Metaverse and Behavioral Change Toward a Pro-Environmental Behavior: the Role of Avatar

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***Abstract*— Pro-environmental behavior has become an important focus area as global challenges such as climate change and resource depletion require urgent and sustainable solutions. The increasing integration of technology in promoting pro-environmental behavior opens opportunities to utilize virtual avatars as an effective tool to influence user engagement and behavior change through interactions in the metaverse world. This study introduces a proposed avatar taxonomy based on two dimensions: form realism and autonomy realism, which are hypothesized to influence user experience and pro-environmental outcomes. In addition, the study also provides a deeper understanding of external factors such as social responses and cognitive responses that can influence human behavior that can be used as mediating and moderating variables. In addition, this study also provides insights and understanding from the synthesis of existing research to develop a conceptual framework that provides opportunities for future research.**

Keywords—pro-environment behavior, metaverse, avatar, taxonomy, framework

I. INTRODUCTION

Various environmental problems that have occurred recently have become challenges in the last few decades. Problems such as global warming, air pollution, clean water, waste, and marine biota ecosystems have become hot discussion topics on social media [1]–[3]. Several studies have shown that these environmental problems are closely related to negative habits such as wasteful energy use, littering, polluting rivers, and other activities [4]–[6]. Modifying human conduct to be more environmentally conscious is essential for maintaining ecological balance and minimizing long-term environmental damage. Environmentally responsible behavior encompasses actions individuals take to lessen their negative environmental impact and promote ecosystem health. [4]. Some actions supporting environmental stability include saving electricity consumption at home, using water wisely, and managing waste [7].

Modifying and shaping human behavior requires effort and strategic interventions. Numerous studies have explored pro-environmental behavior campaigns in both print and digital media, aiming to educate people about the significance of preserving environmental balance, but these initiatives have not achieved optimal results [8], [9]. At the same time, we also see the development of technology, especially the metaverse, which is used to convey messages to users regarding pro-environmental behavior [1], [10]–[12].

Metaverse is defined as an immersive and realistic three-dimensional virtual space supported by advanced extended reality (XR) technology, a combination of virtual reality (VR), augmented reality (AR), and mixed reality (MR) [13]. Metaverse offers a place for people to work, play, learn, and socialize with others using avatars [11], [14]–[16]. There are some technological features and content that can support the development of Virtual Environments, including multisensory stimuli, content and technological stimuli, avatars, and artificial intelligence [17], [18]. Some research has unlocked the potential use of those stimuli and features to deliver persuasive messages and campaigns.

The metaverse's growth creates new ways to share persuasive messages and run campaigns that influence people's behavior, attitudes, and decisions. However, studies show some factors can affect how well these messages work, like how credible the speaker is [19]. A speaker's credibility is key because it involves their skills and trustworthiness. Credibility has three parts: authority, authenticity, and understanding of behavior [20]–[22]. Authority refers to the expertise, knowledge, or legitimate power of the messenger [20]. Authenticity means the speaker seems honest, sincere, and well-meaning, helping them connect emotionally with the audience [21]. Understanding behavior means knowing the audience's habits, biases, and goals so that the message fits them better [23]. In the metaverse, avatars can replace real speakers to deliver these messages.

Avatars are digital versions of users that let them do activities in the metaverse [15], [24]. Avatars can look like people, robots, superheroes, cartoon characters, or animals [25], [26]. They help connect the real and digital worlds, making it easier for people to interact without being limited by physical space, thanks to multisensory features [27]. The characteristic of interactivity has been seen as one of the important benefits of the metaverse [28]. Advanced technology in the metaverse boosts interactions by creating natural-like sensations, making the digital world feel real. Research shows the metaverse isn't just for fun—it can also be used as a social tool to influence users' habits and behaviors. [1], [10], [11], [29].

Understanding how to change people's behavior requires looking at important psychological factors [2]. Recently,

researchers have been exploring Artificial Intelligence (AI) and Explainable AI (XAI), creating new opportunities for avatars to act more autonomously [18]. Autonomous avatars use AI, machine learning, and programmed behaviors to perform specific tasks [14], [30]. These avatars can make interactions in the metaverse more engaging and realistic, improving the overall user experience.

The environment and avatars that are developed must consider several aspects so that users can easily understand the message and encourage behavioral changes. Although the appearance of avatars, known as form realism [31] and autonomous realism (whether avatars are controlled by humans or AI) are two important factors, how do we understand this issue and obtain an optimum result for this kind of behavior? This study aims to explore this issue by offering a conceptual framework in the context of supporting pro-environmental behavior using metaverse and avatar interactions. This study proposes a conceptual framework on how form realism and autonomy realism might influence behavior change. In addition, what are the intended outcomes for this kind of intervention?

