation could improve adolescents' drinking refusal skills.
Freeman et al. (2022)	Active interaction partner	Agent	Explicit Interaction	-	Psychosis	34 6	Patients with psychosis	Automated VR therapy with VH could reduce anxious

	(virtual coach)							avoidance and distress in everyday situations.
Fusaro et al. (2023)	Active interaction partner	Agent and/or avatar	Explicit Interaction	-	Autism	53	General population and individuals with autism spectrum disorder	Autistic adults exhibited greater inter-personal distance with VHs.
Bektas et al. (2023)	Active interaction partner	Agent	Explicit Interaction	-	Eating disorder	70	Patients with anorexia nervosa	The addition of a VH to the virtual kitchen scene could increase the association between food-specific state disgust and symptoms of eating disorders.
Giguère et al. (2023)	Active interaction partner	Semi-autonomous agent	Explicit Interaction	Voice and facial expressions	Substance abuse	19	Patients with cannabis use disorder and severe mental disorders	The VH intervention could reduce the cannabis use among people with cannabis use disorder and severe mental disorders.
Halim et al. (2023)	Active interaction partner	Agent and/or avatar	Explicit Interaction	-	Depression	36	Young adults	Changing the viewer perspective through a virtual body swapping experience can help enhance self-compassion and reduce depressive symptoms.

Wei et al. (2023)	Active interaction partner (virtual coach)	Agent	Explicit Interaction	Head nods and facial expressions	Phobias	120	General population with fear of heights	The detailed design of a virtual coach's emotional attributes could affect people's therapeutic alliance and their confidence of the VR therapy.
Artiran et al. (2024)	Active interaction partner	Agent	Explicit Interaction	Levels of attention (degrees of backchannels)	Autism	30	Patients with autism and non-clinical population	The behaviour of virtual interviewers influenced the gazes and head movements in individuals with autism.
Natali et al. (2024)	Active interaction partner	Agent	Explicit Interaction	-	Eating Disorder	145	Patients with anorexia nervosa	VHs could provide positive social support to patients with anorexia nervosa in a VR food exposure scene.
Hidding et al. (2024)	Active interaction partner	Agent	Explicit Interaction	-	Others	68	Undergraduate students with high levels of self-criticism	Expressing compassion to a VH with similar self-criticism could reduce self-criticism and increase self-compassion.
Freeman et al. (2024)	Active interaction partner	Agent	Explicit Interaction	-	Psychosis	11	Patients with non-affective psychosis and low positive self-	Automated VR therapy with a virtual coach could improve

	(virtual coach)						beliefs, aged 16–26 years old	self-beliefs and well-being in young psychosis patients.
Yamashita and Yamamoto (2024)	Active interaction partner (virtual coach)	Agent and/or avatar	Explicit Interaction	Identity of the VH (Freud or an intimate person of the participant)	Social anxiety	60	Students with had personal problems	VR self-counselling with the intimate other avatar was most effective in improving people’s anxiety.
Banakou et al. (2024)	Active interaction partner	Agent	Explicit Interaction	-	Social anxiety	45	General population with public speaking anxiety	Single-session VR exposure therapy with gradually increasing stimuli intensity may be as effective as multi-session exposure for public speaking anxiety.

Table 2. Studies primarily used VHs as virtual crowds.

Citation	Role	Agency	Virtual Agent Interaction Type	Parameters for manipulation	Condition	N	Participant characteristics	Comment on findings
Slater et al. (1999)	Virtual crowds	Semi-autonomous agent	Implicit Interaction	Attentional focus level	Social anxiety	10	General population	Virtual audience could be used to treat public speaking fears; Higher perceived audience interest reduced public speaking anxiety.
Tarnanas, Tsoukalas and Stogiannidou (2003)	Virtual crowds	Agent	Passive Interaction	-	Social anxiety	120	General population and patients with work-related stress disorders	Virtual crowds triggered psychological and biological reactions in social anxiety.
Freeman et al. (2003)	Virtual crowds	Agent	Passive Interaction	-	Psychosis	24	General population	People tend to attribute their mental states to VHs.
Freeman et al. (2005)	Virtual crowds	Agent	Passive Interaction	-	Psychosis	30	People cover the whole range of the Paranoia.	Neutral characters could elicit people's persecutory thoughts and be used to understand psychosis.
Freeman et al. (2008)	Virtual crowds	Agent	Passive Interaction	-	Psychosis	200	General population	Neutral characters could elicit paranoid ideation among

								general population.
Cho et al. (2008)	Virtual crowd s	Agent	Implicit Interaction	-	Substance abuse	10	Population with a low level of alcohol dependence	The presence of a VH in cue exposure induced stronger cravings.
Rizzo et al. (2010)	Virtual crowd s	Agent	Implicit Interaction	-	PTSD	20	Active duty service members	The VR environment with VHs could simulate war scene for clinical treatment on PTSD and depression.
Brinkman et al. (2011)	Virtual crowd s	Agent	Passive Interaction	Density; Ethnic appearance (white-European or North-African)	Social anxiety	26	General population and patients diagnosed with schizophrenia	VR exposure to the increased density and proportion of VHs with other ethnicity induced strong physiological arousal and distress.
Shiban et al. (2015)	Virtual crowd s	Agent	Passive Interaction	-	Social anxiety	40	General population	VHs can be used to understand social fears in VR.
Mountford, Tchanturia and Valmaggia (2016)	Virtual crowd s	Agent	Passive Interaction	-	Eating disorder	18	General population	The exposure to VHs did not necessarily change people's in-state body image.

