



# Digital human avatars as virtual influencers shape climate engagement and pro-environmental commitment<sup>☆</sup>

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## ABSTRACT

Nurturing pro-environmental commitment among consumers is crucial for mitigating climate change, as commitment is a pledge that precedes and predicts behavior. Given the criticality of the climate crisis and the urgent need for climate action, fostering commitment is vital for future behavioral change. Despite the potential of *digital human avatars (DHAs)* as virtual influencers alternative to human influencers in advocating environmental causes, empirical evidence regarding their effectiveness remains limited. In response, this research integrates *computers as social actors (CASA) paradigm* with *congruity theory* to investigate how DHAs can promote pro-environmental commitment through climate engagement as a mediating mechanism. Data were collected from 476 Chinese and 485 South Koreans from the same generational cohorts (Generations Y and Z) and analyzed using partial least squares path modeling. Results show that DHA-related source cues, content-related social cues, and DHA-content congruence are the key drivers of DHA persuasiveness, with climate engagement operating as a mediator that facilitates pro-environmental commitment while environmental concern serves as a boundary condition. These insights, in turn, contribute to environmental advocacy strategies aligned with the United Nations Sustainable Development Goal 13 (SDG 13) on climate action.

## 1. Introduction

Engaging consumers in combating climate change is essential for environmental sustainability (Odou and Schill, 2020; Sarkar et al., 2022). The United Nations Sustainable Development Goals (SDGs), particularly SDG 13 on climate action, offer a crucial impetus for addressing this challenge (Chuah et al., 2020; Erasmus and Steenkamp, 2021). To effectively address climate change, awareness and commitment at the individual level are vital for achieving the ambitious targets set by SDG 13 (Chuah et al., 2020). Despite today's hyperconnectivity and the pervasive presence of social media (Hoang and Lascaux, 2026; Lervik-Olsen et al., 2024), issues such as competing priorities, the

complexity of climate issues, and the inadequacy of persuasive communication hinder the transition from awareness to action (Köcher et al., 2025; White et al., 2025).

Generations Y and Z, recognized as key drivers of climate change awareness (Statista, 2020), grew up with digital technologies and are often described as digital natives. Known for both their digital fluency and environmental consciousness, they are particularly receptive to innovative communication strategies (Ling et al., 2024). *Digital human avatars (DHAs)*, which can merge the capabilities of emerging technologies like artificial intelligence (AI) and the metaverse with sustainability messaging (Appel et al., 2020; Kim et al., 2023), offer a unique avenue to engage this demographic. Unlike human influencers,

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DHAs—i.e., computer-generated characters with a realistic anthropomorphic appearance (e.g., realistic image) and intelligence (e.g., cognition and emotion) (Miao et al., 2022)—can engage diverse audiences simultaneously, resonating with various demographics and cultures through tailored messaging (Gerrath et al., 2024). Through interactive experiences and personalized messaging, DHAs build rapport with audiences, making sustainable choices more engaging and relatable (Sands et al., 2022; Yang et al., 2023b). Furthermore, DHAs consistently deliver tailored messages without the risk of inconsistent behavior or public relations issues, establishing them as reliable advocates for long-term climate initiatives (Allal-Chérif et al., 2024; Singh et al., 2020). Moreover, the novelty and technological appeal of DHAs effectively capture the attention of digitally-engaged younger audiences, who are more likely to be concerned about climate issues than their older counterparts (Kadic-Maglajlic et al., 2019; Liu and Geng, 2023). This makes DHAs easily scalable and adaptable for young generations, rendering them versatile tools for global climate action initiatives (Jiang et al., 2024).

Despite their promise, DHAs remain an understudied endorser in environmental advocacy, with fragmented evidence of their effectiveness (Table 1). Notably, their transition from commercial endorsers to pro-environmental advocates has invited skepticism. Several studies report that DHAs suffer from lower credibility than human influencers, often attributed to lower perceived altruistic motivation and weaker congruence (Wang et al., 2025), which, in turn, diminishes brand attitudes and purchase intentions (Franke et al., 2023; Li et al., 2023; Ozdemir et al., 2023), while disclosure of a DHA's non-human nature further erodes anthropomorphism and trust (Muniz et al., 2024). Whereas, others identify countervailing conditions, indicating that DHAs' artificial nature can shield brands from reputational harm when endorsements fail, potentially affording them an advantage over human influencers in such scenarios (Liu and Lee, 2024).

The most contested dimension, however, is engagement, particularly its translation into desired behavior. While some evidence finds no difference in parasocial responses between DHAs and human influencers (Stein et al., 2024), others report DHAs generate higher interactions (e.g., likes, comments, shares) and stronger (purchase and recommendation) intentions (Sands et al., 2022; Yi and Lee, 2024), while some reveal reverse patterns (Arsenyan and Mirowska, 2021). Such inconsistency underscores that DHA engagement effects are not inherent but context-dependent, arising only under certain conditions and disappearing under others. These conditions include emotional appeal (gratitude vs. pride; Jiang et al., 2024), product type (functional, experiential, symbolic; Liu and Lee, 2024), and sponsorship disclosure (absent vs. present; Kim et al., 2023), indicating that any advantage DHAs confer may be situational rather than inherent. Indeed, recent field evidence reinforces that engagement with DHAs is cue-contingent, as sociability and emoticon use increase engagement, whereas explicit identity disclosure reduces engagement, with followee count weakening the benefits of relational cues (Dong et al., 2025).

Crucially, very few studies examine DHA endorsements in explicitly pro-environmental contexts (Gerrath et al., 2024; Yang et al., 2023a; Wan et al., 2024), leaving open the question of whether DHAs can both mobilize sustained climate engagement and convert it into action—a progression identified by recent scholars as essential for closing the behavior-conversion gap in environmental advocacy (Köcher et al., 2025). Yet, shifts in attitudes rarely translate into behavior change (D'Acunto et al., 2025; Khan et al., 2024) and the prevailing reliance on intention as the primary precursor to behavior is equally problematic, as intention often overstates likely action, with evidence showing that this inflation occurs in both general ( $R^2 \approx 0.22$ ; Armitage and Conner, 2001) and pro-environmental ( $R^2 \approx 0.27$ ; Bamberg and Möser, 2007) contexts, with such values indicating only low to moderate explanatory power ( $R^2 \approx 0.20$ – $0.30$ ; Chin, 1998).

In sustainability, intention has long been critiqued as a weak surrogate for actual behavior, a view reinforced by research in ethical

consumption (Carrington et al., 2010) and environmental behavior (Bamberg and Möser, 2007). Commitment, in contrast, demands emotional investment and sustained engagement, qualities that are more likely than intention to drive action and that position it as a stronger mechanism for bridging the attitude-behavior gap (Cooper et al., 2024; Wang et al., 2023). As Table 1 indicates, prior endorsement studies have focused on engagement or intention rather than commitment, and no study, to the best of our knowledge at the point of study, has directly examined commitment as an outcome. This omission is material because the available, though limited, research—compared to intention studies—indicates that commitment is more action-proximal (Lokhorst et al., 2013), more effective in producing behavior change (Katzev and Wang, 1994), and less vulnerable to social desirability bias (Davis et al., 2009) than intention (Ajzen, 2020), making it a potent yet overlooked focal outcome for strengthening advocacy effectiveness (Alonso-Paulí et al., 2025). Field evidence further supports its value, showing that commitment-based interventions have altered real pro-environmental behaviors in both classic resource-conservation contexts (Wang and Katzev, 1990) and contemporary pledge-driven designs (Cooper et al., 2024).

In light of these gaps, this research examines whether, how, and under what conditions DHAs can drive climate engagement and pro-environmental commitment, shifting the emphasis from awareness and intention toward sustained action that environmental advocacy seeks to achieve. In doing so, this research answers calls for contemporary, timely, evidence-based solutions for climate engagement and extends recent works to more effectively promote pro-environmental causes (Gerrath et al., 2024; Köcher et al., 2025; Liyanarachchi et al., 2025; Nadeem et al., 2025; Schill and Fosse-Gomez, 2025).

This research offers several noteworthy contributions to knowledge and, by extension, practice.

First and foremost, this research extends the *computers as social actors* (CASA) paradigm (Reeves and Nass, 1996) by using it as an overarching lens to systematically identify how source and social cues in human-computer communication persuade consumers and shape their climate engagement and pro-environmental commitment. Existing research predominantly focuses on anthropomorphism as the key source factor in evaluating communication with digital entities (e.g., Wan et al., 2024; Yang et al., 2023a, 2023b), overlooking the importance of social cues in shared content. Gambino et al. (2020) emphasize that both source cues and social cues are requisite characteristics when the digital entity is perceived as a communication source rather than just a channel. Therefore, it is critical for our research to explore the impact of both source cues and social cues on consumer perception and climate engagement.

Additionally, this research enriches the CASA paradigm (Reeves and Nass, 1996) by integrating *congruity theory* (Osgood and Tannenbaum, 1955) as a supplementary lens to clarify how endorser-content fit (DHA-content congruence) influences consumer evaluations of human-computer communication. As highlighted by Xie-Carson et al. (2023), the congruence between endorser and endorser-shared content (i.e., advertising message) is important in influencing consumer engagement with non-human influencers. In particular, when messages pertain to climate change and pro-environmental advocacy (Boerman et al., 2022; Pittman and Abell, 2021), empirical research remains limited regarding the endorser-content fit and its effectiveness in persuading consumers to engage with climate-related content during human-computer interaction (Eklund and Helmeffalk, 2022). Therefore, it is crucial for our research to investigate the role of DHA-content congruence in influencing its perceived persuasiveness and subsequent climate engagement among consumers.

Furthermore, this research examines and explains the *mediation effects* of climate engagement on pro-environmental commitment. While previous studies have primarily focused on direct relationships between persuasive messages and subsequent responses (Kronrod et al., 2023; Odou and Schill, 2020), they often overlook potential mediators that

**Table 1**  
Overview of influencer endorsement research.

Article	Theory	Characteristic Antecedent	Mediator	Moderator	Outcome	Context Country	Sample	Method
Alboqami (2023)	Complexity theory	Authenticity, Expertise, Homophily, Physical attractiveness, AI influencer-product congruence, Consumer-AI influencer congruence, Consumer-product congruence,	–	–	Trust in AI influencers	Saudi Arabia	683 respondents	fsQCA
Arsenyan and Mirowska (2021)	CASA, Uncanny valley theory	Influencer type – Anime-like virtual influencer (AVI) – Human-like virtual influencer (HVI) – Human influencer (HI)	–	–	Comments/likes/views	USA	381 posts for AVI, 281 posts for HVI, 349 posts for HI	Textual analysis
De Cicco et al. (2024)	CASA	Influencer type – Human influencer – Virtual influencer Message type – Hedonic – Utilitarian	Attitude, Perception of social presence, Perception of trust	–	Brand attitude Brand trust	Italy	238 respondents	Survey
Deng et al. (2024)	–	Influencer type – Human influencer – Virtual influencer	Advertising recognition	Virtual influencer's sensory capacity	Brand attitude	China	160 respondents in Study 1, 160 respondents in Study 2, 2,274 respondents in Study 3	Experiment
El Hedhli et al. (2023)	Stereotype content model	Anthropomorphism of virtual influencer	Competence, Warmth	–	Willingness to follow the virtual influencers' recommendation, Purchase intention	UK	393 respondents – 194 for Shudu Gram – 199 for Lil Miquela	Survey
Franke et al. (2023)	Uncanny valley theory	Influencer type – Human influencer – Virtual influencer	Ad novelty, Expertise, Attitude toward the ad, Attitude toward the endorser	Product category	Brand innovativeness, Purchase intention	Germany	352 respondents	Experiment
Gerrath et al. (2024)	Stereotype content model	Message warmth – Low – High	Attitude toward pro-environmental cause, Social-psychological distance	Trust in experts	Engagement with pro-environmental cause	UK	16 interviewees, 436 respondents	Interviews, Experiment
Jiang et al. (2024)	Elaboration likelihood model	Virtual influencer image – Animal-like – Human-like	Perceived credibility	Emotional appeal – Gratitude – Pride Product involvement	Brand attitude, Purchase intention	China	123 respondents in Study 1, 221 respondents in Study 2, 244 respondents in Study 3, 439 respondents in Study 4	Experiment
Jiang et al. (2025)	Elaboration likelihood model, Emotional contagion theory	Brand stereotype – Competence – Warmth Emotional expression of virtual influencer – Smile – No smile	Affective empathy, Cognitive empathy	–	Brand authenticity, Follow intention, Purchase intention	China	185 respondents in Study 1, 1,290 respondents in Study 2	Experiment
Kim et al. (2023)	CASA	Virtual influencer image – Anime-like – Human-like	Message credibility	Sponsorship disclosure – Absent – Present	Message attitude	USA	250 respondents	Experiment

(continued on next page)

Table 1 (continued)

Article	Theory	Characteristic Antecedent	Mediator	Moderator	Outcome	Context Country	Sample	Method
Li and Ma (2024)	CASA	Human-likeness	Perceived authenticity, Perceived similarity, Wishful identification	–	Attitude toward the ad	USA	178 respondents in Study 1, 162 respondents in Study 2	Experiment
Li et al. (2023)	Mind perception theory	Influencer type – Human influencer – Virtual influencer	Perceived credibility, Perceived sensory capability	Sensory cue salience	Endorsement effectiveness – Brand attitude – Purchase intention	China	466 influencer posts and 107,218 corresponding comments in Study 1, 261 respondents in Study 2a, 511 respondents in Study 2b, 380 respondents in Study 3	Experiment
Liu and Lee (2024)	–	Influencer type – Human influencer – Virtual influencer	Mind perception	Product type – Functional – Experiential – Symbolic	Responsibility attribution, Endorsement effectiveness – Brand attitude – Intention to share	USA	305 respondents in Study 1, 1,347 respondents in Study 2	Experiment
Muniz et al. (2024)	Expectation disconfirmation theory	Disclosure	Anthropomorphism of virtual influencer, Credibility of virtual influencer	–	Brand trust	USA, Brazil	75 respondents in Study 1, 101 respondents in Study 2	Experiment
Ozdemir et al. (2023)	Language expectancy theory	Influencer type – Human influencer – Virtual influencer	Perceived credibility	Language type	Brand attitude	Canada	Five studies (N = 1,734)	Experiment
Sands et al. (2022)	–	Influencer agency – Autonomous – Managed Influencer type – Human influencer – Virtual influencer	Social psychological distance	Need for uniqueness	Perceived commercialization Perceived personalization, Source trust, Word-of-mouth, Intention to follow	USA	455 respondents in Study 1, 1,325 respondents in Study 2	Experiment
Stein et al. (2024)	–	Influencer type – Human influencer – Virtual influencer	Mental human-likeness, Visual human-likeness, Perceived similarity, Wishful identification	–	Parasocial interaction	Germany	179 respondents	Experiment
Wan et al. (2024)	Anthropomorphism theory, Social identity theory	Anthropomorphism – Animal-like – Human-like	Trust in virtual influencer	Racial homophily – Local-like – Foreign-like	Pro-environmental behavior – Low cost – High cost	China	414 respondents in Study 1, 1,402 respondents in Study 2	Experiment
Wang et al. (2025)	Mind perception theory, Match-up hypothesis	Influencer type – Human influencer – Virtual influencer	Perceived altruistic motivation, Perceived congruence	Language type – Emotional – Rational Product type – Green – Ordinary	Endorsement effectiveness – Brand attitude – Purchase intention	China	484 respondents in Study 1, 238 respondents in Study 2	Experiment
Yang et al. (2023a)	Expectancy violation theory	Endorser type – Cartoon-like – Human-like	Source credibility – Attractiveness – Expertise – Similarity – Trustworthiness	Endorser-CSR fit	CSR engagement, Brand attitude	USA	202 respondents	Experiment
Yang et al. (2023b)	Expectancy violation theory	Humanness of social media Influencer type – Human influencer – Virtual influencer	Source credibility – Attractiveness – Expertise – Similarity – Trustworthiness	Interactivity – High – Low	CSR engagement, Brand reputation	USA	219 respondents	Experiment
Yi and Lee (2024)	Construal level theory, Uncanny valley theory	Influencer type – Human influencer – Virtual influencer Message type – Emotional – Rational	–	–	Purchase intention, Sharing intention	South Korea	299 respondents	Experiment