This study aims to fill the gap by developing a framework to promote pro-environmental behavior using the metaverse and avatars. It will combine factors influencing environmental habits, avatar traits, and form-autonomy realism to create a clear framework showing how avatars can encourage eco-friendly actions in the metaverse. Additionally, the study will explore the outcomes and key variables that may impact pro-environmental behavior.

II. Literature Review

A. Pro-environmental Behavior and Its Factor

The linear progression of environmental knowledge can influence individual environmental awareness and concern [8]. This concern can lead to pro-environmental behavior, which includes actions aimed at reducing the negative impact of human activities on the environment [8], [32]. Examples of such behavior include recycling, using public transport, managing waste, saving energy, buying eco-friendly products, and using efficient appliances. These behaviors can be grouped into three main categories: waste reduction, reuse, and recycling. Pro-environmental actions can range from small, everyday tasks like conserving water and recycling (individual level) to larger efforts at the community or societal level, such as promoting renewable energy, addressing climate change, and reducing pollution.

Existing research has examined what drives people to adopt pro-environmental behaviors, focusing on external, internal, and situational factors, including environmental and psychological values [33]. [34] Highlighted some underlying theoretical foundations on why people become pro-environmental friendly. External factors include social norms, convenience, personal benefits, and the use of innovative technologies [33], [35], [36]. Research shows that social norms strongly predict recycling behavior by influencing moral norms. When people internalize social norms, they shift from relying on external pressures to regulating their behavior based on personal values. External factors can act as powerful motivators, making it easier for individuals to adopt eco-friendly behaviors and encouraging environmental protection efforts.

The theory of planned behavior suggests that intentions play a key role in determining whether a specific behavior is carried out. However, some researchers argue that there is a gap between intention and actual behavior, which may be influenced by attitude. Attitude refers to an individual's evaluation of a behavior as either positive or negative [37], [38]. Additionally, factors like bounded rationality, habitual practices, and emotions have a strong impact on behaviors like recycling and waste management. Bounded rationality refers to the mental limits that cause people to focus on only part of the relevant information, often relying on familiar habits, quick decision-making shortcuts, and emotional reactions [39].

B. Dimensions of Avatars: Form Realism and Autonomy Realism

Avatars are digital representations with human-like appearances that can either have artificial intelligence (autonomous avatars) or function without it (non-autonomous avatars). They can interact with systems or other avatars [31]. While the term "avatar" is often used, it can also refer to similar entities like virtual assistants [40], chatbots [41], and virtual agents [42]. Despite the differences in definitions, avatars share three key characteristics highlighted in the literature: their human-like appearance (form realism) [16], [17], [31], controlling entity [40], and communication ability [16].

Form realism or anthropomorphism denotes how avatars look like humans with other bodily parts [16], [17]. Most extant literature discussed how the avatar's appearance might influence credibility and competence [16], [43]. For instance, [16] show how human-like avatars might influence the customer-brand relationship in the hospitality context. People are generally more comfortable interacting with avatars that look human, finding them less unsettling and more approachable. Human-like avatars can influence behaviors and encourage communication more effectively. This tendency to treat human-like avatars differently could be an advantage when using them in campaigns to promote pro-environmental behavior.

Another key aspect is how avatars behave and who controls them [40]. There are two main types: fully autonomous avatars and non-fully autonomous avatars. Researchers frequently distinguish between agents or bots, controlled by technology, and avatars, managed by humans. While fully autonomous avatars are still evolving, previous research on human-agent interactions offers valuable insights. The modality–agency–interactivity–navigability (MAIN) model, used in virtual environments, suggests that agency cues within an interface strongly shape users' perceptions by triggering cognitive shortcuts based on the interaction's nature and content [44], [45]. Whether users perceive they are interacting with an AI-driven avatar or a human-controlled one significantly affects their perceptions and behaviors, as different cognitive processes are activated for machine-based and human agents. The controlling entity plays a key role in shaping human perceptions and behaviors, especially regarding the avatar's competence and credibility. This highlights the importance of designing avatars in virtual environments in a way that effectively encourages pro-environmental behavior.