Atherton et al. (2016)	Virtual crowds	Agent	Passive Interaction	-	Psychosis	26	Males reporting paranoid ideation within the past month	People' own self-confidence could affect their paranoid thoughts towards the VHs.
Gürerk et al. (2019)	Virtual crowds	Agent	Passive Interaction	Different working behaviours	Social anxiety	108	General population	VHs with better working performance could motivate people to perform better.
Takac et al. (2019)	Virtual crowds	Agent	Implicit Interaction	Crowd size; Attentional focus level	Social anxiety	19	General population	Virtual audiences could elicit public speaking distress, which also lasted beyond VR session.
Wei et al. (2024)	Virtual crowds	Agent	Implicit Interaction	Facial expressions	Psychosis	122	General population with elevated paranoia	The detailed design of VH faces affected people's paranoid interpretations.
Gayer-Anderson et al. (2024)	Virtual crowds	Agent	Implicit Interaction	-	Psychosis	481	Adolescents	VR school scene with VHs could help understand the precursors of adolescents' paranoid ideation.
Rovira et al. (2024)	Virtual crowds	Agent	Explicit Interaction	-	Substance abuse	100	People who smoke daily	VR exposure to smoking-cue VHs elicited stronger cigarette cravings than a neutral

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								environment without VHs.

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Table 3. Studies primarily used VHs as virtual body.

Citation	Role	Agency	Virtual Agent Interaction Type	Parameters for manipulation	Condition	N	Participant characteristics	Comment on findings
Riva and Melis (1997)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	119	General population	Virtual figures could be used to understand people's body images.
Perpiñá et al. (1999)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	13	Patients with eating disorders	VR body image treatment could have stronger impact than standard treatment.
Aymerich-Franch, Kizilcec and Bailenson (2014)	Virtual body	Avatar	Passive Interaction	Different levels of visual similarity to the participant	Social anxiety	187	General population	Having an avatar with an in-similar face could reduce anxiety.
Ferrer-Garcia et al. (2017)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	23	College students	Owning a fatter virtual body triggered higher levels of body anxiety and fear of weight gain.
Ferrer-Garcia et al. (2018)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	40	Female students	Owning a virtual body with different body sizes produced changes in body dissatisfaction.
Porras-Garcia et al. (2018)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	35	College students	Owning the larger-size virtual body increased people's body checking

								behaviours.
Porras-Garcia et al. (2019a)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	85	College students	Woman paid more attention to the weight gained areas on the virtual figure than man.
Porras-Garcia et al. (2019b)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	50	Undergraduates	Participants embodied through synchronous visuo-tactile technique had higher anxiety associated body dissatisfaction.
Mertens, Wagensveld and Engelhard (2019)	Virtual body	Agent	Passive Interaction	-	Phobias	48	General population and spider fearful individuals	Embodying participant into a virtual body from 1PP could improve the validity of fear conditioning.
Provenzano et al. (2019)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	20	Patients with eating disorders	Different perspectives (1PP vs 3PP) of viewing the virtual body could change people's body image perception.
Scarpina et al. (2019)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	30	General population and participants with obesity	Body ownership illusion could be created for both people with obesity and general population.
Spanlang et al.	Virtual	Agent	Passive	Interaction pattern	Psychosis	27	General	The body ownership

(2018)	body		Interaction				population	illusion could trigger people's biological reactions.
Fisher et al. (2020)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	31	Female adolescents	Body size evaluation result from VR was comparable to the paper-based measurement.
Porras-Garcia et al. (2020)	Virtual body	Agent	Passive Interaction	Body size	Eating disorder	41	Female college students	People could have attentional bias towards the embodied virtual figure because of their own body dissatisfaction.
Gorisse et al. (2021)	Virtual body	Agent and/or avatar	Explicit Interaction	Interaction pattern (engagement level with the virtual crowds)	Psychosis	30	General population	Observing a body-double successfully engage in a VR social interaction could reduce paranoia.
Wolf et al. (2021)	Virtual body	Agent and/or avatar	Passive Interaction	-	Eating disorder	56	Females of normal weight	Embodiment through a VH could affect people’s self-evaluation of their body weights.
Van Gelder et al. (2022)	Virtual body	Agent and/or avatar	Explicit Interaction	Age (current self and future self)	Others	24	Convicted male offenders	Offenders’ interaction with a VH representing their future self could reduce their self-defeating behaviours.
Yamamoto and	Virtual	Agent	Passive	Colour	Depersonalizatio	31	Male with	People with