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Table 1 (continued)

Article	Theory	Characteristic Antecedent	Mediator	Moderator	Outcome	Context Country	Sample	Method
You and Liu (2024)	–	Egoistic Influencer type – Human influencer – Virtual influencer	Authenticity	Autonomy – Control – High – Low Influencer novelty	Altruistic motive	USA	163 respondents in Study 1a, 171 respondents in Study 1b, 238 respondents in Study 2a, 229 respondents in Study 2b	Experiment
Yu et al. (2024)	CASA	Core emotions – Anger – Disgust – Fear – Happiness – Sadness – Surprise Influencer type – Human influencer – Virtual influencer	–	–	Engagement	USA	1,028 posts	Data mining, Facial recognition algorithms
Zhou et al. (2024)	–	–	Imagery difficulty, Perceived sensory capacity	Sensory type – Distal – Proximal	Click-through rate, Purchase intention	–	200 participants in Study 1, 982 participants in Study 2, 6,522 participants in Study 3, 3,387 participants in Study 4, 589 participants in Study 5, 379 participants in Study 6	Experiment

Notes: AI = Artificial intelligence. CASA = Computers as social actors paradigm. fsQCA = Fuzzy-set qualitative comparative analysis.

explain how and why these messages are effective within the context of pro-environmental consumer behavior, which can include perception, engagement, and commitment. Although the importance of engagement has been suggested (Barger et al., 2016; O’Neill et al., 2013), it has not been thoroughly explored as a mediating factor. This research addresses this gap by empirically examining climate engagement as a key mediating variable in DHA-human interaction, and thus, providing empirical evidence of its role in driving pro-environmental commitment among consumers.

Moreover, this research explores and reveals the *moderation effects* of environmental concern on the relationships among perceived persuasiveness, climate engagement, and pro-environmental commitment. Exploring environmental concern as a moderating factor allows for a finer-grained understanding of how individual differences shape responses to DHA-driven climate advocacy (De Canio et al., 2021). Environmental concern often intensifies motivation for sustainable behavior (Laheri et al., 2024), which suggests that DHAs’ impact on climate engagement and pro-environmental commitment may be amplified among those with high environmental concern. Identifying this moderating effect, therefore, clarifies how DHAs can be tailored to resonate with consumers possessing varying levels of environmental concern, thereby ensuring that their messaging is maximally impactful.

Last but not least, this research provides *targeted insights* into Generations Y and Z, who are increasingly proactive and vocal about climate action (Skeiryte et al., 2022). This demographic, characterized by digital fluency and a willingness to embrace novel technological experiences (Ghouse et al., 2025), represents a vital target group for advancing pro-environmental norms through DHAs. Their familiarity with digital platforms and openness to engaging with digital entities make them particularly receptive to DHA-driven messaging. As digital natives, these generations also exhibit a strong sense of collective responsibility toward environmental issues (Bolgi, 2023; Statista, 2020), which aligns closely with the objectives of sustainable development. Thus, understanding the efficacy of DHAs in fostering pro-environmental commitment within this demographic not only extends current research on climate engagement but also offers practical insights for designing scalable, tech-forward approaches to climate action that resonate with digitally-connected audiences.

## 2. Literature review

### 2.1. Conceptual foundation

#### 2.1.1. Digital human avatars (DHAs)

DHAs, resembling real people, are gaining popularity in marketing (Ameen et al., 2024; Miao et al., 2022; Mouritzen et al., 2024). They endorse eco-friendly products and advocate for environmental causes digitally, fostering authenticity and relatability (Jiang et al., 2024; Mouritzen et al., 2024; Pucci et al., 2020). Notable examples include virtual influencers like ELISA, Imma, and Lil Miquela, who engage in pro-environmental content on social media (Jiang et al., 2024).

Existing literature on DHAs and pro-environmental behavior remains limited. From a *source-related* perspective, DHA attributes such as anthropomorphism, credibility, and demographic similarity (racial homophily) are crucial in building trust and enhancing the effectiveness of virtual influencers (Wan et al., 2024; Yang et al., 2023a, 2023b). From a *content-related* perspective, emotional appeals, such as those invoking gratitude, pride, and message warmth, reduce social-psychological distance, thereby fostering greater engagement with pro-environmental causes (Gerrath et al., 2024; Jiang et al., 2024). However, these findings remain limited as they often view *DHA-related source cues* and *content-related social cues* independently, without examining the congruity between DHAs and the content they share. This gap highlights the need for comprehensive research to explore how the alignment between DHA attributes and the content they deliver influences endorsement effectiveness of pro-environmental advocacy.

### 2.1.2. Climate engagement

*Climate engagement* refers to consumer engagement with climate change, which is most prominently seen on social media (Chuah et al., 2020; Odou and Schill, 2020; Schill and Fosse-Gomez, 2025). Notably, there are several definitions of consumer engagement in the existing literature.

A representative approach is to define consumer engagement as consumers' cognitive, affective, and behavioral activities during interactions (Hollebeek et al., 2014). *Cognitive engagement* involves a consumer's level of thought processing and elaboration during a particular interaction, whereas *affective engagement* refers to a consumer's level of positive affect during a particular interaction, while *behavioral engagement* is a consumer's level of effort, energy, and time spent during a particular interaction. Another approach to consumer engagement focuses on behaviors prompted by motivational factors (Alsaad et al., 2023; Barger et al., 2016). This involves activities like liking, commenting, posting, and sharing related to campaigns, indicating different levels of engagement: consumption, contribution, and creation (Schivinski et al., 2016). *Consumption* is passive, involving viewing content without active participation, whereas *contribution* includes feedback and sharing, while *creation* involves generating new content, such as posts, images, or videos (Alsaad et al., 2023; Schivinski et al., 2016).

In this study, we adopt the behavioral interpretation of consumer engagement (Alsaad et al., 2023; Schivinski et al., 2016). Focusing on patterns and types of campaign-related activities on social media, we view engagement behaviors, such as liking, commenting, and sharing, as proxies for assessing how individuals respond to persuasive content. These behaviors reveal levels of interaction with pro-environmental content, reflecting both immediate reactions and more active participation. Engagement thus serves as a crucial intermediary, enabling the initial attention and interest sparked by persuasive content to evolve into a sustained commitment. Through continued interaction, individuals are more likely to internalize the content's message, thereby fostering a deeper commitment to pro-environmental actions. This approach underscores the role of engagement not only as an outcome of persuasive communication but as an essential step in the pathway to long-term commitment to climate-related actions.

### 2.1.3. Pro-environmental commitment

*Pro-environmental commitment* extends beyond mere intention, as it embodies a firm pledge to translate awareness into concrete action (Lokhorst et al., 2013; Wang, Sheng, et al., 2023). In this regard, integrating commitment as a focal point aligns closely with the goal of promoting pro-environmental behaviors (actions). In addition, unlike intention, which signifies a readiness or plan to act (Ajzen, 1991), commitment embodies a definitive resolution that one "will" act, rather than simply "intend to" act (Fishbein and Ajzen, 2011; Harris, 2019). This distinction is significant, as commitment is more persistent and resilient over time (Lokhorst et al., 2013; Wang et al., 2023), thus arguably serving as a more reliable predictor of actual behavior than intention, particularly in contexts requiring immediate and sustained action, such as pro-environmental behavior amid the ongoing climate crisis.

Conceptually, commitment binds the self to a chosen course of action, creating consistency pressures that sustain effort in the face of obstacles (Demarque and Girandola, 2017; Kiesler, 1971). Operationally, commitment can be expressed through definite, pledge-like wording, which sharpens measurement and reduces non-committal responses that state a plan rather than a promise (Fisher, 1993; Harris, 2019). Hence, commitment functions as an actionable bridge between attitude and behavior, sitting closer to action than intention while, like intention, remaining more accessible for measurement than actual behavior (Laheri et al., 2024).

Within self-reported surveys, commitment arguably serves as a more potent and reliable proxy for behavioral change than intention, given its

association with a firm resolve to act, even amidst obstacles (Kiesler, 1971; Lokhorst et al., 2013). Surveys, while limited in measuring direct behavior, can capture commitment effectively by employing definitive language (Harris, 2019), which, in turn, reduces social desirability bias and aligns more closely with the likelihood of future pro-environmental behaviors (Fisher, 1993). Field evidence is consistent with this view. Written pledges and public declarations increase actual conservation and recycling with observable changes in resource use (Katzev and Wang, 1994; Wang and Katzev, 1990). Contemporary evidence points in the same direction, from utility-run digital pledges that deliver measurable energy savings (Peterson, 2023), to internet-based interventions that combine information, goals, feedback, and an explicit commitment to reduce real purchases (Joanes et al., 2025), to large-scale municipal recycling pledges that generate durable behavior change (Alonso-Paulí et al., 2025). While these demonstrations are intervention-based, the present study operationalizes commitment through definite survey language. The routes differ, yet they converge on the same construct, namely, commitment as the bridge between persuasion and behavior.

Accordingly, a survey-based commitment measure is adopted to establish groundwork for this DHA-focused inquiry, opening a path for future research to test causal leverage by embedding commitment-inducing interventions in DHA campaigns. More importantly, the focus on commitment herein not only acknowledges the realities of survey-based research but also leverages a theoretically sound predictor of pro-environmental behavior (Cooper et al., 2024; Demarque and Girandola, 2017), thereby enhancing the ability to assess the potential of initiatives to inspire lasting behavioral changes toward climate action.

## 2.2. Theoretical foundation

The conceptual model, illustrated in Fig. 1, integrates the CASA paradigm with congruity theory to examine the factors influencing DHA persuasiveness in promoting pro-environmental commitment. In addition, the model explores the mediating role of climate engagement and the moderating role of environmental concern in shaping individuals' pro-environmental commitment.

### 2.2.1. Computers as social actors (CASA) paradigm

The CASA paradigm, introduced by Reeves and Nass (1996), suggests that people subconsciously treat computers and digital entities as social actors, applying social rules and expectations to their interactions (Lou et al., 2022; Sundar and Nass, 2000). The CASA paradigm has been widely applied in various fields, including educational technology (Kim and Baylor, 2006), health communication (Bickmore and Picard, 2005), virtual assistants and chatbots (Gambino et al., 2020), and virtual influencers (Arsenyan and Mirowska, 2021). This paradigm emphasizes attributes like anthropomorphism and emotional expression in human-computer interactions (Ham et al., 2024; Lou et al., 2022; Yu et al., 2024). Anthropomorphism can reduce the uncertainty of interactions and enhance perceived social presence (Schroeder and Epley, 2016), making exchanges with virtual agents feel more akin to those with human counterparts (Abendschein et al., 2021). As technologies grow more interactive and assume tasks once handled by humans, designers increasingly strive to streamline communication with computers and digital entities, reducing the mental effort required for users to engage effectively. The CASA paradigm, focusing on source cues and social cues (Reeves and Nass, 1996), provides a lens for understanding how digital entities engage and influence their audience (Gambino et al., 2020).

*Source cues* refer to the perceived origin of the interaction or information provided by digital entities (Nass and Moon, 2000). Prior research highlights that DHA characteristics, such as credibility and authenticity, play a key role in building trust and enhancing influencer effectiveness (Yang et al., 2023a, 2023b; You and Liu, 2024). However, concerns remain regarding the credibility of DHAs, with some studies suggesting they are inherently less persuasive than human influencers

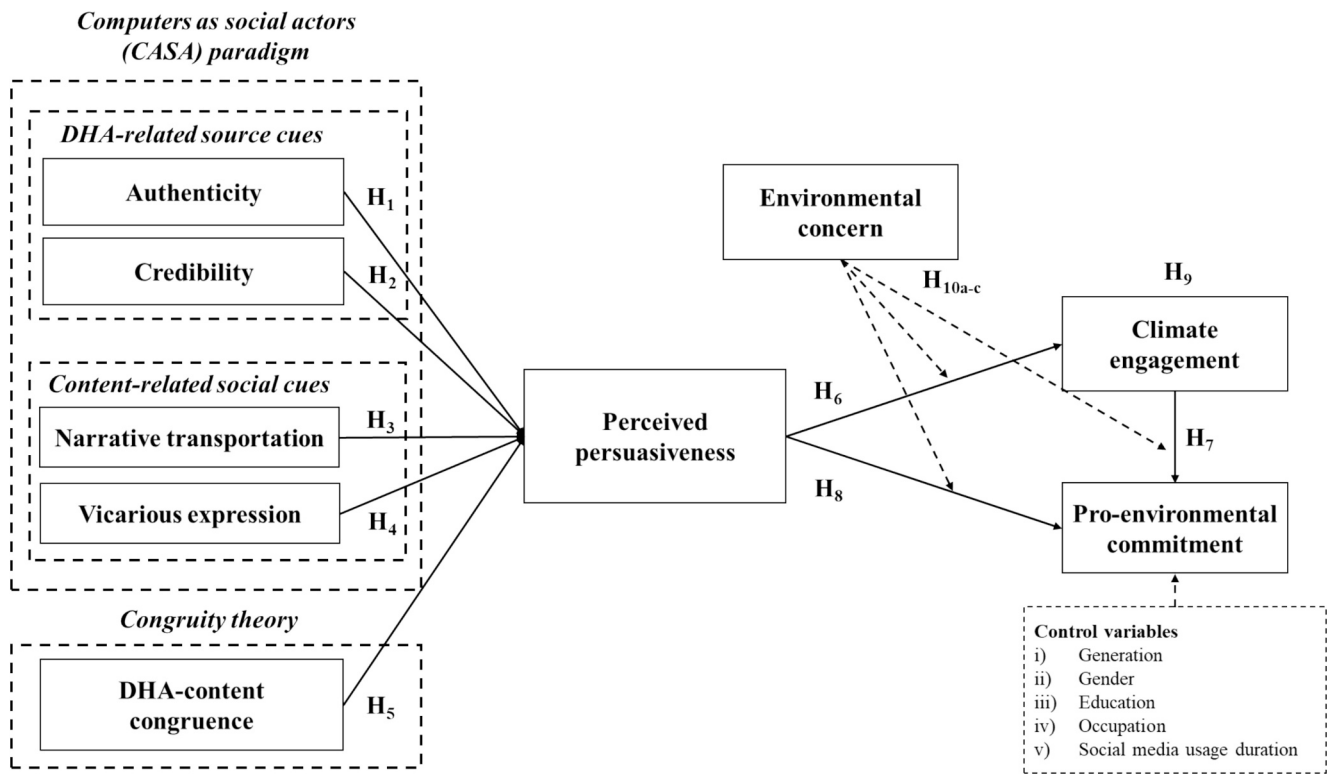


Fig. 1. Research model and hypothesized relationships.

due to doubts about trustworthiness (Franke et al., 2023; Ozdemir et al., 2023). Similarly, the artificial nature of DHAs raises ongoing questions about the authenticity of their endorsements, which often lack the genuineness and personal connection associated with human influencers (El Hedhli et al., 2023; Lou et al., 2023). Simply put, audiences in technology-mediated exchanges often default to source cues as part of their diagnostic, elevating credibility and authenticity (Dietvorst et al., 2015), with recent studies emphasizing that gaps in these cues, which audiences lean on to act, can reduce endorsement effectiveness (Alboqami, 2023; Sands et al., 2022), thereby imposing a threshold condition whereby, without sufficient credibility and authenticity, advocacy is unlikely to persuade. Moreover, artificial spokespersons such as DHAs bring fewer verifiable, other-generated cues (e.g., independent coverage, third-party histories) into the exchange, a warranting deficit well documented in communication research and structurally acute for virtual influencers who may be constrained by their fictive status (DeAndrea and Vendemia, 2019; Koles et al., 2024), while algorithm aversion—the tendency to discount or avoid machine-generated judgments, especially after observing errors (Dietvorst et al., 2015) or when tasks require human capacities such as empathy (Heßler et al., 2022)—further raises the trust threshold for nonhuman advocates, thereby heightening the reliance on credibility and authenticity to survive persuasion-knowledge scrutiny, especially in a marketplace already skeptical of environmental claims (Sivapalan et al., 2024). Given these debates, we foreground *credibility* and *authenticity* as the core source cues through which DHAs can persuade in pro-environmental advocacy.