C. Metaverse, Avatars, and Behavior Change

Research has shown that immersive technology, like Virtual Reality (VR), can effectively influence individuals' attitudes and behaviors [1], [46]. This effectiveness comes from its ability to simulate scenarios that are impractical or too risky to experience in real life, especially when the situation involves significant health or safety risks. For instance, [47] and [48] used VR to create a virtual experience of a burning process, demonstrating how VR can effectively simulate high-risk events. Additionally, immersive technology allows for personalized and tailored interventions by offering adjustable scenarios or customized avatars, which can act as a user's "doppelganger."

One factor that can influence users to change their behavior is the content within the immersive metaverse environment. This content includes various technological features that need careful design. A key element in this design is the user's representation in the virtual world, called an avatar. Because the metaverse provides an immersive experience, users may perceive the avatar as their own body—a concept known as body ownership [49], [50].

The impact of avatars can be explained through the Proteus Effect in social settings [49]. This idea connects with the deindividuation process, tied to group membership, and behavioral confirmation, seen in social contexts. In non-social settings, changes in behavior and attitudes are influenced by higher-level cognitive processes, such as identifying with the social group represented by the avatar and adopting certain traits temporarily. Although originally rooted in social interaction theories, this study uses the term "Proteus Effect" to describe this phenomenon. The Proteus Effect is particularly useful for understanding how avatars can encourage behavior change, especially pro-environmental behavior. By leveraging digital self-perception, users who see their avatars in virtual environments can adopt positive traits and be motivated to practice eco-friendly actions in both the virtual and real worlds.

III. Conceptual Framework and Proposition

A. Avatar Taxonomy

Based on the literature review and avatar characteristics studied in the previous section, we propose a 2 x 2 avatar taxonomy that can promote and influence people to care more about the environment and start pro-environment habits. We present this proposal in Fig. 1.

This taxonomy provides a basis for predicting the extent to which avatars in the metaverse succeed or fail to influence users' pro-environment behaviors and informs the strategic design of avatars. In the matrix, we identify four distinct avatar categories: simple cartoon avatars (low form realism – low autonomy realism), standard cartoon avatars (low form realism – high autonomy realism), simple humanoid avatars (high form realism – low autonomy realism), and intelligent humanoid avatars (high form realism – high autonomy realism). Simple cartoon avatars represent animals as characters fully controlled by humans and have standard intelligence (e.g., programmed and task-specific communication). Standard cartoon avatars can move autonomously and have smooth movements, but only have general intelligence around environmental awareness. Simple humanoid avatars rely on user input to move but have the intelligence to respond realistically to user questions or requests. On the other hand, intelligent humanoid avatars operate entirely without user input, have human-like cognitive and emotional knowledge, and are designed to provide a high level of realism during interactions with users.

B. Insight and Proposition

To propose an avatar taxonomy, we highlight the importance of considering the relationship between an avatar's form and autonomy (Fig. 2). Previous studies have shown that form and autonomy realism are related to user experience. For example, studies conducted by [51], [52] stated that the higher the form realism, the higher the user's expectations of the avatar during their interaction. On the other hand, autonomy does not make users feel in control of the interaction with the avatar, but users feel supported by automatic control to a certain extent [53]. Therefore, we propose proposition 1 as follows:

Proposition 1: As avatar form realism and autonomy increase, so do user expectations.

Meanwhile, the results obtained when interacting with avatars (positive/negative) will shape user perceptions of avatar technology. Positive experiences will provide trust and engagement, while negative experiences can cause users to feel skeptical and reduce interest in use. This was stated in a study conducted by [25], [54] regarding avatar behavior influencing user perceptions and actions. In addition, as an avatar becomes more intelligent, it will increase the good perception of the avatar itself. Therefore, we propose proposition 2 as follows:

Proposition 2: Positive or negative outcomes from interactions with avatars influence users' perceptions of the avatar technology.

The effects of realistic simulations and the avatar's ability to convey information have a direct impact on a person's behavior [55]. Interventions given to a person through stimuli in the metaverse world supported by sophisticated avatars will directly influence users during interactions. This will also encourage individual motivation to engage and adopt pro-environmental behavior. Therefore, we propose proposition 3 as follows:

Proposition 3: The form–autonomy realism effect directly and significantly influences pro-environmental outcomes.

We also argue that if the avatar has high form-autonomy realism, it will improve the user's experience, perception of the avatar, entertainment, and intention to adopt the technology. This is in line with research conducted by [56] which states that avatars with high-form realism can increase the sense of presence and quality of user interaction. Therefore, we propose proposition 4 as follows:

Proposition 4: As an avatar's form-autonomy realism effect increases, the user experience will also increase.