Nakao (2022)	body		Interaction		n		various depersonalizatio n tendencies	depersonalization had weaker body ownership of the self-representative figure.
Burin et al. (2022)	Virtual body	Agent and/or avatar	Passive Interaction	Embodiment perspectives (first person perspective or third person perspective)	Others	52	General population	Experiencing a moving virtual body from the 1PP could enhance stress coping ability.
Vahle and Tomasik (2022)	Virtual body	Avatar	-	Age (age-congruent and age-incongruent with the participants)	Others	74	General population aged between 18 and 30	The embodiment of an older avatar increased young adults' social motivation.
Mendoza-Medialdea et al. (2023)	Virtual body	Avatar	-	Body size	Eating disorder	57	College women	Manipulating the VH body size could produce changes in body dissatisfaction.
Ascione et al. (2023)	Virtual body	Avatar	-	-	Eating disorder	23	Adolescent patients with anorexia nervosa	The VR body attentional bias modification task could reduce body-related attentional bias among people with anorexia nervosa.
Schroeder et al. (2023)	Virtual body	Avatar	-	Body size	Eating disorder	43	Women with high or low body dissatisfaction	People with low body dissatisfaction show stronger disembodiment during self-avatar

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								mirror exposure.

Mental health conditions

VHs were used in the following research areas in mental health: social anxiety (n = 20), eating disorders (n = 18), psychosis (n = 17), substance abuse (n = 5), phobias (n = 4), depression (n = 3), autism (n = 3), post-traumatic stress disorder (PTSD) (n = 2), dissociative disorders (n = 1) and others without specific mental health conditions (n = 6).

Roles of VHs

We categorised the studies based on our previous taxonomy, which provides a clear and functional framework for classifying VHs in mental health. Studies with overlapping roles were assigned to their primary role or the one with the highest interactivity. The roles of VHs in the included studies could be categorised into active social interaction partners (n = 40), virtual crowds (n = 16), and virtual bodies (n = 23).

Active social interaction partners

In 40 studies, VHs primarily served as active social interaction partners. These studies tested these VHs in three different ways: (1) manipulating specific VH characteristics to assess their influence, (2) comparing the responses of clinical and non-clinical individuals, and (3) validating whether VHs in VR could trigger participants' responses or replicate the effects of real-world experiences.

Manipulating VH Characteristics: Twelve studies explicitly examined VH characteristics in social interaction. Wieser et al. [42] investigated the anxiety-inducing effects of VH gender and gaze behaviours, finding that male agents with direct gaze elicited stronger anxiety and heart rate elevation among socially anxious women compared to female agents. A similar gender-related effect was observed in a VR fear conditioning program by Reichenberger et al. [43], where female patients reported higher anxiety levels in response to aversive behaviours (e.g. unpleasant air blasts) from male VAs than from female VAs. Park et al. [44] and Nijman et al. [45] focused on non-verbal behaviours, implementing different facial expressions on VHs to help individuals with psychotic disorders practise emotion recognition.

Researchers also manipulated the dialogue responses (positive or negative) [46] and responsive frequency (high or low) [4] in conversation agents. Both the attitude and reply frequency of the VHs in a conversation were shown to affect participants' behavioural (e.g. interpersonal distance) and physiological (e.g. heart rate) responses. In another study by Slater et al. [13], participants engaged in a self-conversation by switching between two virtual bodies: first embodying a VH resembling themselves to describe their problem to a virtual Sigmund Freud, and then embodying Freud to offer advice to their virtual self. This method resulted in a better perception of help compared to scripted dialogue. Similar design was then adopted by Yamashita and Yamamoto [47], who found out that VR self-counselling with an intimate-other avatar was most effective in reducing anxiety. Furthermore, Pan, Gillies and Slater [48] explored the impact of VH personality traits (confident vs. shy) on participants' perceptions, showing that the shy VH was perceived as more positive and friendly. The effects of VH emotional attributes were further demonstrated in a study by Wei et al. [49], where a virtual coach with positive facial expressions and affirmative head nods enhanced participants' therapeutic alliance and treatment confidence during a VR fear-of-heights consultation. Lastly, the perceived agency of VHs was studied by Kothgassner et al. [36,50], who compared participants' reactions when they believed they were interacting with a human versus a computer. Both experiments indicated that interactions with VHs can be as effective as real-life counterparts, provided participants believe the VH is controlled by a human in real time.