*Social cues* are signals that digital entities exhibit, mimicking human social behavior, including conversational style, empathy, emotion, and verbal or non-verbal cues (e.g., body language, facial expression) (Liu and Sundar, 2018; Nass and Moon, 2000). As interactions with media agents become richer, users form dedicated “human-media scripts” that hinge on emotional resonance and narrative immersion (Gambino et al., 2020). Under the CASA paradigm (Nass and Moon, 2000), social cues do not merely decorate interactions, rather, they shape empathic concern, self-efficacy, and willingness to act or comply, which are nearer to action

than surface liking (Cialdini and Goldstein, 2004; Small and Verrochi, 2009)—a point that is also aligned to social cognitive theory, as affective arousal, modeled behavior, and vicarious reinforcement build efficacy beliefs and outcome expectancies that regulate choice, effort, and persistence (Bandura, 2001). Building on this foundation, we focus on *vicarious expression* and *narrative transportation* as the social cues most likely to move audiences from perception to action in DHA-driven environmental advocacy. *Vicarious expression*, defined as the observation and internalization of a DHA’s projected emotions and behaviors (Chen et al., 2019), triggers the very social inferences (personality attribution, empathy) that CASA predicts, even when users know the agent is artificial, by transmitting affect and efficacy-relevant appraisal through observable displays, fostering empathic concern and self-efficacy—both proximal antecedents of calls to action (Bandura, 2001, Liu and Sundar, 2018; Small and Verrochi, 2009)—rather than merely increasing perceived humanness or liking (Söderlund and Oikarinen, 2021). *Narrative transportation*, defined as deep immersion in a narrative world (Green and Brock, 2000; Green and Appel, 2024), engages audiences affectively and cognitively through storytelling, thereby reducing counterarguing and resistance and producing durable changes in beliefs and attitudes with downstream effects on intention and behavior (Green and Brock, 2000; van Laer et al., 2014). These cues are arguably diagnostically superior to generic anthropomorphic touches because they supply the emotional meaning and efficacy information people use when deciding whether to act (Sundar, 2008). Consistent with this emphasis on social cues, evidence in environmental persuasion shows that narrative evidence reliably outperforms statistical evidence on risk perception and behavioral intention (Choi et al., 2026) and that transportation in environmental stories predicts stronger pro-environmental behavior (Liu, 2023). Vicarious emotional expression can activate sympathy and raise donations (Small and Verrochi, 2009), expressive nonverbal displays from artificial agents can increase compliance (Harjunen et al., 2018), and warm, empathic messaging in virtual influencer appeals can increase engagement with green causes (Gerrath et al., 2024). Nevertheless, several pertinent *gaps* make renewed

examination necessary rather than replicative. Most demonstrations of vicarious expression and narrative transportation feature human advocates (van Laer et al., 2014) or experiential settings (Luo et al., 2026), leaving unresolved whether these cues retain persuasive force when the advocate is nonhuman and disclosure is salient, conditions in which warranting is thin, as in altruistic domains such as environmental advocacy. Evidence, to date, also skews toward engagement and intention (Picot-Coupey et al., 2023; Thomas and Grigsby, 2024) while action-proximal endpoints and persistence are rarely modeled (Lokhorst et al., 2013), despite being the relevant test for advocacy impact (Alonso-Paulí et al., 2025; Cooper et al., 2024; Wang and Katzev, 1990). Relatedly, studies typically isolate social cues (Peng et al., 2024) from source cues (Lee and Kang, 2024), yet theory implies complementarity or compensation (Nass and Moon, 2000), whereby vicarious expression and transportation may either amplify credible and authentic sources or compensate for deficits by supplying affect and efficacy information under active persuasion-knowledge conditions. Given these debates, we foreground vicarious expression and narrative transportation as the core social cues through which DHAs can persuade in pro-environmental advocacy, and in line with the CASA paradigm (Nass and Moon, 2000), we argue that enhancing these social cues—individually and in concert with credibility and authenticity—is essential for overcoming audience skepticism and maximizing persuasive impact of DHAs in sustainability communication.

### 2.2.2. Congruity theory

*Congruity theory*, which addresses communication and persuasion, asserts that consumers favor information that is cognitively coherent and consistent (Osgood and Tannenbaum, 1955). In this account, a source takes a stance toward an object, either associating with it or distancing from it. Audience judgments reflect their evaluations of both source and object, and when these evaluations conflict, pressure arises to reduce the inconsistency. Adjustment occurs where the smallest overall change is required, by revising the attitude toward the source or the object, or by weakening either evaluation. Alignment requires less reconciliation and is processed more fluently, so congruent messages are more likely to be remembered, preferred, and accepted. The practical inference thus follows naturally that a stronger perceived fit between who the source is and what the message claims yields greater persuasive impact, whereas a poor fit results in the opposite (e.g., raises skepticism, reduces acceptance).

In influencer endorsements, congruity refers to the alignment of the influencer's conduct, image, and knowledge with the endorsed brand or message (Kim and Kim, 2021; Till and Busler, 2000). This alignment is crucial because higher endorser-message fit improves evaluations of the brand and the claim, whereas poor fit invites discounting and resistance (Boerman et al., 2022; Knoll and Matthes, 2017; Shan et al., 2020). The literature identifies various types of congruity, such as brand-advertising message congruity (Dahlén and Lange, 2004), consumer-brand congruity (Montaguti et al., 2023), consumer-product congruity (Huang et al., 2013), and consumer-influencer congruity (Jamil, 2026). This research extends these variations by examining DHA-content congruence, defined as the perceived fit between a DHA's persona and the post it shares. In a DHA setting, *persona* refers to the DHA's authenticity (e.g., clarity of purpose, passion, reliability, transparency; Li and Ma, 2024) and credibility (e.g., expertise, trustworthiness; Ohanian, 1990) signaled through source cues while *post* refers to the content's narrative transportation (e.g., imagery, story structure; Green and Brock, 2000) and vicarious expression (e.g., emotional tone, message framing; Chen et al., 2019) signaled through social cues, and thus, DHA-content congruence represents the fit between the persona bundle (authenticity + credibility) and the post bundle (transportive storytelling + expressive displays). When persona and post cohere, audiences need less effort to connect source and message, processing becomes more fluent, and downstream responses strengthen. Evidence from virtual environments lends support. For instance, Huang et al. (2023) investigated the link

between self-congruence and social presence in virtual settings, revealing that the degree of social presence felt by users is related to their perception of the self-congruence of their avatars. Similarly, Freeman et al. (2020) found that participants who used avatars resembling themselves experienced a heightened sense of presence, as they viewed their avatars as extensions of themselves.

Given the above, the adoption of congruity theory herein this research builds on the CASA paradigm's focus on DHA source cues (credibility, authenticity) and social cues (vicarious expression, narrative transportation) by supplying a missing alignment logic, namely, DHA-content congruence, which reflects the fit between a DHA's persona and its post. Within this premise, congruity theory posits that high fit yields fluent, low-resistance processing, whereas low fit disrupts fluency, increases processing difficulty, heightens resistance, and reduces acceptance (Osgood and Tannenbaum, 1955). Integrating congruity with the CASA paradigm, therefore, yields a dual lens, whereby CASA explains why people respond socially to human-like agents while congruity explains when those responses convert into persuasion—namely, when source signals and storytelling signals cohere. This integration guides the design of DHA-content combinations that can move audiences toward action-proximal outcomes such as commitment in environmental advocacy.

### 2.2.3. Robustness of theory selection and integration

Following the IMPACT framework (i.e., interestingness, matching, parsimony, applicability, conceptual rigor, and testability; Hollebeek et al., 2025), this research treats the selection and integration of the CASA paradigm and congruity theory as a deliberate *matching* decision—namely, a co-infusion that aligns the focal persuasion process in DHA-mediated sustainability communication with complementary explanatory logics. In particular, the CASA paradigm explains why audiences respond socially to DHAs by relying on diagnostic source cues and social cues (Nass and Moon, 2000; Reeves and Nass, 1996) while congruity theory explains when those cue-based responses translate into persuasion (Osgood and Tannenbaum, 1955), that is, when the DHA's persona and the post cohere in a cognitively fluent, low-resistance manner. This co-infusion, in turn, yields a more complete account of DHA persuasion as it couples social-response formation with an alignment mechanism that determines acceptance versus resistance.

The *matching* of the two theoretical lenses is also defensible against the remaining IMPACT criteria (Hollebeek et al., 2025). More specifically, *interestingness* is strengthened as the integration links cue-based human-computer interaction reasoning with an endorsement-fit mechanism to explain sustainability persuasion, which enable theoretically meaningful predictions that extend or challenge prevailing assumptions about DHA effectiveness in high-stakes advocacy settings, whereas *parsimony* is maintained, with congruity theory contributing a single, necessary alignment logic rather than redundant constructs and thus keeping the framework centered on the minimal explanatory elements required to account for persuasion and downstream commitment while *applicability* is high, given that the integration translates directly into actionable guidance for designing DHA persona-post combinations that maximize perceived fit and persuasive impact in pro-environmental communication, *conceptual rigor* is safeguarded through explicit articulation of the fit between the two theories, precise definition of key concepts, and preservation of internal coherence across the proposed relationships and boundary conditions, and *testability* is ensured, as the integrated model yields empirically verifiable predictions and the focal constructs and relationships are operationalizable within a structured model.

## 2.3. Hypothesis development

### 2.3.1. Source cues and perceived persuasiveness

Authenticity refers to the context-bound perception that endorsers present genuine and real selves to their audiences (Li and Ma, 2024;

Wellman et al., 2020). While DHAs do not possess human emotions, lived experiences, or internal motivations, the CASA paradigm posits that audiences still respond to them as if they were social entities when human-like cues are present (Nass and Moon, 2000). This anthropomorphic processing opens the door for simulated authenticity, crafted through consistent behavior, emotionally expressive communication, and context-appropriate narratives, to generate the same relational inferences as authenticity in human endorsers (Alboqami, 2023). As a source cue, perceived authenticity enhances engagement and persuasion by making the DHA appear relatable and trustworthy (Gambino et al., 2020; Nass and Moon, 2000). Notably, authentic interactions involve clear communication of purpose and transparent, passionate promotion of information (e.g., a call for pro-environmental consumer behavior), which reduces the psychological distance between the consumer and the DHA, thereby fostering trust and increasing receptivity to advocacy appeals (Onofrei et al., 2022).

As a determinant of endorsement effectiveness, DHAs build their authenticity through creating authentic content, sharing media, and interacting with their audiences (Li and Ma, 2024). Social media audiences, in turn, expect endorsers to be genuine, realistic, and aligned in values (Koles et al., 2024), which is especially pertinent when the message addresses altruistic domains such as environmental and social responsibility (Hartmann et al., 2025; Lee and Chung, 2025). Authenticity in this regard signals moral alignment, which strengthens message credibility and reduces perceptions of opportunism, a known risk in cause-related marketing (Becker-Olsen et al., 2006; Yang and Chunterawong, 2026; Yang and Mundel, 2021). Despite the uncanny valley theory suggesting that overly authentic virtual endorsers can bring doubts and rejection of the content they post (Arsenyan and Mirowska, 2021; Lou et al., 2023), some recent studies have discovered that the authenticity of DHA is positively associated with audiences' perceived persuasiveness of DHAs (Li et al., 2023; Li and Ma, 2024). In particular, "authentically fake" digital endorsers who are perceived as authentic within their own digital context (Lou et al., 2023) can significantly enhance consumer awareness on social media. When such endorsers present rich, context-consistent cues, they are more likely to be viewed as knowledgeable and trustworthy, which, in turn, strengthens both attitudinal and behavioral responses, including those related to green consumption (Jiang et al., 2024). Accordingly, we posit:

**H<sub>1</sub>.** DHA's authenticity is positively associated with perceived persuasiveness.

Credibility, characterized by expertise and trustworthiness (Kapitan and Silvera, 2016; Ohanian, 1990), plays a vital role as a source cue in determining how persuasive a source is to its audience and has been used in influencer marketing to explain endorsement effectiveness (Belanche et al., 2021; Lou and Yuan, 2019). Expertise signifies the endorser's breadth and depth of knowledge of a specific topic, while trustworthiness indicates the extent to which an endorser can be perceived as honest, ethical, and believable (Erdogan, 1999). Despite the artificial nature of DHAs, the CASA paradigm suggests that customers apply the same social heuristics to digital entities as they do to humans (Nass and Moon, 2000). This means that perceived credibility, when effectively simulated through accurate, consistent, and well-framed information, remains a powerful persuasive source cue for DHAs, enabling them to trigger persuasion and influence how audiences respond to their messages (Kim et al., 2023).

Empirical evidence shows that highly credible sources are more influential in shaping audiences' attitudes and behaviors than those with lower credibility (Alam et al., 2024; de Boissieu and Baudier, 2023). This effect is amplified in contexts where skepticism is high, such as climate change advocacy, because audiences depend on credibility as a heuristic or mental shortcut to judge the legitimacy of the information and the motives of the source (Kim et al., 2022; Jiang et al., 2024; Pornpitakpan, 2004). In human communication, source credibility enhances information evaluation because credible and professional endorsers create a favorable impression that extends to the endorsed advocacy, brand, or

product (Belanche et al., 2021; Jiang et al., 2024; Mainolfi et al., 2022). The mechanism underlying this effect operates in two ways, whereby credibility increases message acceptance through expertise and trust (Ohanian, 1990) and reduces counterarguing by lowering the perceived risk of misinformation (Guo, 2024).