The results received by users, both positive and negative, will have an impact on user experience and the adaptation of pro-environmental habits. Positive experiences such as responsive avatars and ease of navigation will improve user experience and vice versa [57]. Therefore, in the context of this pro-environmental study, we propose proposition 5 as follows:

Proposition 5: The outcomes the user receives (positive/negative) when interacting with the avatar will increase (reduce) the user experience.

User experience plays an important role will influencing user behavior and decisions. Studies show that high user experience will increase emotional engagement, satisfaction, and entertainment, and motivate users to take positive actions [58].

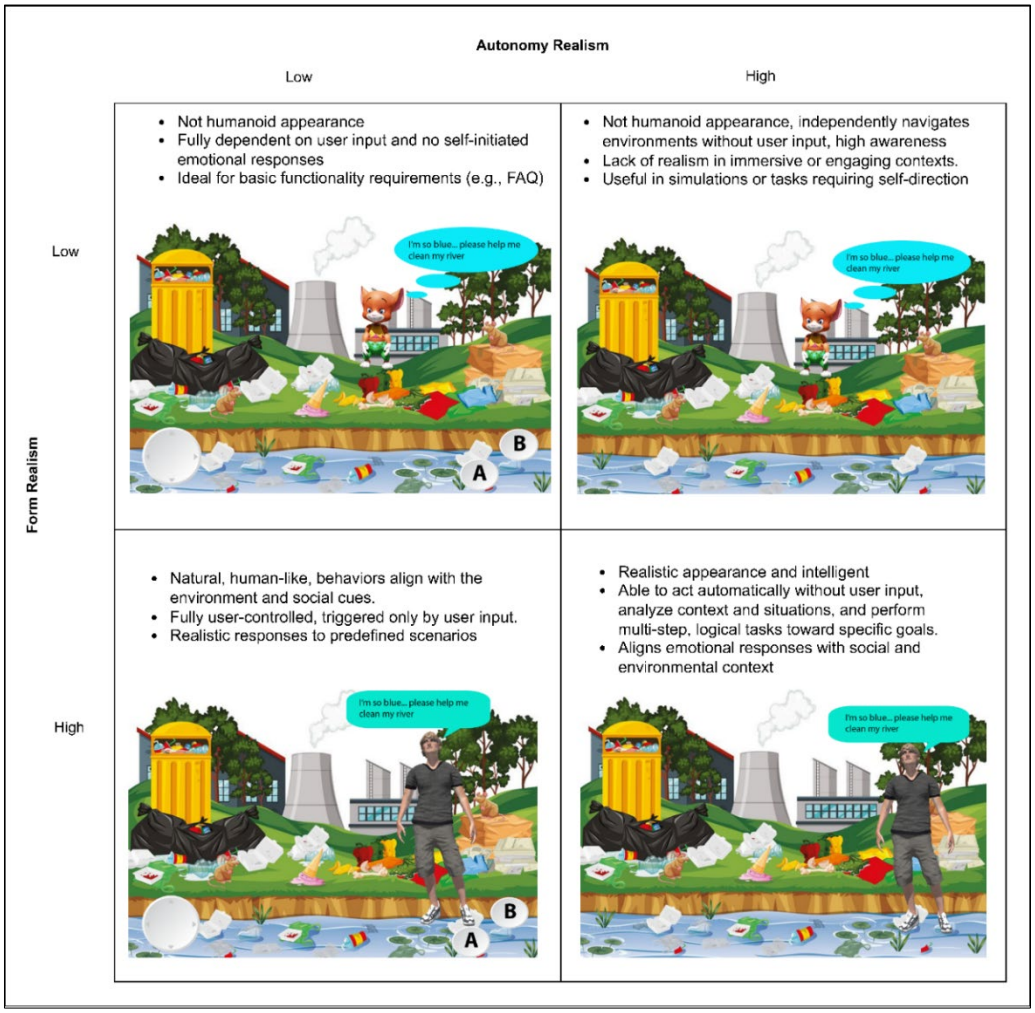

Fig. 1 Autonomy realism vs. Form realism taxonomy

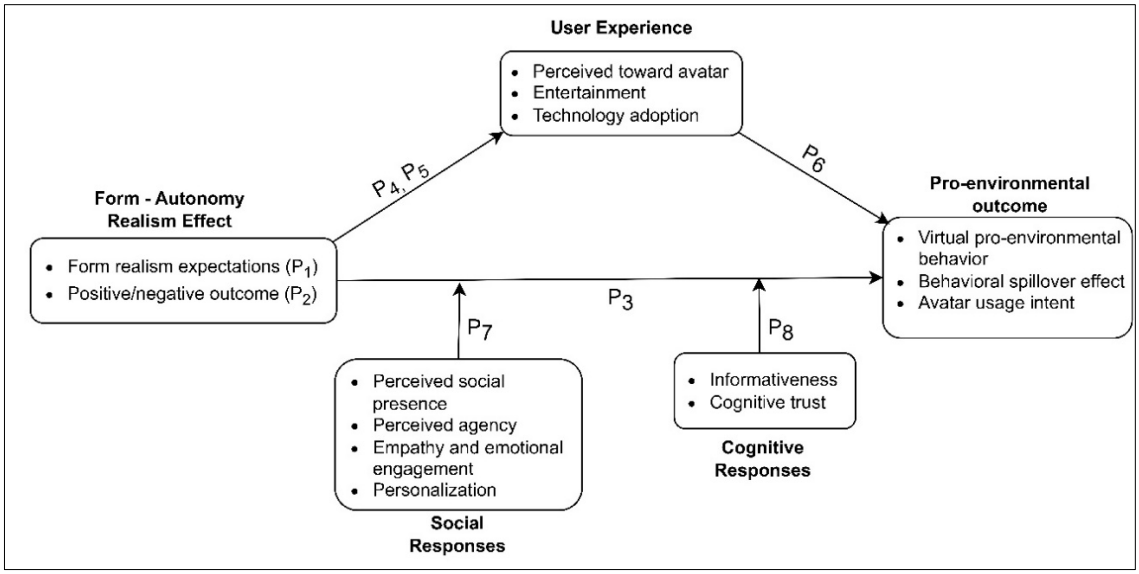

Fig. 2 Conceptual Framework

In addition, a high user experience will strengthen the user's sense of immersion and can influence long-term behavior [59]. Therefore, we propose proposition 6 as follows:

Proposition 6: As user experience improves (decreases) when using avatars, it will increase (decrease) pro-environmental outcomes.

We also consider additional factors that could strengthen the link between the form-autonomy realism effect of avatars and pro-environmental outcomes. Based on our literature review, we identify two external factors that may moderate this relationship: social responses and cognitive responses [31]. Social responses include perceived social presence, agency, empathy, emotional engagement, and personalization. When users feel that an avatar aligns with their persona, is more autonomous and realistic, and evokes emotions and empathy, they are more likely to feel involved in a specific context [31], [60]. Cognitive responses, on the other hand, focus on the avatar's ability to provide accurate and informative content about environmental sustainability. This informativeness builds user trust, which is crucial for achieving the intended pro-environmental outcomes. [61]. Therefore, we propose propositions 7 and 8 as follows:

Proposition 7: Social responses moderate the relationship between the form–autonomy realism effect and pro-environmental outcome.