Comparing Clinical and Non-Clinical Populations: In another use case, five studies used active interaction partners to assess the responses differences between the clinical and non-clinical populations. In a conversation involving three people (two VHs and the participant), Han et al. [51] observed that patients with schizophrenia avoided eye contact more frequently during interactions with the VHs. Lee et al. [52] used a ball game to study self-disturbances (e.g., a distorted perception of one's own body boundary) from schizophrenia. When a virtual man threw a ball to the participants, patients with schizophrenia exhibited longer reaction times in picking up the ball and had a weaker sense of body boundary compared to the non-clinical group. Robitaille et al. [53] designed a scenario to detect executive functioning difficulties in military personnel with traumatic brain injury. In a military patrol scene, a virtual male dressed as a civilian was used to simulate a divided attention task by approaching the participant. Both groups tolerated the experience, but those with post-traumatic brain injury displayed navigation difficulties after a divided attention task was added. Lastly, Fusaro et al. [7] and Artiran et al. [54] studied the differences in responses to VHs between participants with autism and non-clinical controls. People with autism maintained a greater interpersonal distance from the VHs and displayed fewer responses to VHs' social cues (e.g. head turning and direct eye gaze) in virtual interview scenarios.

Validation Studies with VHs: Twenty-two studies used active interaction partners to understand whether VHs in VR could trigger participants' responses or replicate the effects of real-world experience. Ten studies involved participants with mental health conditions or specific phobias. Three of them were related to psychosis. Du Sert et al. [55] tested a therapy for auditory verbal hallucinations (AVH) in psychosis. Patients interacted with a VH representing the harmful voice they heard, and this exposure reduced their AVH-related depressive symptoms. Freeman et al. [9] developed gameChange, an automated VR therapy designed to address agoraphobia in psychosis. Patients were guided by a virtual coach through everyday scenarios like visiting a GP or shopping, resulting in significant anxiety reduction, particularly in those with severe symptoms. More recently, Freeman et al. [10] described an ongoing study Phoenix, in which a virtual coach named Farah helps young psychosis patients build self-confidence by guiding them through a series of tasks, offering instructions and encouragement. Two other studies focused on eating disorders. Bektas et al. [56] used a virtual kitchen scene with anorexia nervosa patients, finding that a VH encouraging patients to challenge their disorder elicited stronger disgust reactions towards food. Natali et al. [57] used the same scenario to induce positive mood, showing that supportive VHs can reduce anxiety and improve mood in anorexia patients. Regarding phobias, Freeman et al. [58] conducted a clinical trial for individuals with a fear of heights. A VR coach called Nic guided the participant through the different stages of the experience, leading to a significant reduction in their fear. Similarly, Miloff et al. [59] used a holographic-style virtual coach to guide patients

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confront their fear of spiders, with positive relationships toward the coach predicting better outcomes. Falconer et al. [11] explored self-compassion in depression. Participants first delivered compassionate lines to a virtual child and then embodied the child, watching their compassionate actions from a third-person perspective, which fostered self-compassion. Amaral et al. [6] conducted a clinical trial using VHs for social and cognition training for autistic individuals. A further study [60] applied VR to treat addiction to cannabis. Participants interacted with a VH representing a key figure in their cannabis consumption, such as a friend, a drug dealer or those triggering their cravings, showing potential to reduce usage.

For the remaining thirteen validation studies with participants from the non-clinical populations, six focused on social anxiety. Kwon, Powell and Chalmers [61] compared the effects of displaying VHs on a desktop monitor versus an immersive VR system, finding that immersive VR elicited stronger anxiety. This was further supported by a VR self-compassion induction [62] and a joint attention study [63], both of which concluded that VR had a greater capacity to induce anxiety compared to non-immersive setups, with better training outcomes in reducing anxiety levels. Powers et al. [64] examined participants' fear levels during VR and real-life interactions, noting that VR interactions triggered fear and anxiety similar to real-life situations. It was also suggested by Banakou et al. [65] that single-session VR exposure therapy with gradually increasing stimuli intensity may be as effective as multi-session exposure for public speaking anxiety. Quintana et al. [66] investigated the effects of smells on perceptions of VHs. They discovered that exposure to fear-related odorants increased anxiety and reduced the trust towards the virtual character.

Halim et al. [12] tested a VR system designed to improve depression by allowing users to practice giving and receiving compassion with a VH. It demonstrated early benefits in enhancing self-compassion and reducing depressive symptoms. Brander et al. [67] examined the usability of a therapeutic VR tool for treating auditory hallucinations (AH), presenting it to psychiatric hospital staff. The tool allows operators to customise the appearance and behaviour of VHs, to whom patients attribute their AH. Additionally, Guldager et al. [68] introduced VR FestLab, a party simulation game where adolescents practice refusing alcohol in peer-pressure scenarios with VHs. A similar approach was also employed by Shin et al. [69] to address gaming addiction and by Lee et al. [70] to help with nicotine addiction, where participants practiced regulating their cravings to refuse invitations to play or smoke from other characters. Lastly, VR was used to promote subjective well-being and self-confidence among young people by introducing positive perspectives that helped them acknowledge their strengths [71] and reducing self-criticism [72] through structured conversation with virtual characters.