Similarly, according to the CASA paradigm (Reeves and Nass, 1996), people apply social rules to humanlike avatars, treating them as social actors (Miao et al., 2022). In the context of DHAs, credibility functions as a diagnostic cue that reassures audiences about the quality, integrity, and relevance of the information being presented, even when the source is artificial (Yoo et al., 2025), thereby compensating for the warranting deficit inherent in nonhuman advocates (Wang et al., 2025). For instance, de Boissieu and Baudier (2023) found that credible virtual influencers have demonstrated persuasive efficacy in shaping audiences' perceptions toward green consumption. Given the persistence of the attitude-behavior gap, where audiences often agree with the message yet fail to follow through with action (Ballew et al., 2024), credibility can help bridge the attitude-behavior gap by reinforcing perceptions of competence in the subject matter (Leite et al., 2024) and genuine commitment to the cause (Lee et al., 2019; Yang and Chunterawong, 2026) while reducing suspicion of opportunistic greenwashing motives (Szabo and Webster, 2021). As such, we propose:

**H<sub>2</sub>.** Credibility is positively associated with perceived persuasiveness.

### 2.3.2. Social cues and perceived persuasiveness

Narrative transportation refers to the process by which audiences are transported into a narrative world, where they are extensively immersed in emotional and informational experiences, resulting in changes to real-world beliefs, attitudes, and responses (Green and Appel, 2024; Green and Brock, 2000; Liu, 2023). Based on the CASA paradigm (Reeves and Nass, 1996), narrative transportation is considered a social cue because it involves deep, immersive engagement with a narrative that typically includes social contexts, interactions, and relationships, which activate social information processing, even when the story is delivered through a non-human medium (Arsenyan and Mirowska, 2021; Gambino et al., 2020), such as DHAs (Luo et al., 2026). This is critical for DHAs because immersive narratives can mask the artificiality of the source by shifting cognitive focus from the medium to the message, thereby enhancing the perception of human-like social presence (Van Laer et al., 2014).

Past studies suggest that a narrative in green messaging is more persuasive than a factual approach (Cao et al., 2021; Kim et al., 2022), as narratives can reduce resistance by lowering counterarguing and promoting identification with characters and scenarios (Thomas and Grigsby, 2024). This mechanism is especially valuable for pro-environmental advocacy, where skepticism, reactance, and message fatigue can undermine persuasion (Hart and Feldman, 2014; Naidu et al., 2023), and where emotionally resonant storytelling may be one of the few strategies capable of sustaining attention long enough to influence attitude and induce behavioral change (Green and Brock, 2000; Nabi and Green, 2015). Hence, by immersing audiences in cause-relevant narratives, transportation can reframe issues in personally meaningful terms, shifting attitudes and strengthening supportive responses (Liu, 2023; Rickard et al., 2021). Indeed, several studies find that audiences are more likely to develop a positive outlook toward environmental protection after watching environmental-related videos (Braddock and Dillard, 2016; Korfiatis et al., 2020; Liu, 2023), with the visualization properties of narratives enabling audiences to mentally simulate the story and thereby strengthening self-referencing and personal relevance (de Graaf, 2023), both of which are key to persuasion in environmental communication (Chen et al., 2024). Other studies further argue that textual narratives are more effective in persuading audiences than video narratives, leading to higher environmental support (Rickard et al., 2021). Regardless of the narrative form, these findings collectively indicate that narrative transportation effectively enhances the persuasive impact of messaging. As a result, we posit:

**H<sub>3</sub>**, Narrative transportation is positively associated with perceived persuasiveness.

Vicarious expression involves the observation and imitation of experiences and responses projected (Chen et al., 2019) and thus serves as a social cue according to the CASA paradigm (Reeves and Nass, 1996). Consumers can learn and adopt new responses by observing the expressions of others—a process grounded in social cognitive theory, which holds that modeled experiences can shape beliefs, attitudes, and behaviors without requiring direct personal experience (Bandura, 2001). This vicarious learning relies on social cues, such as DHA's facial expressions, body language, and verbal signals, to convey appropriate social norms, attitudes, and behaviors (Gambino et al., 2020).

Previous studies have suggested that online content with high vicarious expression is perceived as more engaging and persuasive (Appel et al., 2020; Chen et al., 2019) because it triggers empathic concern and perspective-taking, both of which enhance message receptivity (Small and Verrochi, 2009; Shen, 2010). This makes vicarious expression particularly impactful in online endorsements, where physical co-presence is absent and mediated warmth must be conveyed through observable expressive behaviors (Luo et al., 2026).

Drawing upon the CASA paradigm (Reeves and Nass, 1996), vicarious expression embedded in the content curated by a DHA, which goes beyond emotional display and information sharing (Yang et al., 2024), can simulate human expressiveness, enhance perceived social presence, and strengthen parasocial bonds (Yu et al., 2024). These connections can serve as trust surrogates, reducing uncertainty and skepticism, which, in turn, increases the likelihood that audiences will accept and internalize the DHA's advocacy message (Yang et al., 2024). In pro-environmental advocacy, where many audiences may already agree with the cause yet lack motivation to act, vicarious expression can make advocacy messages feel more personally relevant and emotionally urgent, thereby improving persuasiveness and subsequent responses (Gustafson et al., 2020). Consequently, we propose:

**H<sub>4</sub>**, Vicarious expression is positively associated with perceived persuasiveness.

### 2.3.3. DHA-content congruence and perceived persuasiveness

Drawing upon congruity theory (Osgood and Tannenbaum, 1955), DHA-content congruence refers to the extent to which the image of DHAs matches the pro-environmental messages they post on social media (Boerman et al., 2022). The theory holds that audiences seek cognitive consistency between their evaluation of the source and the message, and when this alignment is present, processing is more fluent, resistance is reduced, and persuasion is enhanced (Boerman et al., 2022; Eklund and Helmeffalk, 2022; Kim and Kim, 2021). In this context, congruity is achieved when the DHA's source cues, such as authenticity and credibility, are in harmony with the social cues embedded in the message, including narrative transportation and vicarious expression. This alignment signals that the DHA's advocacy is value-consistent and not opportunistic, an important consideration in domains like environmental communication where audiences are sensitive to perceived hypocrisy (Boerman et al., 2022; Yang et al., 2023a).

Indeed, research has consistently shown that strong source-message congruence is crucial in marketing communication (Baudier et al., 2023; Eklund and Helmeffalk, 2022). In pro-environmental advocacy, this congruence can reinforce the perceived integrity of the message, making it more resistant to skepticism and more likely to strengthen pro-environmental tendencies (Boerman et al., 2022; Sparkman and Attari, 2020). For instance, when DHAs' personal image and the content they share are congruent, audiences experience the message as both more believable and more personally relevant, which amplifies perceived authenticity and credibility and, in turn, strengthens persuasive impact (Kim and Kim, 2021). The effect is not merely additive, as congruity can act as a multiplier that allows a strong fit to magnify the influence of each cue on the audience's evaluation of the message (Ponnappan et al., 2026; Zhang et al., 2024). Given that climate advocacy often struggles

with audience disengagement and message fatigue (Ferreira et al., 2024), DHA-content congruence offers a way to present pro-environmental appeals in a coherent and compelling form that maximizes processing fluency and minimizes cognitive dissonance, wherein such an alignment creates a coherent and convincing narrative that resonates with the audience, making the pro-environmental message more compelling (Boerman et al., 2022). Hence, we posit:

**H<sub>5</sub>**, DHA-content congruence is positively associated with perceived persuasiveness.

### 2.3.4. Perceived persuasiveness and endorsement effects

Perceived persuasiveness refers to the extent to which an audience finds a message compelling (Chang et al., 2020). In the context of climate engagement, perceived persuasiveness functions as a pivotal attitudinal gateway, shaping not only awareness but also the motivational strength behind subsequent behaviors (Coleman et al., 2024). When the source is seen as authentic and credible, the message is often perceived as persuasive, thereby increasing message acceptance, reducing resistance, and enhancing the perceived personal relevance (Petty and Cacioppo, 1986; Pornpitakpan, 2004) of climate issues. In turn, this lower cognitive effort required to process and accept the message helps audiences recognize the urgency and direct impact of climate change on their lives (Huang and Benyoucef, 2014; Yang et al., 2023a).

From a persuasion process perspective, perceived persuasiveness strengthens the likelihood of central-route processing for audiences already motivated to engage while serving as a powerful peripheral cue for those with lower initial involvement (Petty and Cacioppo, 1986; Tormala and Petty, 2004), and thus, increasing the willingness to interact with climate change-related content (Huang and Benyoucef, 2014; Yang et al., 2023a). Persuasive social media tactics also enhance consumer engagement by leveraging social connectedness and network effects, enabling persuasive messages to spread beyond the initial audience (Weiger et al., 2018). It is therefore reasonable to expect that higher perceived persuasiveness would be associated with a greater likelihood of audiences engaging across a continuum of actions, ranging from low-effort digital behaviors (e.g., liking, sharing) to more effortful pro-environmental commitments (e.g., donating, lifestyle adjustments, pledging support). In this way, stronger persuasiveness could increase the probability that audiences take steps contributing to climate engagement. Given the importance of persuasion on climate engagement, we advance the following hypothesis:

**H<sub>6</sub>**, Perceived persuasiveness positively influences climate engagement.

Exposure to DHAs' climate-related content and active participation in discussions can shape consumer behavior toward environmental issues (Gerrath et al., 2024). Climate engagement, in this sense, reflects not only the consumption of environmental content but also active involvement in dialogue, advocacy, and behavior aligned with climate goals, which strengthens both cognitive and emotional investment in the cause (Köcher et al., 2025). As consumers become more engaged with environmental topics like climate change, their likelihood to adopt green behavior increases (Laheri et al., 2024). This relationship is consistent with the logic of behavioral reinforcement, which suggests that repeated engagement with a cause strengthens identification with its values (Ajzen and Kruglanski, 2019), making pro-environmental choices more habitual and self-reinforcing (van der Werff et al., 2014). Indeed, empirical evidence supports that consumer engagement in sustainable consumption is positively associated with green buying (Mansoor et al., 2022) and influences mindful consumption (Mohammad et al., 2021). Engagement in environmental topics can also lead to pro-environmental behavior, such as participating in environmental-related events, connecting and interacting with like-minded consumers, paying attention to environmental issues, and practicing environmentally responsible behavior (Alsaad et al., 2023; Kadic-Maglaljic et al., 2019; Saleem et al., 2021).

From a psychological perspective, climate engagement fosters a deeper sense of moral obligation and self-identity as an environmentally responsible individual (van der Werff et al., 2013; Whitmarsh and O'Neill, 2010). Such engagement increases knowledge and salience of environmental issues and provides repeated opportunities to publicly affirm and reinforce environmental values, strengthening commitment over time (Brick and Lewis, 2016; Thøgersen, 2004). This process aligns with the logic of commitment (Lokhorst et al., 2013), where active participation and public expression of support for a cause increase the likelihood of maintaining consistent behaviors to avoid cognitive dissonance and preserve self-concept. Importantly, sustained engagement serves as a psychological bridge between attitudinal support and enduring commitment, helping to close the attitude-behavior gap (Bissing-Olson et al., 2016; Whitmarsh and O'Neill, 2010). Moreover, given that engagement often involves public or socially visible actions, it also generates reputational incentives that reinforce pro-environmental self-identity (van der Werff et al., 2014). Hence, climate engagement is arguably not simply a precursor to isolated actions but a pathway to stable and ongoing pro-environmental commitment, making it reasonable to expect that higher levels of engagement will lead to stronger and more enduring commitment behaviors. Given this discussion, we establish the following hypothesis:

**H<sub>7</sub>.** Climate engagement positively influences pro-environmental commitment.

Perceived persuasiveness plays a crucial role in influencing consumers' decisions to adopt environmentally-friendly behaviors. The social cognitive perspective of persuasion suggests that a message judged as highly persuasive is more likely to be internalized and integrated into the recipient's value system, making its effects more durable and predictive of long-term behavioral commitment (Petty and Cacioppo, 1986; Tormala and Petty, 2004). When persuasive messages foster both cognitive agreement and emotional alignment, they can strengthen the perceived personal relevance of the cause, which, in turn, motivates individuals to act in ways consistent with those values over time (Bertolotti and Catellani, 2014; Nabi et al., 2018).

The persuasiveness of green advertising has been shown to positively affect word of mouth, purchase intentions, and future behavior, highlighting that persuasive influence can extend beyond immediate attitudes into sustained action (Yoon et al., 2020). This is consistent with evidence that messages perceived as credible, emotionally engaging, and personally relevant are more likely to produce enduring behavior change (Bertolotti and Catellani, 2014; Nabi et al., 2018). Persuasive communication from digital influencers can also significantly impact consumers' brand attitudes and purchase behavior (Rodrigues et al., 2024), suggesting that persuasive DHA advocacy can similarly drive meaningful pro-environmental outcomes (Gatersleben, 2023).

When audiences view DHA advocacy as compelling, it is reasonable to expect, based on persuasion theory and empirical evidence linking persuasive climate communication to sustained pro-environmental action, that they will be more likely to shift from passive agreement to active commitment (Ballew et al., 2024) and to adopt advocated behaviors consistently over time to maintain self-concept alignment and avoid cognitive dissonance (Lokhorst et al., 2013; Whitmarsh and O'Neill, 2010). In this way, perceived persuasiveness not only shapes immediate reactions but also acts as a catalyst for ongoing, value-driven engagement that aligns with the principles of pro-environmental commitment. Given these insights, we formulate the following hypothesis:

**H<sub>8</sub>.** Perceived persuasiveness positively influences pro-environmental commitment.

### 2.3.5. Mediating role of climate engagement

Climate engagement encompasses consumers' continuous interaction with climate change campaign-related posts, ranging from passive consumption to active creation (Schivinski et al., 2016). As a psychological and behavioral construct, it reflects the depth of an individual's

cognitive, emotional, and behavioral investment in climate-related discourse, making it a critical mechanism for converting message reception into committed action (Köcher et al., 2025). This engagement is crucial in bridging the gap between persuasive communication and active pro-environmental consumer behavior (Han et al., 2018).

According to the CASA paradigm (Reeves and Nass, 1996), the social communication between the avatar and viewers directly influences their perceptions and behaviors (Lou et al., 2022). When DHAs deliver persuasive messages, the human-like interaction cues they employ can trigger reciprocal social responses, increasing the likelihood that audiences will progress from message acceptance to active participation (Ham et al., 2024; Luo et al., 2026). Due to the social and interactive nature of computer-human communication, the perceived persuasiveness of the message leads to higher engagement levels, from liking and commenting to sharing and creating related content (Ham et al., 2024; Han et al., 2021).

Evidently, previous studies have shown that persuasive social media content can stimulate sustainable consumption practices and lifestyles by increasing online engagement (Han et al., 2018; Mansoor et al., 2022). In this context, climate engagement plays a significant role in information processing, transitioning viewers from passively receiving messages from DHAs to actively engaging in online conversations and co-creating climate change campaign-related posts (Barger et al., 2016). Such active engagement deepens personal relevance, strengthens environmental self-identity, and generates social accountability cues (Chen and Hsieh, 2023; Hartmann et al., 2025). Drawing on self-identity theory (Burke and Tully, 1977), these factors increase the likelihood of consistent, long-term pro-environmental behavior because people are motivated to preserve a coherent self-image as environmentally responsible, particularly when their identity is affirmed through public or social engagement (van der Werff et al., 2014). Hence, climate engagement is expected to mediate the link between perceived persuasiveness and pro-environmental commitment on the basis that persuasiveness encourages deeper involvement, which, in turn, fosters stronger commitment through repeated, socially visible actions and ongoing reinforcement of environmental values. Therefore, we posit:

**H<sub>9</sub>.** Climate engagement mediates the relationship between perceived persuasiveness and pro-environmental commitment.