Proposition 8: Cognitive responses moderate the relationship between the form–autonomy realism effect and pro-environmental outcome.

C. Research Direction

Our analysis highlights several opportunities for research on using avatars to promote pro-environmental behavior. The proposed propositions open the door for studies using various methods. For example, researchers could design different avatar types and test them in specific settings (e.g., slums or areas with high waste) as stimuli in experiments based on the 2x2 taxonomy (Fig. 1). These experiments could provide evidence on the effects of avatar form (P1) and participant outcomes (P2) and how they influence user experience and pro-environmental behavior. Additionally, researchers could use a difference-in-differences (DiD) approach to explore how user experience impacts pro-environmental behavior through interactions with avatars accurately.

Researchers could also examine how social and cognitive responses influence the link between avatar form-autonomy realism and pro-environmental outcomes. This could be tested using randomized controlled trials (RCTs), dividing participants based on the taxonomy. To study long-term effects, longitudinal RCTs with repeated avatar-based interventions could encourage sustainable behaviors like reducing plastic waste or conserving energy. Additionally, cross-cultural studies could explore how cultural differences affect this relationship, using multi-level analysis to compare behavior patterns across cultures.

IV. Conclusion

The impact of avatars on user behavior depends on advances in digital technology and user experience. However, their effectiveness in promoting pro-environmental behavior remains unclear. To address this, we propose a theoretical framework to clarify definitions, synthesize research, and provide insights for future studies. Our 2x2 taxonomy of avatar form realism and autonomy offers propositions on how avatars can influence pro-environmental behavior. Drawing on literature about avatar features and behavior-shaping factors, we create a framework that provides theoretical insights, research ideas, and practical implications for future exploration.

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