Virtual crowds

Sixteen studies used virtual crowds. Six of them were related to anxiety. In one of the earliest studies, Slater et al. [56] used a virtual audience and participants gave a speech in front of them. The study compared two scenarios: one where the audience listened attentively and another where they exhibited disruptive behaviour. The results provided early evidence that virtual crowds can trigger anxiety levels comparable to real-life situations, with participants performing better when the audience was more attentive.

Similar findings were reported by Takac et al. [73], who suggested that the distress created in virtual public speaking scenario could have lingering effects after the VR session. Virtual crowds were also used to populate a virtual office, finding that watching other VHs working was effective in triggering work-related stress [40], or creating peer effects to make people work more efficiently [14]. Brinkman et al. [39] explored the effect of the size and ethnicity of virtual crowds in a bar scene, showing that the VR exposure to the increased density and proportion of VHs with other ethnicity could induce stronger distress. Additionally, Shiban et al. [74] incorporated air blasts and the sound of a female character screaming when participants approached a virtual crowd to study how individuals develop social fears and how these fears can be diminished or overcome through repeated exposure.

Six studies used a virtual crowd for research in psychosis. Early tests examined people's appraisals of neutral characters in a library scene, demonstrating that virtual crowds effectively elicited persecutory thoughts for insights into psychosis [75,76]. Later research employed daily VR scenarios populated with VHs, such as underground train or school canteen, to understand factors associated with paranoid thinking. Findings suggested that paranoia could be predicted by anxiety, worry, perceptual anomalies and cognitive inflexibility [15] and was influenced by individuals' self-confidence [77]. For adolescents, interpersonal threat or hostility heightened state paranoia [78]. Further, Wei et al. [79,80] explored detailed design of VH faces and suggested it could impact the occurrence of paranoid thoughts and people's visual attention in VR.

Mountford, Tchanturia and Valmaggia [81] used a virtual crowd in a virtual bus ride to study eating disorders. Participants were tested for their body image satisfaction, and the results showed that exposure to the virtual scenario with VHs did not necessarily change people's current feelings or perceptions about their body image. Cho et al. [82] designed a VR bar to study alcohol craving and found that the introduction of drinking characters led to a stronger drinking desire compared to simply displaying the alcohol in the scene. Similarly, Rovira et al. [83] found that VR exposure to smoking-cue VHs elicited stronger cigarette cravings than neutral environments without VHs. Rizzo and colleagues [30] used virtual soldiers and Middle Eastern civilians to simulate Iraqi military experiences for military training. Service members who suffered from trauma were exposed to the VR environment, resulting in a reduction of the severity of PTSD scores for 80% of the participants who completed the study.

Virtual bodies

VHs were used as body representation in twenty studies, fifteen of which were related to eating disorders. Riva and Melis [1] conducted first study found in the literature of body image representation using VR. Participants were asked to choose the virtual figures that best represented their current and the ideal body size. Perpiñá et al. [84] introduced a feature allowing patients with eating disorders to adjust the size of a virtual body to reflect their body image. Both studies demonstrated the feasibility of using virtual figures to understand body image disturbances. It was also suggested that virtual bodies could provide comparable evaluation results to traditional paper-based measurements, with higher levels of engagement [18]. While these early studies did not aim to elicit the illusion of body ownership, many subsequent eating disorder studies sought to make participants perceive the virtual figures as their own.

Studies employing the body ownership illusion paradigm found that embodying a larger virtual figure led participants to check their virtual body more frequently [85,86] and experienced higher degree of self-dissatisfaction and anxiety [31,87–90]. In contrast, Schroeder et al. [91] found that body dissatisfaction was not necessarily affected by the weight of the avatar, although people with higher body dissatisfaction exhibited more body-checking behaviours on weight-related areas.

Ferrer-Garcia et al. [92] created a paradigm to reduce anxiety related to the body image in female students by making them return to the normal-size virtual figure after experiencing a larger body. A similar method was used to alleviate body image distortion in both healthy-weight participants and those with obesity [93]. Wolf and colleagues [94] compared bodyweight perceptions of two groups of females: one that embodied a VH and another that observed the VH as another person's avatar. The self-embodiment group underestimated the bodyweight of the VH compared to those who rated the VH as another's avatar. Furthermore, Ascione et al. [95] conducted a body-related attention bias modification task to reduce excessive visual focus on weight-related areas of a self-represented VR body, which significantly decreased body dissatisfaction.