### 2.3.6. Moderating role of environmental concern

Environmental concern reflects consumers' cognitive consciousness and intrinsic motivation to protect the environment and thus encompasses their knowledge of environmental issues, the belief that adopting certain behaviors can help solve these problems, and their willingness to act on these behaviors (De Canio et al., 2021; Laheri et al., 2024). Research has consistently shown that environmental concern is a critical driver for consumers to adopt a sustainable lifestyle (Newton et al., 2015; Wei et al., 2018). For instance, consumers with high environmental concern tend to be more responsive to eco-friendly and sustainable purchasing decisions, demonstrating a belief that these choices contribute to a lower environmental impact (Al-Quran et al., 2020; Filieri et al., 2021). Environmentally conscious individuals are thus more inclined to prioritize products they perceive as environmentally beneficial, reinforcing their commitment to minimizing ecological harm (Mannem et al., 2023; Schill and Fosse-Gomez, 2025). Moreover, consumers with higher environmental concern are more likely to have positive attitudes toward persuasive climate-related messages due to their pre-existing interest and commitment to environmental causes (He et al., 2022; Sulphrey and Faisal, 2021). Consequently, the perceived persuasiveness of climate-related messages is more likely to lead to greater climate engagement among those with higher environmental concern, as they are motivated to process information that supports their pro-environmental beliefs, as opposed to their lower counterparts (De Canio et al., 2021; Han et al., 2022).

Furthermore, consumers exhibiting higher levels of environmental concern are more likely to actively engage with climate-related content

on social media platforms, including actions such as sharing, commenting, and creating posts about environmental issues (Alsaad et al., 2023). They perceive climate engagement as a means of expressing their beliefs and values about environmental stewardship, which reinforces their engagement in pro-environmental behavior (Han et al., 2022). For example, those who are more concerned about the environment may feel a stronger sense of responsibility to act on climate-related issues and are more likely to translate their engagement into concrete actions (Alsaad et al., 2023; Lee and Hong, 2016).

Moreover, consumers with higher levels of environmental concern are also more likely to engage in pro-environmental and pro-community behaviors due to their shared goals and values (Chuang et al., 2025). They tend to evaluate information more favorably, leading to a stronger commitment to engage in pro-environmental behaviors (Cerri et al., 2018). The presence of environmental concern amplifies the influence of persuasive communication on future behavior, such as energy conservation and waste sorting. In this regard, consumers with high concern are more likely to align their actions with their environmental values when persuaded by compelling messages (Bamberg and Möser, 2007; He et al., 2022).

More importantly, environmental concern as a moderator holds the potential to provide deeper insights regarding sustainable behaviors (Cachero-Martínez, 2020; Gómez-Carmona et al., 2022). This concern could strengthen the relationship among perceived persuasiveness, climate engagement, and pro-environmental commitment by amplifying consumers' motivations to engage in and commit to environmental conservation. Thus, we propose:

**H<sub>10a</sub>.** Environmental concern moderates the relationship between perceived persuasiveness and climate engagement, such that when environmental concern is high, the relationship between perceived persuasiveness and climate engagement is stronger.

**H<sub>10b</sub>.** Environmental concern moderates the relationship between climate engagement and pro-environmental commitment, such that when environmental concern is high, the relationship between climate engagement and pro-environmental commitment is stronger.

**H<sub>10c</sub>.** Environmental concern moderates the relationship between perceived persuasiveness and pro-environmental commitment, such that when environmental concern is high, the relationship between perceived persuasiveness and pro-environmental commitment is stronger.

### 2.3.7. Control variables

Prior research indicates that social media usage significantly influences pro-environmental consumer behavior (Han et al., 2018). Other studies have also shown that age, gender, education, and occupation play important roles in shaping pro-environmental consumer behavior (Odou and Schill, 2020; Sreen et al., 2021), wherein these demographic factors can reflect potential differences in consumer awareness, concern, and engagement with environmental issues, thereby influencing their pro-environmental commitment. Given these findings, we incorporate age (generation), gender, education, occupation, and social media usage duration (daily) as control variables to provide a better understanding of the factors influencing pro-environmental consumer behavior. Fig. 1 presents the research model and hypothesized relationships.

## 3. Methodology

A two-country survey conducted in China and South Korea was designed to assess DHA's endorsement effectiveness in persuading audiences to commit to pro-environmental behavior (H<sub>1</sub>–H<sub>8</sub>) and test the mediating role of climate engagement (H<sub>9</sub>) and the moderating role of environmental concern (H<sub>10a-c</sub>).

### 3.1. Instrumentation

Established measurement items from reputable sources were adapted

to ensure reliability and validity (Table 2). Authenticity was measured using items adapted from Li and Ma (2024), credibility from Ohanian (1990), narrative transportation from Green and Brock (2000), vicarious expression from Chen et al. (2019), DHA-content congruence from Zhang and Xu (2024), perceived persuasiveness from Chang et al. (2020), environmental concern from De Canio et al. (2021), climate engagement from Schivinski et al. (2016), and pro-environmental commitment from Boerman et al. (2022) and Wang et al. (2023). Given the context of data collection in China and South Korea, the online questionnaire was translated using a back-translation method to ensure construct validity (Brislin, 1970). A pretest was conducted with a panel of 12 members (four marketing professors and eight Gen Y or Gen Z individuals who follow DHAs) to ensure content validity. Following this, a pilot test with 50 valid responses was performed to establish face validity and evaluate the reliability of the constructs. The composite reliability of the scale items exceeded the generally acceptable 0.70 threshold, confirming their internal consistency and reliability.

### 3.2. Sampling

Data were collected in China and South Korea via online surveys targeting both Generations Y and Z. A purposive sampling approach was employed to ensure that participants had recent exposure to DHA content on social media. The overall data collection process remained consistent across both countries, with minor adjustments made to the distribution platform. For China, data collection was conducted through an online survey hosted on Wenjuanxing (<https://www.wjx.com>) and distributed via the social media platform Little Red Book. As a popular social commerce and lifestyle platform, Little Red Book has a strong user base of digitally savvy individuals, with 77% of users aged 18–34 (Sohu, 2024). This demographic aligns well with our target participants—Generations Y and Z—who are key drivers of climate awareness and digital engagement. Little Red Book also hosts numerous virtual influencers (de Boissieu and Baudier, 2023), making it ideal for studying the effects of DHA-led pro-environmental advocacy. For South Korea, the same survey procedure was implemented, with data collection facilitated by Embrain (<https://embrain.com>) via popular social media platforms such as Facebook and Instagram. These platforms were selected to ensure access to a digitally engaged Generations Y and Z audience, who actively consume DHA-related content and engage in discussions about environmental issues and sustainability. This ensured that the South Korean sample was comparable to the Chinese sample, enabling meaningful cross-country analysis.

Respondents, regardless of whether they were in China or South Korea, had to meet two screening criteria. First, respondents were required to confirm their age by answering, “Were you born between 1982 and 2010?” (Generation Y: 1982–1994; Murray et al., 2011; Generation Z: 1995–2010; Upadhyay et al., 2024). Second, they had to confirm recent exposure to DHA content by responding affirmatively to the question, “Have you watched any social media posts from a DHA within the last one month?” These criteria ensured participants were social media-active digital natives, familiar with DHAs, and capable of providing relevant insights into DHA-led pro-environmental consumer behavior (Ameen et al., 2023; Statista, 2020). Respondents who did not meet these criteria were excluded. Eligible participants were then required to view a pro-environmental DHA post featuring Imma for two minutes (Appendix Exhibit A1) before proceeding with the survey (Appendix Exhibit A2–A4). This step ensured uniform exposure to DHA content, thereby enhancing response reliability across both countries.

Participation in the survey was entirely voluntary and respondents provided informed consent before proceeding. To encourage participation, respondents in China and South Korea were offered a random incentive of RMB5–10 (China) or an equivalent amount of KRW1,000 (South Korea) upon completing the questionnaire (USD1 ≈ RMB7, USD1 ≈ KRW1468). In China, 550 responses were collected, of which 74 were discarded due to incompleteness or uniform answers, resulting in 476

**Table 2**  
Measurement items.

Construct and item	Source
<b>Authenticity</b>	Li and Ma (2024)
AUT1 I think that Digital Human Avatar (DHA) behaves the same way as human influencers.	
AUT2 I think that Digital Human Avatar (DHA) is relatable to my daily life.	
AUT3 I think that Digital Human Avatar (DHA) clearly communicates their purpose (e.g., environmental protection).	
AUT4 I think that Digital Human Avatar (DHA) transparently and passionately promotes information.	
<b>Credibility</b>	Ohanian (1990)
<i>Expertise</i>	
EXP1 I feel that Digital Human Avatar (DHA) is credible.	
EXP2 I feel that Digital Human Avatar (DHA) is experienced.	
EXP3 I feel that Digital Human Avatar (DHA) is knowledgeable.	
EXP4 I feel that Digital Human Avatar (DHA) is convincing.	
<i>Trustworthiness</i>	
TRU1 I feel that Digital Human Avatar (DHA) is trustworthy.	
TRU2 I feel that Digital Human Avatar (DHA) is reliable.	
TRU3 I feel that Digital Human Avatar (DHA) is believable.	
TRU4 I feel that Digital Human Avatar (DHA) is honest.	
<b>Narrative transportation</b>	Green and Brock (2000)
NT1 The post content really intrigued me.	
NT2 The post content affected me emotionally.	
NT3 I wanted to know how the post content ended.	
NT4 I could picture myself in the scene of the events described in the post content.	
NT5 The post content reminded me of experiences or feelings I've had in my own life.	
NT6 I would like to have an experience like the one shown in the post content.	
<b>Vicarious expression</b>	Chen et al. (2019)
VE1 By watching the post content, I can feel what the Digital Human Avatar (DHA) is trying to say about her experience in environmental protection.	
VE2 By watching the post content, I can imagine what the Digital Human Avatar (DHA) is trying to say about her experience in environmental protection.	
VE3 By watching the post content, I can envision what the Digital Human Avatar (DHA) is trying to say about her experience in environmental protection.	
<b>DHA-content congruence</b>	Zhang and Xu (2024)
After viewing the Digital Human Avatar (DHA)'s post, I feel that her image and post content are ...	
DCC1 Compatible	
DCC2 Suitable	
DCC3 Good fit	
DCC4 Relevant	
<b>Perceived persuasiveness</b>	Chang et al. (2020)
PP1 I consider the post content to be convincing.	
PP2 I consider the post content to be believable.	
PP3 I consider the post content to be trustworthy.	
PP4 The post content changed my impression toward environmental protection.	
<b>Climate engagement</b>	Schivinski et al. (2016)
<i>Climate content consumption</i>	
CSP1 I want to read DHA's posts related to climate change.	
CSP2 I want to watch DHA's pictures/videos related to climate change.	
CSP3 I want to 'follow' DHA's content related to climate change.	

**Table 2 (continued)**

Construct and item	Source
<i>Climate content contribution</i>	
CTB1 I want to 'comment' on DHA's posts related to climate change.	
CTB2 I want to 'share' DHA's content related to climate change.	
CTB3 I want to 'like' DHA's posts related to climate change.	
<i>Climate content creation</i>	
CRE1 I want to initiate posts related to climate change.	
CRE2 I want to post pictures/videos related to climate change.	
CRE3 I want to 'tag' my friends in posts related to climate change.	
<b>Environmental concern</b>	De Canio et al. (2021)
EC1 I pay attention to using recycled materials.	
EC2 I pay attention to reducing waste generated.	
EC3 I pay attention to water saving.	
EC4 I pay attention to energy saving.	
<b>Pro-environmental commitment</b>	Boerman et al. (2022), Wang et al. (2023)
PEC1 I will bring reusable bags with me to the grocery store.	
PEC2 I will reuse items rather than throwing them in the trash bin.	
PEC3 I will make sure that all lights are switched off in unoccupied rooms.	
PEC4 I will make sure that air conditioner is turned off when I am away.	
PEC5 I will take short showers to save energy and water.	
PEC6 I will wash my clothes at low temperatures to save energy.	
PEC7 I will bike, walk, or use public transportation when that is an option, instead of driving.	

valid responses. In South Korea, 500 responses were collected, with 15 discarded for similar reasons, leaving 485 valid responses.

Descriptive statistics revealed several socio-demographic differences between the Chinese ( $n = 476$ ) and the South Korean ( $n = 485$ ) samples. For instance, the proportion of female participants was slightly higher among the Chinese sample (57.77%) compared to the South Korean sample (50.72%). While both samples included respondents from Generations Y and Z, the Chinese sample had a higher proportion of Generation Z participants (55.25%), whereas the South Korean sample featured a more balanced distribution between the two generations (Generation Y: 49.90%; Generation Z: 50.10%). Regarding occupation, the Chinese sample included a notably larger share of students (63.24%), whereas the South Korean sample had a significantly higher proportion of private employees (49.90%). Although undergraduate education was the most common qualification in both samples (China: 47.27%; South Korea: 72.99%), the Chinese sample had a considerably higher proportion of respondents holding master's (28.15%) or doctoral (5.67%) degrees compared to the South Korean sample (Master's: 5.98%; Doctorate: 1.03%). Regarding daily social media usage, most respondents in both samples reported spending between one and three hours per day on social media (China: 49.16%; South Korea: 46.39%), with slightly higher engagement (3–6 h daily) observed in the South Korean sample (25.77%) compared to the Chinese sample (23.74%). These demographic differences provide valuable insights into respondent characteristics and social media engagement patterns in China and South Korea (Table 3).

### 3.3. Analysis

The data analysis began with checks for common method variance (CMV) using the SPSS v. 30 software. Partial least squares path modeling (PLSPM) was subsequently conducted using the SmartPLS v. 4 software to test the hypothesized relationships (Becker et al., 2023). PLSPM was

**Table 3**  
Profile of survey respondents.

Socio-demographic	Characteristic	China (n = 476) %	South Korea (n = 485) %
Gender	Female	57.77	50.72
	Male	42.23	49.28
Generation	Generation Y (1982–1994)	44.75	49.90
	Generation Z (1995–2010)	55.25	50.10
Education	Secondary or below	18.91	20.00
	Undergraduate	47.27	72.99
	Master	28.15	5.98
	Doctorate	5.67	1.03
Occupation	Student	63.24	22.89
	Government employee	6.51	4.33
	Entrepreneurs	5.25	0.00
	Private employee	12.39	49.90
	Self-employed	5.67	4.12
	Freelance	4.62	9.69
	Other	2.31	9.07
	Social media usage duration (daily)		
Less than 1 h	20.59	23.09	
1–3 h	49.16	46.39	
3–6 h	23.74	25.77	
More than 6 h	6.51	4.74	

Notes: The 0.00% for entrepreneurs in South Korea reflects a true zero count ( $n = 0$ ), not rounding.

chosen for its exploratory-predictive nature, which aligns well with the exploratory goals of this research (Chin et al., 2020; Sharma et al., 2024).

## 4. Results

### 4.1. Measurement model

Given the cross-sectional nature of this research, two statistical methods were used to assess *common method variance (CMV)*. First, Harman's single-factor test revealed that the first factor accounted for 38.756% of the variance in China and 43.787% in South Korea, both below the 50% threshold, indicating CMV is not a significant issue (Podsakoff et al., 2012). Second, the full collinearity test showed that variance inflation factor (VIF) in both China and South Korea remained below the threshold value of 5 (Hair et al., 2021), further confirming that CMV is not a concern in our dataset (Table 4).

Next, we examined the reliability and validity of the reflective measures (Cheah et al., 2018). All outer loading and average variance extracted (AVE) values exceeded the minimum benchmark of 0.50 (Table 4), indicating *convergent validity* (Hair et al., 2021), whereas all heterotrait-monotrait (HTMT) ratio of correlations were below the maximum cutoff of 0.90 (Table 5), indicating *discriminant validity* (Henseler et al., 2015). The Cronbach's alpha ( $\alpha$ ) and composite reliability ( $\rho_c$ ) surpassed the minimum threshold of 0.70 (Table 4), indicating good internal consistency or reliability (Hair et al., 2021).

The disjoint two-stage approach was used to assess the higher-order constructs (HOCs) of climate engagement and credibility (Becker et al., 2023; Sarstedt et al., 2019). Redundancy analysis revealed path coefficients of 0.802 and 0.808 for the HOCs to the criterion construct in China and 0.843 and 0.881 in South Korea (Table 6), respectively, demonstrating that the HOCs, formed from their corresponding lower-order constructs (LOCs), explained more than 50% of the variance in the criterion constructs, which were unidimensional (global) reflective measures of climate engagement and credibility. These findings confirm strong convergent validity for the formative HOCs (Cheah et al., 2018). The VIF values for the LOCs in both countries ranged from 1.802 to 3.258, remaining below the maximum threshold of 5, indicating no significant collinearity issues (Hair et al., 2021). All LOCs had

statistically significant weight values, indicating that each LOC significantly contributed to the formation of their respective HOCs (Cheah et al., 2018).

### 4.2. Structural model

The results of the structural model for both countries are presented in Table 7. We first checked for potential collinearity among predictors. The VIF values for all paths in both countries (China and South Korea) fell below the maximum threshold of 5, indicating no collinearity issues (Hair et al., 2021). Using bootstrapping with 10,000 subsamples, we evaluated the significance of inter-construct relationships (Becker et al., 2023).

**Main effects.** For China and South Korea, credibility (China:  $\beta = 0.277, p < 0.01$ ; South Korea:  $\beta = 0.219, p < 0.01$ ), narrative transportation (China:  $\beta = 0.327, p < 0.01$ ; South Korea:  $\beta = 0.308, p < 0.01$ ), vicarious expression (China:  $\beta = 0.086, p < 0.05$ ; South Korea:  $\beta = 0.244, p < 0.01$ ), and DHA-content congruence (China:  $\beta = 0.269, p < 0.01$ ; South Korea:  $\beta = 0.202, p < 0.01$ ) positively influence perceived persuasiveness, supporting  $H_2, H_3, H_4$  and  $H_5$ . However, authenticity (China:  $\beta = 0.026, p = 0.261 > 0.05$ ; South Korea:  $\beta = 0.038, p = 0.198 > 0.05$ ) did not significantly affect perceived persuasiveness, not supporting  $H_1$ . Whereas, perceived persuasiveness significantly influences climate engagement (China:  $\beta = 0.693, p < 0.01$ ; South Korea:  $\beta = 0.775, p < 0.01$ ), supporting  $H_6$ . Both climate engagement (China:  $\beta = 0.102, p < 0.05$ ; South Korea:  $\beta = 0.200, p < 0.01$ ) and perceived persuasiveness (China:  $\beta = 0.183, p < 0.01$ ; South Korea:  $\beta = 0.221, p < 0.01$ ) show positive and significant relationships with pro-environmental commitment, supporting  $H_7$  and  $H_8$ .

**Mediation effects.** For China and South Korea, climate engagement mediates the relationship between perceived persuasiveness and pro-environmental commitment (China:  $\beta = 0.071, p < 0.05$ ; South Korea:  $\beta = 0.155, p < 0.01$ ), supporting  $H_9$ .

**Moderation effects.** We used a two-stage approach for the moderation analysis (Becker et al., 2023). For China, environmental concern significantly moderates the relationships between climate engagement and pro-environmental commitment ( $\beta = 0.081, p < 0.05$ ) and between perceived persuasiveness and pro-environmental commitment ( $\beta = 0.228, p < 0.01$ ). The interaction plot in Fig. 2 Panels A and B illustrates that consumers with high environmental concern experience a stronger influence of climate engagement and perceived persuasiveness on pro-environmental commitment. However, environmental concern does not moderate the relationship between perceived persuasiveness and climate engagement ( $\beta = -0.059, p = 0.169 > 0.05$ ). Therefore,  $H_{10b}$  and  $H_{10c}$  were supported, but not  $H_{10a}$ . For South Korea, environmental concern moderates only the relationship between perceived persuasiveness and pro-environmental commitment ( $\beta = 0.120, p < 0.05$ ), supporting  $H_{10c}$ , whereas  $H_{10a}$  ( $\beta = -0.035, p = 0.115 > 0.05$ ) and  $H_{10b}$  ( $\beta = -0.021, p = 0.385 > 0.05$ ) were not supported. The interaction plot in Fig. 2 Panel C illustrates that consumers with high environmental concern experience a stronger influence of perceived persuasiveness on pro-environmental commitment.

**Multi-group effects.** The measurement invariance of composite models (MICOM) procedure (Henseler et al., 2016) was applied to assess whether the measurement properties were equivalent across groups, namely, the China and South Korea datasets, in order to proceed to multi-group analysis (MGA). MICOM follows a three-step process: the first step assesses configural invariance, the second establishes compositional invariance, and the third evaluates equal means and equal variances. The results of MICOM are presented in Table 8.

The first condition, *configural invariance*, assesses whether the model setup (algorithm setting and indicator configuration) is identical across groups. All constructs achieved configural invariance as both groups used the same model specification. The second condition, *compositional invariance*, evaluates whether the composite scores are constructed equivalently across groups and is considered achieved when the original

**Table 4**  
Assessment of convergent validity, internal consistency or reliability, and common method variance.

Construct	Item	China Convergent validity		Internal consistency or reliability		Common method variance		South Korea Convergent validity		Internal consistency or reliability		Common method variance	
		$\lambda$	AVE	$\alpha$	$\rho_c$	VIF	Harman's single factor	$\lambda$	AVE	$\alpha$	$\rho_c$	VIF	Harman's single factor
Authenticity	AUT1	0.690	0.54	0.71	0.82	1.070	38.756%	0.738	0.63	0.81	0.87	2.511	43.787%
	AUT2	0.599						0.808					
	AUT3	0.827						0.778					
	AUT4	0.789						0.855					
Credibility: Expertise	EXP1	0.841	0.63	0.80	0.87	1.085		0.892	0.78	0.91	0.94	3.251	
	EXP2	0.814						0.885					
	EXP3	0.699						0.880					
	EXP4	0.816						0.881					
Credibility: Trustworthiness	TRU1	0.911	0.77	0.90	0.93	1.662		0.893	0.85	0.94	0.96	3.356	
	TRU2	0.910						0.940					
	TRU3	0.887						0.934					
	TRU4	0.797						0.912					
Narrative transportation	NT1	0.817	0.66	0.90	0.92	1.979		0.849	0.79	0.95	0.96	3.387	
	NT2	0.841						0.890					
	NT3	0.854						0.861					
	NT4	0.837						0.893					
	NT5	0.794						0.936					
	NT6	0.722						0.888					
Vicarious expression	VE1	0.886	0.78	0.86	0.91	2.388		0.840	0.82	0.89	0.93	2.875	
	VE2	0.886						0.937					
	VE3	0.878						0.929					
DHA-content congruence	DCC1	0.893	0.81	0.92	0.95	2.598		0.913	0.86	0.95	0.96	2.678	
	DCC2	0.909						0.943					
	DCC3	0.915						0.945					
	DCC4	0.881						0.907					
Perceived persuasiveness	PP1	0.860	0.73	0.88	0.91	3.180		0.916	0.85	0.94	0.96	1.106	
	PP2	0.904						0.943					
	PP3	0.835						0.929					
	PP4	0.812						0.903					
Climate engagement: Creation	CRE1	0.887	0.76	0.84	0.91	2.116		0.944	0.87	0.93	0.95	1.922	
	CRE2	0.909						0.957					
	CRE3	0.817						0.903					
Climate engagement: Consumption	CSP1	0.909	0.82	0.89	0.93	2.861		0.955	0.90	0.95	0.97	4.506	
	CSP2	0.889						0.965					
	CSP3	0.918						0.933					
Climate engagement: Contribution	CTB1	0.933	0.87	0.85	0.93	3.029		0.939	0.90	0.89	0.95	4.253	
	CTB2	0.932						0.958					
	CTB3	0.895						0.898					
Environmental concern	EC1	0.824	0.66	0.83	0.89	2.552		0.831	0.60	0.84	0.85	1.043	
	EC2	0.783						0.823					
	EC3	0.849						0.519					
	EC4	0.791						0.866					
Pro-environmental commitment	PEC1	0.823	0.59	0.88	0.91	2.911		0.709	0.53	0.86	0.89	1.057	
	PEC2	0.749						0.740					
	PEC3	0.712						0.745					
	PEC4	0.669						0.721					
	PEC5	0.813						0.783					
	PEC6	0.824						0.722					
	PEC7	0.768						0.661					

Notes:  $\lambda$  = Outer loading. AVE = Average variance extracted.  $\alpha$  = Cronbach alpha.  $\rho_c$  = Composite reliability. VIF = Variance inflation factor.

correlation between composites is very close to 1.0 and lies within the 95% permutation-based confidence interval (CI), with a permutation  $p$ -value that is not significant ( $p > 0.05$ ). All constructs met these criteria, indicating compositional invariance for the measurement model. The third condition, *equal mean and variance*, tests whether the groups have statistically equivalent composite means and variances. Only climate engagement and credibility had no significant differences in means and variances residing within the permutation-based confidence interval, with permutation  $p$ -values that are not significant ( $p > 0.05$ ), thereby signaling their equality of means and variances across groups, but not for the rest of the constructs. All in all, *partial measurement invariance* is established in our study when configural invariance (first condition) and compositional invariance (second condition) hold for every construct, regardless of whether equality of means or variances (third condition) is

achieved.

Since China and South Korea datasets achieve partial measurement invariance, we can proceed to make valid cross-group comparisons of path coefficients in MGA (Henseler et al., 2016). More specifically, MGA reveals that China and South Korea yield similar results, as the differences in standardized beta values remain relatively small across most hypothesized relationships. For instance, credibility's impact on perceived persuasiveness differs by only 0.058 ( $\beta = 0.277$  in China,  $\beta = 0.219$  in South Korea) while narrative transportation's effect is nearly identical, with only a 0.019 difference ( $\beta = 0.327$  in China,  $\beta = 0.308$  in South Korea). Similarly, perceived persuasiveness significantly influences climate engagement in both countries, with a minor variation of 0.082 ( $\beta = 0.693$  in China,  $\beta = 0.775$  in South Korea). Although a few larger differences are observed, such as vicarious expression's influence

**Table 5**  
Assessment of discriminant validity using heterotrait-monotrait (HTMT) ratio of correlations.

Country	Construct	AUT	CSP	CTB	CRE	DCC	EC	EXP	NT	PP	PEC	TRU	VE
China	Authenticity (AUT)												
	Consumption (CSP)	0.627											
	Contribution (CTB)	0.493	0.736										
	Creation (CRE)	0.516	0.627	0.795									
	DHA-content congruence (DCC)	0.688	0.702	0.465	0.442								
	Environmental concern (EC)	0.247	0.420	0.376	0.385	0.277							
	Expertise (EXP)	0.737	0.541	0.415	0.403	0.589	0.131						
	Narrative transportation (NT)	0.693	0.778	0.630	0.595	0.637	0.328	0.571					
	Perceived persuasiveness (PP)	0.700	0.822	0.683	0.613	0.760	0.320	0.671	0.779				
	Pro-environmental commitment (PEC)	0.365	0.524	0.477	0.479	0.441	0.880	0.281	0.468	0.494			
	Trustworthiness (TRU)	0.643	0.551	0.397	0.387	0.548	0.162	0.857	0.536	0.712	0.296		
	Vicarious expression (VE)	0.694	0.730	0.495	0.507	0.842	0.333	0.663	0.702	0.748	0.501	0.548	
	South Korea	Authenticity (AUT)											
Consumption (CSP)		0.830											
Contribution (CTB)		0.726	0.865										
Creation (CRE)		0.505	0.620	0.750									
DHA-content congruence (DCC)		0.813	0.673	0.565	0.322								
Environmental concern (EC)		0.216	0.201	0.194	0.110	0.172							
Expertise (EXP)		0.819	0.776	0.694	0.454	0.704	0.198						
Narrative transportation (NT)		0.847	0.833	0.762	0.526	0.751	0.190	0.797					
Perceived persuasiveness (PP)		0.866	0.818	0.724	0.450	0.816	0.230	0.814	0.884				
Pro-environmental commitment (PEC)		0.319	0.356	0.298	0.359	0.351	0.082	0.238	0.332	0.351			
Trustworthiness (TRU)		0.841	0.745	0.664	0.427	0.663	0.230	0.869	0.754	0.793	0.202		
Vicarious expression (VE)		0.865	0.770	0.602	0.379	0.780	0.158	0.736	0.821	0.868	0.412	0.703	

Notes: Consumption, contribution, and creation are part of climate engagement while expertise and trustworthiness are part of credibility.

**Table 6**  
Assessment of higher-order and lower-order constructs using redundancy analysis.

Country	Higher-order construct (HOC)	Lower-order construct (LOC)	Weight	Confidence interval	t-value	Variance inflation factor	Path coefficient of HOC to criterion construct
China	Climate engagement	Consumption	0.698	[0.614; 0.775]	14.143**	1.802	0.802
		Contribution	0.185	[0.068; 0.307]	2.524**	2.272	
		Creation	0.247	[0.129; 0.360]	3.493**	1.880	
	Credibility	Expertise	0.341	[0.201; 0.476]	4.105**	2.193	0.808
Trustworthiness		0.722	[0.594; 0.844]	9.605**	2.193		
South Korea	Climate engagement	Consumption	0.863	[0.759; 0.955]	14.371**	2.731	0.843
		Contribution	0.165	[0.034; 0.292]	2.134*	3.258	
		Creation	0.175	[0.078; 0.317]	2.364**	1.873	
	Credibility	Expertise	0.560	[0.464; 0.656]	9.551**	2.799	0.881
		Trustworthiness	0.494	[0.394; 0.588]	8.315**	2.799	

Notes: \* =  $p < 0.05$ . \*\* =  $p < 0.01$ . Weights represent the relative contribution of each LOC to the formation of the HOC.

on perceived persuasiveness (difference: 0.158;  $\beta = 0.086$  in China,  $\beta = 0.244$  in South Korea) and climate engagement’s effect on pro-environmental commitment (difference: 0.098;  $\beta = 0.102$  in China,  $\beta = 0.200$  in South Korea), the overall pattern of relationships remains consistent. Moreover, the effect of perceived persuasiveness on pro-environmental commitment through climate engagement is present in both countries, with a relatively small difference of 0.084 ( $\beta = 0.071$  in China,  $\beta = 0.155$  in South Korea). Overall, the consistency of findings across China and South Korea reinforces the robustness of the structural model and its relationships.

**5. Discussion**

Drawing on the CASA paradigm (Reeves and Nass, 1996) and congruity theory (Osgood and Tannenbaum, 1955), this research examined how DHA-related source cues, content-related social cues, and DHA-content congruence influence perceived persuasiveness, climate engagement, and pro-environmental commitment among consumers, which, in turn, provided triangulated empirical support from China and South Korea on the effectiveness of DHAs in promoting pro-environmental causes.

**5.1. On the factors influencing DHA-human interaction**

This research investigated two DHA-related source cues (authenticity and credibility), two content-related social cues (narrative transportation and vicarious expression), and DHA-content congruence in influencing DHA-human interaction on environmental issues.