Three other studies used virtual bodies for psychosis research. Spanlang et al. [96] examined whether self-fragmentation in VR, where participants embodied a VH while retaining physical presence in the real world, impacted the biological responses in patients with schizophrenia. Yamamoto and Nakao [97] explored the relationship between the participants and virtual characters, finding that perceiving a fake body as one's own reduced the sense of body ownership in individuals with depersonalization. Gorisse et al. [98] used a virtual body-double resembling each participant, created by scanning them and generating a digital figure for a social VR task. They concluded that observing a body-double engaging in VR social interactions could reduce persecutory thoughts during the task.

Additionally, Van Gelder et al. [99] demonstrated that alternating convicted offenders between their current and aged future selves reduced self-defeating behaviours. Similarly, Vahle and Tomasik [100] found that embodying an older body social motivation among young adults. Besides, Burin et al. [101] presented participants with a moving character from a first-person and third-person perspective. They concluded that body illusion from the first-person perspective created stronger physiological activation to help people practise stress coping. Aymerich-Franch et al. [102] assessed the impact of the facial similarity of a VH on participants, finding that embodying a figure with a dissimilar face reduced anxiety during VR presentations.

VA and avatar

Out of 79 studies, 74 involved the use of VAs. Nine of them adopted a semi-autonomous agent design, where facilitators manually triggered an audio effect [3,55], adjusted VH voices [60] or played pre-recorded animations [4,64] to customise characters' behaviours in real time.

Regarding interaction types of VAs, approximately half (39/74) engaged in explicit interactions with participants, primarily serving as active interaction partners. In ten studies, VAs exhibited implicit interactions (e.g. occasionally looking at participants and then looking away). Passive interactions were observed in 26 studies where VHs were

used as virtual crowds and virtual bodies.
In the reviewed studies, the term ‘avatar’ was often used to describe any type of VH, even when they did not represent the participant’s self. Only five studies used VHs as participant’s avatars. For example, Aymerich-Franch et al. [102] used an avatar with varying levels of visual similarity to the participant’s face to study self-embodiment experience. Additionally, twelve studies combined the use of agents and avatars to create perspective changes through body-swapping experiences in social interactions [11,13,99] or to explore the effects of vicarious agency (the perception of control over the VH) [98]. Kothgassner et al. [36,50] further examined the effect of perceived agency by comparing participants’ VR experiences with VAs and avatars. The results indicated that avatars could elicit stronger emotional responses compared to VAs.

Human characteristics

Of the 79 studies reviewed, 44 examined the effects of manipulating specific characteristics of VHs. These manipulations aimed to assess how physical and behavioural attributes of VHs influence participant’s perception and behavioural responses. The manipulated features included their visual appearance [39,44,93] (e.g. gender, ethnicity, body size), interaction behaviour [7,54,73] (e.g. interpersonal distance, eye gaze behaviour patterns and responsiveness towards participants), perceived agency [36,50] (VA or avatar), and emotions [44,60] (e.g. emotional facial expressions) or personality [48]. While most of the traits were non-verbal behaviours, four studies explored the effects of verbal behaviour, including dialogue content [13], conversation attitude (e.g. positive VS neutral dialogue) [46,51] and the voice of the VHs [60]. The most frequently studied traits was body size (n = 13), while traits such as sense of affirmation [49] and personality [48] received limited investigation.

In addition to individual traits, two studies examined the effects of crowd size and density as independent variables in virtual crowd settings [39,73]. These studies explored how variations in the number and arrangement of virtual characters influence participants' sense of presence and anxiety in crowded environment.

Discussion

This paper reviewed VR studies that included VHs in the scenarios to understand and treat mental health difficulties. We examined 79 studies and categorised them based on the primary role of the VHs - active social interaction partners, virtual crowds, and virtual bodies. We focused on the use of agency, interaction types and characteristics of the VH. VHs have served diverse purposes and demonstrated the ability to create psychological, behavioural, and physiological influences. However, few studies provide comprehensive descriptions of VHs' visual appearance or behavioural capabilities. Without such details, it becomes challenging to assess their actual impact and reduces replicability. The potential of each VH role requires further exploration to address these gaps and associated challenges.

Active social interaction partners

Active social interaction partners interact explicitly with participants. A persistent challenge in this context has been enhancing the realism and responsiveness of these interactions, particularly during close-up engagements [19,103,104]. Improving both visual fidelity and behavioural plausibility is essential for achieving lifelike interactions [105–107]. Consistent design of both visual and behavioural elements is needed to avoid the Uncanny Valley, where characters appear almost human but evoke discomfort due to subtle imperfections, as also seen in VR interaction [108,109]. Additionally, it is important to consider VH behavioural plausibility and consistency across multiple behavioural channels, including both verbal and non-verbal communication (e.g. body movement, facial expressions, voice, and dialogue content) [110]. For example, Choudhary et al. [111] demonstrated that mismatches between facial expressions and vocal tone (e.g. a happy face with unhappy voice) negatively impacted participants' immersion and engagement, highlighting the importance of aligning these communication modes.