For source cues, credibility significantly influences perceived persuasiveness across countries (China and South Korea), supporting H<sub>2</sub>. This is a counterintuitive finding because it contradicts prior research suggesting that DHAs are inherently less persuasive than human influencers due to credibility deficits (Ozdemir et al., 2023). Our results challenge this assumption by demonstrating that, in sustainability advocacy, DHAs can overcome these supposed limitations and exert strong persuasive influence when they successfully project expertise and trustworthiness. This suggests that credibility deficits are not an inherent, fixed property of DHAs but may be context-contingent and mitigable. In particular, sustainability messaging may provide a credibility “bridge” by aligning DHAs with socially valued, non-commercial causes, allowing audiences to judge them more on informational quality than on human authenticity. More importantly, our findings are consistent with emerging evidence that credible DHAs, when supported by technological sophistication and message-audience alignment, can shape perceptions and motivate sustainability-related behaviors (de Boissieu and Baudier, 2023; Yang et al., 2023a). In this light, credibility

**Table 7**  
Assessment of structural model.

Country	Effect	Relationship	Standardized beta	Standard error	t-value	95% BCa CI	Significant? (yes/no)	VIF	R <sup>2</sup>	Q <sup>2</sup> <sub>predict</sub>	
China	Main (direct)	H <sub>1</sub> . Authenticity → Perceived persuasiveness	0.026	0.040	0.640	[-0.039; 0.091]	No	1.905	0.661	0.475	
		H <sub>2</sub> . Credibility → Perceived persuasiveness	0.277	0.043	6.418**	[0.206; 0.349]	Yes	1.720			
		H <sub>3</sub> . Narrative transportation → Perceived persuasiveness	0.327	0.051	6.429**	[0.242; 0.409]	Yes	1.880			
		H <sub>4</sub> . Vicarious expression → Perceived persuasiveness	0.086	0.049	1.738*	[0.009; 0.168]	Yes	2.680			
		H <sub>5</sub> . DHA-content congruence → Perceived persuasiveness	0.269	0.063	4.257**	[0.163; 0.372]	Yes	2.558			
		H <sub>6</sub> . Perceived persuasiveness → Climate engagement	0.693	0.038	18.456**	[0.628; 0.751]	Yes	1.088	0.602	0.412	
		H <sub>7</sub> . Climate engagement → Pro-environmental commitment	0.102	0.047	2.158*	[0.029; 0.184]	Yes	2.576	0.692	0.392	
		H <sub>8</sub> . Perceived persuasiveness → Pro-environmental commitment	0.183	0.048	3.835**	[0.100; 0.256]	Yes	2.415			
		H <sub>9</sub> . Perceived persuasiveness → Climate engagement → Pro-environmental commitment	0.071	0.033	2.116*	[0.020; 0.128]	Yes				
	Moderation (interaction)	H <sub>10a</sub> . Perceived persuasiveness × Environmental concern → Climate engagement	-0.049	0.035	1.417	[-0.106; 0.010]	No				
		H <sub>10b</sub> . Climate engagement × Environmental concern → Pro-environmental commitment	0.081	0.047	1.718*	[0.004; 0.151]	Yes				
		H <sub>10c</sub> . Perceived persuasiveness × Environmental concern → Pro-environmental commitment	0.228	0.059	3.896**	[0.123; 0.314]	Yes				
		Control (direct)	Generation → Pro-environmental commitment	0.019	0.051	0.375	[-0.069; 0.097]	No			
			Gender → Pro-environmental commitment	0.041	0.023	1.752	[0.002; 0.078]	No			
			Education → Pro-environmental commitment	0.132	0.057	2.333*	[0.041; 0.226]	Yes			
		Occupation → Pro-environmental commitment	-0.026	0.030	0.855	[-0.076; 0.023]	No				
		Social media usage duration → Pro-environmental commitment	-0.018	0.030	0.606	[-0.069; 0.032]	No				
	South Korea	Main (direct)	H <sub>1</sub> . Authenticity → Perceived persuasiveness	0.038	0.045	0.850	[-0.034; 0.115]	No	3.247	0.812	0.686
			H <sub>2</sub> . Credibility → Perceived persuasiveness	0.219	0.046	4.736**	[0.139; 0.294]	Yes	3.086		
			H <sub>3</sub> . Narrative transportation → Perceived persuasiveness	0.308	0.043	7.228**	[0.237; 0.377]	Yes	3.494		
H <sub>4</sub> . Vicarious expression → Perceived persuasiveness			0.244	0.042	5.772**	[0.176; 0.314]	Yes	3.096			
H <sub>5</sub> . DHA-content congruence → Perceived persuasiveness			0.202	0.038	5.362**	[0.140; 0.265]	Yes	2.593			
H <sub>6</sub> . Perceived persuasiveness → Climate engagement			0.775	0.026	30.065**	[0.733; 0.817]	Yes	1.067	0.606	0.404	
H <sub>7</sub> . Climate engagement → Pro-environmental commitment			0.200	0.076	2.634**	[0.073; 0.321]	Yes	2.693	0.195	0.086	
H <sub>8</sub> . Perceived persuasiveness → Pro-environmental commitment			0.221	0.075	2.940**	[0.100; 0.348]	Yes	2.707			
H <sub>9</sub> . Perceived persuasiveness → Climate engagement → Pro-environmental commitment			0.155	0.059	2.632**	[0.056; 0.249]	Yes				
Moderation (interaction)		H <sub>10a</sub> . Perceived persuasiveness × Environmental concern → Climate engagement	-0.035	0.029	1.201	[-0.082; 0.014]	No				
		H <sub>10b</sub> . Climate engagement × Environmental concern → Pro-environmental commitment	-0.021	0.073	0.292	[-0.137; 0.105]	No				
		H <sub>10c</sub> . Perceived persuasiveness × Environmental concern → Pro-environmental commitment	0.120	0.066	1.818*	[0.003; 0.252]	Yes				
		Control (direct)	Generation → Pro-environmental commitment	-0.172	0.101	1.700	[-0.340; -0.005]	No			
			Gender → Pro-environmental commitment	0.020	0.046	0.436	[-0.055; 0.096]	No			
			Education → Pro-environmental commitment	0.359	0.091	3.959**	[0.212; 0.508]	Yes			

(continued on next page)

Table 7 (continued)

Country	Effect	Relationship	Standardized beta	Standard error	t-value	95% BCa CI	Significant? (yes/no)	VIF	R <sup>2</sup>	Q <sup>2</sup> <sub>predict</sub>
		Occupation → Pro-environmental commitment	-0.075	0.050	1.507	[-0.155; 0.007]	No			
		Social media usage duration → Pro-environmental commitment	0.014	0.044	0.324	[-0.057; 0.089]	No			

Notes: \* =  $p < 0.05$ . \*\* =  $p < 0.01$ . BCa CI = Bias-corrected and accelerated confidence interval. VIF = Variance inflation factor.

should be viewed not simply as a background trait for DHAs but as a strategic lever which, if cultivated, can unlock audience trust and acceptance even in contexts where emotional authenticity may be limited, thereby expanding the scope of campaigns in which DHAs can be effectively deployed.

However, authenticity does not significantly influence perceived persuasiveness across countries (China and South Korea), providing triangulated non-support for H<sub>1</sub>. This unexpected result contradicts prior research that frequently positioned authenticity as a cornerstone of persuasive communication, especially in influencer marketing (Li and Ma, 2024; Li et al., 2023). More specifically, our findings challenge this assumption by showing that, for DHAs, authenticity may not operate in the same way as it does for human endorsers. One explanation is that, as artificial entities, DHAs inherently lack the lived experiences and emotional depth that audiences often associate with “genuine” authenticity (Koles et al., 2024). Hence, even if audiences recognize DHAs as credible and informative, awareness of their non-human nature may limit the emotional resonance of their messages. This limitation may be particularly pronounced in environmental advocacy, where emotional connection and perceived authenticity are often critical to mobilizing support (Ju et al., 2024; Jiang et al., 2025). Our findings, therefore, suggest that, in emotionally charged domains like climate change, authenticity may be harder for DHAs to simulate convincingly, raising strategic questions about the types of causes and campaigns for which DHAs are most suitable (You and Liu, 2024). Rather than relying on emotional authenticity, DHA-driven advocacy in such domains may need to leverage other persuasive levers, such as narrative richness, message-audience value alignment, or technological credibility cues, to offset authenticity constraints.

For *social cues*, narrative transportation significantly influences perceived persuasiveness across countries (China and South Korea), providing triangulated support for H<sub>3</sub>. While this finding is consistent with past literature on immersive storytelling in influencer marketing and persuasive communication (Cao et al., 2021; Kim et al., 2022), its novelty lies in showing that narrative transportation retains its persuasive power even when the storyteller is an artificial, non-human advocate. When considered alongside the non-significant finding for authenticity, this result indicates that audiences can still become cognitively and emotionally absorbed in a story regardless of the messenger’s human authenticity, provided the narrative is contextually rich and emotionally engaging. This further suggests that audiences are willing to suspend disbelief and immerse themselves in a narrative, even if delivered by a DHA, so long as the story meets these conditions. This has important implications for DHA-based environmental advocacy because, rather than being hindered by their artificiality, DHAs can use compelling narrative design to evoke the same cognitive and emotional involvement that drives persuasion in human-led campaigns. In this way, immersive storytelling may serve as an equalizer, enabling DHAs to match or even surpass the persuasive impact of human advocates when promoting pro-environmental consumer behavior. This underscores the strategic value of incorporating well-crafted, cause-relevant narratives into DHA content to foster deeper engagement and stronger persuasive outcomes.

Moreover, vicarious expression significantly influences perceived persuasiveness across countries (China and South Korea), providing triangulated support for H<sub>4</sub>. While this is consistent with prior research

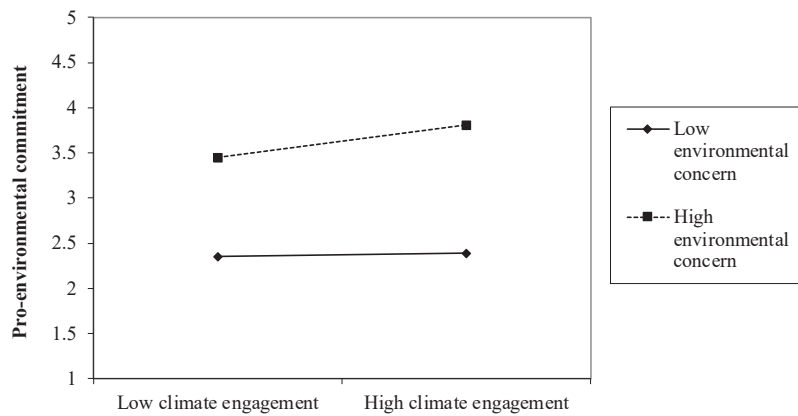
showing that robot storytellers with vicarious expressions can enhance audience transportation (Appel et al., 2020; Yang et al., 2024), its novelty lies in demonstrating that vicarious expression remains persuasive even when deployed by DHAs in the emotionally charged and value-laden domain of climate change communication. This suggests that audiences can respond positively to simulated emotional cues from artificial advocates, provided these cues are well-executed and embedded in meaningful, context-rich narratives. In this way, vicarious expression may help DHAs compensate for the emotional authenticity gap that limits their effectiveness in other areas, enabling them to evoke empathy and identification without being human. While skepticism toward artificial emotions persists (e.g., De Cicco et al., 2024), our results indicate that contextually relevant and strategically designed vicarious expressions can enhance message effectiveness, making DHAs not only a functional content delivery mechanism but an affective and relational actor capable of deepening engagement on complex issues such as climate change (Zhou et al., 2024). This, in turn, positions vicarious expression as a critical design lever for maximizing the persuasive potential of DHAs in sustainability advocacy.

To this end, *DHA-content congruence* significantly influences perceived persuasiveness across countries (China and South Korea), providing triangulated support for H<sub>5</sub>. While congruity theory traditionally emphasizes the surface-level match between an endorser and a product (Kim and Kim, 2021; Shan et al., 2020), our findings extend this logic by showing that in the DHA-environmental advocacy context, deeper, experiential congruence between the source and the message is equally critical. This means that it is not enough for a DHA to only appear aligned with a cause on an aesthetic or a superficial level, rather, the DHA’s persona (expertise, values) must also cohere with the substance and tone of the pro-environmental post. Such alignment appears to enhance message credibility and processing fluency, which, in turn, heightens persuasive impact (Baudier et al., 2023; Boerman et al., 2022). This insight is particularly novel in the context of artificial endorsers because it suggests that audiences apply congruity judgments to DHAs much like they do to human influencers but may weigh persona-post fit more heavily when authenticity is less of a deciding factor. Ensuring high DHA-content congruence, therefore, is not only a matter of brand consistency as it is also a strategic design choice that can significantly boost audience receptiveness, deepen engagement, and drive sustainable behavior.

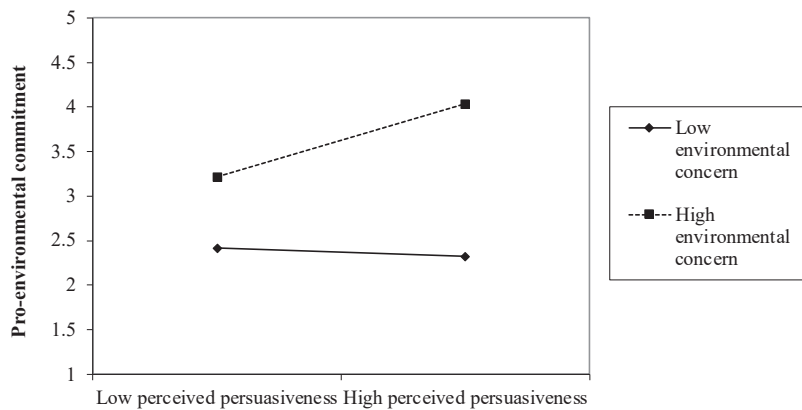
## 5.2. On perceived persuasiveness, climate engagement, and pro-environmental commitment

Our results show that perceived persuasiveness positively affects climate engagement across countries (China and South Korea), providing triangulated support for H<sub>6</sub>. While prior research has shown that persuasive content encourages behavioral engagement (Chang et al., 2020; Weiger et al., 2018), our findings extend this relationship into the context of DHA-driven environmental advocacy and across two culturally distinct markets. This demonstrates that the persuasiveness-engagement link is not dependent on human authenticity but can be activated when artificial endorsers convey messages perceived as credible and compelling. This challenges the implicit assumption that DHAs’ primary role is to draw superficial attention, instead, it suggests they can initiate meaningful climate engagement when persuasive quality is high.