Regarding responsiveness and interactivity, current feedback in mental health VR often relies on pre-recorded actions triggered by participant inputs, such as UI selections, position, or response time [40,53,66]. Future applications could integrate machine learning algorithms, such as reinforcement learning, to create autonomous VHs that learn from experience [112,113]. These VHs could adjust parameters such as the interpersonal distance to maximise attention and keep participants engaged. Algorithms could detect interaction dynamics (e.g., participant attitudes, responsiveness) and adjust VH behaviours in real-time to achieve specific therapeutic goals, particularly in applications encouraging positive behaviours. Another area to explore is the real-time monitoring of physiological responses to create adaptive interactions based on participants' affective state. A few studies reviewed used biometric data (e.g. salivary alpha-amylase, heart rate, galvanic skin) to evaluate physiological responses [44,96,101], but none have leveraged this data to enhance interaction fidelity. Real-time estimates of emotional arousal and valence could enable VHs to respond meaningfully to participants' emotional changes [114].

A virtual coach represents a specific type of active social interaction partner, designed to guide and motivate users towards positive behavioural changes while facilitating the automation of therapy delivery. Focus group feedback indicated that users valued the convenience, accessibility, and anonymity provided by a virtual coach, but they also expressed concerns about the coach feeling unrelatable and difficult to engage with [115]. The development of a VR coach should incorporate knowledge and feedback from domain experts and targeted user groups to ensure it is tailored to the specific age range and mental health conditions it aims to address [116,117]. Generally, increasing the engagement and friendliness of communication from virtual coaches is likely to improve their effectiveness and the outcomes of VR therapy [59].

Virtual crowds

In virtual crowds studies, it is standard practice to use identical designs and behaviours for characters that share common objectives to achieve a balance between realism and computational efficiency [118,119]. However, visual and behavioural repetition patterns in a group of VHs are very noticeable and decrease fidelity. Introducing variations in appearance and movements is important to diversify crowds and avoid these patterns [120,121]. Visual diversity can be achieved for example by randomising height, body shape, hair colour, and clothing. Behavioural diversity can be enhanced by blending animations, using motion capture data from multiple individuals, and implementing procedural animations with certain degree of randomisation to generate varied movements in real-time based on environmental and interaction dynamics.

There are additional considerations When virtual crowds have autonomy to move around a space, each one should navigate naturally, avoiding collisions with static and dynamic obstacles. For example, Trivedi and Mousas [122] implemented a crowd behaviour system for a VR street scene, where each VA had navigation scripts with steering and pathfinding capabilities to avoid collisions. Each agent also had customisable target locations, walking speeds, and animations (e.g. head direction and gaze patterns). Other advanced virtual crowd control systems generate real-time behaviours driven by user input and the dynamics of other virtual entities within the crowd [123]. These designs could be applied in mental health applications to improve crowd interactions and better understand responses to busy environments.

Virtual bodies

Studies involving virtual bodies predominantly helped individuals reassess their body image biases or gain new perspective, provided by the body ownership illusion. These use cases require improved methods to enable the sense of embodiment. Existing methods like visual-motor synchrony [124] and visual-tactile synchrony [88,93] are designed to align visual feedback with participants' movements or tactile sensations to enhance the illusion of ownership over the virtual body. While effective in initiating this illusion, sustaining or manipulating it throughout the VR experience remains challenging. Mismatched sensory feedback or slight discrepancies in motion can disrupt the sense of embodiment [125,126]. Integrating other sensory modalities such as auditory (e.g. footsteps, voice modulation) or olfactory feedback (e.g. simulating scent experience based on the participant's location) could enhance the body ownership illusion. Combined multisensory feedback has been shown to strengthen and prolong the influence on embodiment, affect, and behaviours [127,128].

Customising virtual bodies to closely resemble participants can enhance the sense of embodiment. Aymerich-Franch et al. [102] found that embodying a virtual body with a similar face increased self-association and anxiety during public speaking tasks compared to dissimilar faces. This provides evidence towards the importance of avatar personalisation and its potentials to modulate emotional responses. Customisation should consider not only physical appearance but also factors like ethnic background [129] and voice [130]. These factors can significantly contribute towards the body ownership illusion.

Limitations

There are several limitations to this systematic review. First, our search strategy may not capture all VR mental health studies involving VHs. We examined four databases using title and abstract searches with specific keyword combinations, which likely excluded studies that did not simultaneously address VR, VHs, and mental health conditions. Through citation chaining, we identified six additional studies that were not included in the initial query results, suggesting that some relevant studies may have been missed. Second, there may be limitations in our categorisation of VH roles and characteristics. Existing taxonomies used to classify virtual characters and their behaviours [107,131] are at least a decade old and do not specifically focus on VR studies in mental health. We developed our own classification based on the usage of VHs in the reviewed studies. This framework is tailored to mental health research, and it may require adaptation for application in other research areas. Third, regarding result analysis, we opted for a narrative review approach instead of a quantitative evaluation to measure the quality and effectiveness of VHs across studies. This choice was made due to the variability in study objectives (ranging from validation and assessment to clinical treatments) and the diversity in participant characterises. Additionally, there is limited availability of detailed descriptions and information about the VHs. This further constrained our ability to conduct a comparative analysis or rigorous quality assessments for meta-analysis.

Conclusions

VHs play a central role in several fields of VR mental health research, yet many studies lack comprehensive descriptions of their design. Classified as active interaction partners, virtual crowds, or virtual bodies, VHs are predominantly computer-controlled virtual agents rather than user-controlled avatars, with perceived agency significantly influencing participants' emotions and behaviours. While the impact of VH characteristics varies, most studies have focused primarily on body size and gender, leaving an insufficient understanding of their emotional expressions and personality. To advance the field, future studies should systematically examine the VH characteristics and develop standardized reporting frameworks that include technical and visual documentation (e.g. images, videos) to enhance replicability, clinical relevance, and evidence-based VH design for effective mental health interventions.

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Conflicts of Interest

Daniel Freeman is the scientific founder of Oxford VR, a University of Oxford spin-out company, which commercialises automated VR therapies. The other authors do not have any competing interests.

Abbreviations

AH: auditory hallucinations
ASD: autism spectrum disorder
AVH: auditory verbal hallucinations
OCD: obsessive-compulsive disorder
PTSD: post-traumatic stress disorder
1PP: first-person perspective
3PP: third-person perspective
VA: virtual agent
VH: virtual human
VR: virtual reality

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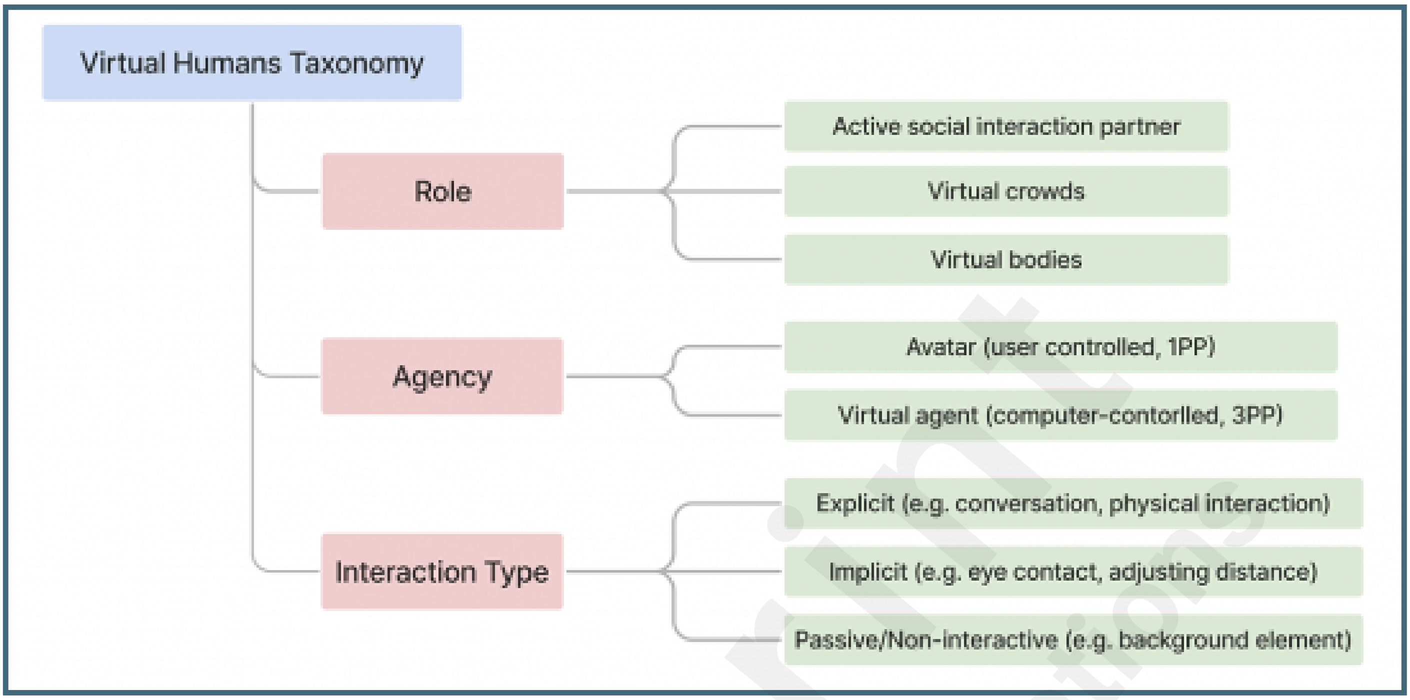
Virtual human taxonomy based on existing mental health VR studies.



PRISMA flow diagram.