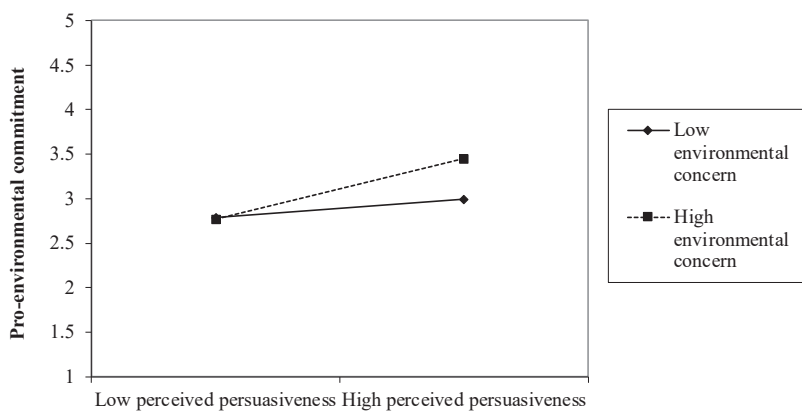
**Panel A.** Interaction of environmental concern and climate engagement on pro-environmental commitment in China



**Panel B.** Interaction of environmental concern and perceived persuasiveness on pro-environmental commitment in China



**Panel C.** Interaction of environmental concern and perceived persuasiveness on pro-environmental commitment in South Korea



**Fig. 2.** Significant moderation **Panel A.** Interaction of environmental concern and climate engagement on pro-environmental commitment in China. **Panel B.** Interaction of environmental concern and perceived persuasiveness on pro-environmental commitment in China. **Panel C.** Interaction of environmental concern and perceived persuasiveness on pro-environmental commitment in South Korea.

**Table 8**  
Assessment of measurement invariance.

Construct	Configural invariance	Compositional invariance		Partial measurement invariance		Equal mean Difference		Equal variance Difference		Full measurement invariance		
		Original correlation	Confidence interval	p-value	invariance	Equal mean Difference	Confidence interval	p-value	Equal variance Difference	Confidence interval	p-value	
Authenticity	Yes	0.999	[0.998; 1.000]	0.058	Yes	0.325	[-0.101; 0.103]	<0.001	-0.307	[-0.159; 0.154]	<0.001	No
Climate engagement	Yes	0.992	[0.991; 1.000]	0.051	Yes	0.000	[-0.102; 0.099]	0.466	-0.048	[-0.133; 0.142]	0.283	Yes
Credibility	Yes	0.999	[0.992; 1.000]	0.057	Yes	0.025	[-0.107; 0.103]	0.333	-0.026	[-0.164; 0.157]	0.397	Yes
DHA-content congruence	Yes	1.000	[1.000; 1.000]	0.075	Yes	0.336	[-0.101; 0.098]	<0.001	-0.453	[-0.157; 0.157]	<0.001	No
Environmental concern	Yes	0.997	[0.997; 1.000]	0.059	Yes	-0.224	[-0.114; 0.108]	<0.001	0.431	[-0.178; 0.180]	<0.001	No
Narrative transportation	Yes	1.000	[1.000; 1.000]	0.074	Yes	0.558	[-0.103; 0.099]	<0.001	-0.563	[-0.155; 0.137]	<0.001	No
Perceived persuasiveness	Yes	1.000	[1.000; 1.000]	0.067	Yes	0.239	[-0.110; 0.099]	<0.001	-0.502	[-0.170; 0.149]	<0.001	No
Pro-environmental commitment	Yes	0.998	[0.997; 1.000]	0.055	Yes	0.160	[-0.105; 0.110]	0.010	0.089	[-0.176; 0.194]	0.227	No
Vicarious expression	Yes	1.000	[1.000; 1.000]	0.078	Yes	0.243	[-0.109; 0.098]	<0.001	-0.460	[-0.160; 0.163]	<0.001	No

Notes: Confidence interval (CI) and p-value are permutation-based estimates derived from the distribution of test statistics generated by randomly permuting the observed data, and unlike traditional tests that assume specific probability distributions (e.g., normality), permutation-based tests make no such assumptions, thereby making it robust to outliers (Henseler et al., 2016).

Strategically, this reinforces the importance of designing DHA content that integrates strong credibility cues, clear value alignment, and cause-relevant narratives to trigger active engagement in sustainability initiatives.

Our results also lend weight to prior studies (Alsaad et al., 2023; Kadic-Maglajlic et al., 2019; Saleem et al., 2021) by confirming the positive relationship between climate engagement and pro-environmental commitment across countries (China and South Korea), providing triangulated support for H<sub>7</sub>. We extend this body of work by showing that in DHA-led campaigns, engagement is more than a measure of online interaction as it functions as a bridge between message reception and enduring behavioral change. This is consistent with commitment theory (Lokhorst et al., 2013) and self-identity theory (Whitmarsh and O’Neill, 2010), and aligns with Odou and Schill’s (2020) conceptualization of behavioral engagement toward environmental protection as encompassing three categories: consumption, environmental citizenship, and policy support. In our context, repeated and socially visible engagement with climate content can span all three categories, strengthening individuals’ environmental self-identity and making them more likely to maintain behaviors consistent with that identity. This suggests that DHA campaigns should be designed not only to inform but to create multiple touchpoints for visible engagement, such as interactive challenges, user-generated content opportunities, and public pledges, that reinforce commitment over time. Our research further extends Odou and Schill (2020) by showing that when consumers engage with climate-related content through consumption, contribution, and creation, they are more likely to translate this engagement into tangible actions, such as adopting sustainable practices or purchasing eco-friendly products. This deeper focus on climate engagement underscores its role in enhancing consumers’ commitment to pro-environmental behaviors and highlights the importance of persuasive communication in environmental advocacy.

Our results further add evidence in line with recent work (Rodrigues et al., 2024; Yoon et al., 2020) that perceived persuasiveness positively influences pro-environmental advocacy across countries (China and South Korea), providing triangulated support for H<sub>8</sub>. While prior work suggests that persuasive messaging can lead to pro-environmental actions, for instance, in serious games encouraging green behavior through psychological mechanisms like self-efficacy and ownership (Chen et al., 2025) and in climate action campaigns promoting internalized commitment (Miller, 2025), our research extends these insights into the DHA context, demonstrating that artificial endorsers can directly shape value-driven commitment without solely depending on engagement as an intermediary. This challenges the assumption that DHAs only attract transient attention, rather, when perceived as persuasive, their messages appear capable of engaging audiences at deeper cognitive and emotional levels that translate into lasting climate action. Theoretically, this suggests that persuasiveness can circumvent intermediate behavioral steps when both source signals and social messaging are strong, thereby expanding our understanding of digital persuasion pathways. Practically, DHAs’ consistent, interactive messaging—unburdened by issues like inconsistent behavior or public relations crises—positions them as reliable forces for long-term environmental advocacy, capable of status-setting credibility and steady message reinforcement that contribute meaningfully to shaping sustainable consumer mindsets.

### 5.3. On the mediating role of climate engagement

Our examination of climate engagement’s mediating role confirms that it serves as a bridge between perceived persuasiveness and pro-environmental commitment across countries (China and South Korea), providing triangulated support for H<sub>9</sub>. This mediation effect underscores the importance of engaging consumers in climate-related content to foster a pro-environmental mindset, demonstrating that persuasive DHA communication exerts its full influence when it stimulates active participation rather than remaining at the level of message exposure.

Past research highlights the crucial role of engagement in facilitating green behavior decision-making (Odou and Schill, 2020), where engagement acts as a bridge between persuasive messages and tangible environmental actions, emphasizing that mere awareness is insufficient without active consumer involvement. Moreover, engagement's mediating effect on customer citizenship behavior further supports this critical intermediary step in transforming commitments into actions (Chuah et al., 2020).

Our results provide new insights into DHA-based strategies for promoting environmental advocacy. DHAs can serve as powerful tools for generating engagement through compelling and interactive content, making environmental messages more relatable and impactful. While prior work has often treated consumer engagement as a desirable endpoint in itself (Barger et al., 2016; O'Neill et al., 2013), we demonstrate that in the DHA-environmental advocacy context, engagement functions as a psychological bridge between source and social cues (credibility, narrative transportation, vicarious expression, DHA-content congruence) and downstream pro-environmental commitment. This positioning integrates the CASA paradigm (Reeves and Nass, 1996), where audiences treat DHAs as real communicators, with active climate engagement (Köcher et al., 2025), in which environmental messages are internalized before being translated into committed action. This reframing carries two key implications. First, it underscores the strategic value of DHAs for environmental advocacy, whereby developing credible personas, crafting immersive narratives, and embedding vicarious expressions, DHAs can ignite and sustain the deep engagement necessary to move audiences from awareness to commitment. Second, it positions engagement as the operational core of DHA-driven campaigns, emphasizing that success lies not only in achieving exposure or reach but in designing pro-environmental content to actively attract, involve, and retain audience participation so as to foster long-term pro-environmental commitment.

#### 5.4. On the moderating role of environmental concern

Our investigation of the moderation effects of environmental concern revealed that the relationship between perceived persuasiveness and pro-environmental commitment varies with the level of environmental concern. In both China and South Korea, environmental concern significantly moderated the relationship between perceived persuasiveness and pro-environmental commitment, providing triangulated support for  $H_{10c}$ . This finding aligns with prior research indicating that individuals with higher environmental concern are more receptive to persuasive messages, which, in turn, enhances their commitment to pro-environmental behaviors (Al-Quran et al., 2020; Wei et al., 2018). Our results extend this evidence into the DHA context, showing that environmental concern can amplify the persuasive-commitment pathway even when the messenger is an artificial advocate. This suggests that persuasive climate messaging is particularly potent among consumers who already prioritize environmental issues, reinforcing their predisposition to act and highlighting the value of segmenting audiences by attitudinal orientation.

Key differences, however, do emerge between China and South Korea. In China, environmental concern also strengthened the link between climate engagement and pro-environmental commitment ( $H_{10b}$ ). This indicates that Chinese consumers with high environmental concern are more likely to convert their engagement into tangible climate action. This pattern can be understood in the context of China's national climate agenda and its strong policy signaling. As a global leader in climate change mitigation efforts, China aims to achieve carbon neutrality by 2060, a goal with profound implications for global sustainability (World Bank, 2022). Notably, China has implemented significant initiatives to reduce carbon emissions, including becoming the world's largest investor in renewable energy (World Economic Forum, 2024). Since 2013, China has accounted for over 40% of the annual additions to global renewable energy capacity (China Daily, 2024) and leads in solar

and wind power capacity installations, with more than half of the world's total in 2023 (Reuters, 2023). Large-scale afforestation programs (Global Times, 2023) and the establishment of emissions trading schemes (International Carbon Action Partnership, 2024) further demonstrate China's commitment to environmental leadership. Younger generations in China, particularly Generations Y and Z onwards, are increasingly embracing sustainable lifestyles and showing higher environmental awareness, partly due to the promotion of sustainability through various educational, governmental, and social channels (Ling et al., 2024; Su et al., 2019). For instance, educational initiatives, such as environmental curricula in schools and universities, which were implemented in response to China's Ministry of Education call for adding environmental education into the curriculum in 2003 (Efrid, 2020), have fostered environmental consciousness among the youth (Li et al., 2024). The widespread adoption of bike sharing and electric vehicles among young urban residents also reflects this shift toward sustainability (Bloomberg, 2021; Honda, 2024). In this context, high environmental concern interacts with existing institutional and structural support for climate action, strengthening the engagement-commitment link.

Whereas, this moderation effect was absent in South Korea, indicating that climate engagement, regardless of its magnitude, can, given its main effects, significantly drive pro-environmental commitment among consumers in this country. The magnitude of this commitment, however, needs to be interpreted with caution, as the variance in pro-environmental commitment explained by perceived persuasiveness and climate engagement is much lower in South Korea ( $R^2 = 19.5\%$ ) than in China ( $R^2 = 69.2\%$ ). Notably, South Korea's consumer culture is, arguably, convenience-oriented, as evidence shows, for example, that the country has one of the highest per capita rates of single-use plastic consumption in the world, especially in food delivery and packaging (Blaszczuk, 2022). While South Korea has a strong recycling infrastructure (e.g., recycling more than 70% of plastic waste), its policy efforts have been inconsistent (e.g., initially banning certain single-use plastics in 2022 but easing restrictions in 2023) (Lee, 2024). As a result, the average consumer may experience weaker motivation to reduce consumption or inconvenience themselves for climate reasons. Consequently, even when digital campaigns successfully encourage pro-environmental behaviors, these efforts encounter established consumer habits and systems that prioritize comfort and efficiency, potentially weakening the translation of advocacy into lasting personal commitment. Moreover, South Korea's climate activism often takes the form of appeals to government or industry (e.g., campaigns to pressure companies, lawsuits against the government for climate inaction) rather than mass grassroots lifestyle movements (Correa, 2025). Consumers in South Korea may, therefore, externalize responsibility, expecting policy solutions, rather than feeling personally empowered by advocacy to change their own behavior.

Lastly, environmental concern did not moderate the relationship between perceived persuasiveness and climate engagement in both countries ( $H_{10a}$ ), suggesting that persuasive DHA content can, given its main effects, significantly stimulate climate engagement regardless of the magnitude of environmental concern. One plausible explanation is that highly persuasive digital communications, particularly when involving credible influencers (Belanche et al., 2021) and compelling narratives (Chang et al., 2020), might override individual differences in baseline environmental concern, prompting engagement even among consumers who are initially indifferent or less environmentally conscious. In other words, persuasive messaging itself may act as a sufficient motivator for climate engagement, independent of consumers' pre-existing attitudes toward environmental issues. This finding highlights the immense potential of DHA-based persuasive strategies, suggesting their efficacy is not confined only to environmentally conscious segments—i.e., not limited to “preaching to the converted”—but extends to a wider audience, thereby expanding the potential impact of environmental advocacy campaigns.

## 6. Implications

### 6.1. Theoretical implications

Integrating the CASA paradigm (Reeves and Nass, 1996) and congruity theory (Osgood and Tannenbaum, 1955), this research advances theory at the intersection of AI-mediated communication, influencer marketing, and pro-environmental consumer psychology by offering an integrated explanatory model of how AI-generated DHAs can drive climate engagement and pro-environmental commitment. Drawing on Lim (2026), these contributions reflect theoretical novelty, as this research synthesizes the CASA paradigm with congruity theory and specifies a cue-based process model that explains how DHA cues translate into climate engagement and pro-environmental commitment with evidence from two countries (i.e., China and South Korea). These contributions also reflect theoretical interestingness through counterintuitive and noteworthy insights, including the non-effect of authenticity on perceived persuasiveness and the capacity of persuasive DHA content to stimulate climate engagement regardless of baseline environmental concern. The paragraphs that follow unpack these novelty- and interestingness-driven contributions in detail.

First and foremost, this research deepens and recontextualizes the CASA paradigm (Reeves and Nass, 1996) by examining how source cues (authenticity, credibility) and social cues (narrative transportation, vicarious expression) in DHA-human interaction influence climate engagement and pro-environmental commitment. Through the validation of these cues, apart from authenticity, as key drivers of DHA persuasiveness in a pro-environmental context, this research moves CASA's application beyond its traditional commercial (Saenger et al., 2024) and entertainment (Yu and Zhao, 2024) domains into the high-stakes sphere of environmental advocacy. This represents a substantive theoretical shift, as it shows that CASA's "media as social actors" principle applies even when the persuasive goal is not transactional but value-driven (Gambino et al., 2020), thereby expanding the paradigm's explanatory reach to sustainable behavior change in the digital era.

Additionally, this research makes an integrative theoretical contribution by linking the CASA paradigm (Reeves and Nass, 1996) to congruity theory (Osgood and Tannenbaum, 1955) to address a notable gap in human-computer interaction scholarship. While congruity theory has traditionally centered on brand-message fit in marketing (Huang et al., 2013; Montaguti et al., 2023), our findings provide empirical evidence that its principles extend to AI-generated endorsers, where the perception of DHA-content congruence is pivotal in enhancing both perceived persuasiveness and climate engagement. This integrative insight elevates theoretical understanding by demonstrating that persuasive success in AI-mediated environmental advocacy is contingent on both how DHAs appear (source cues) and communicate (social cues) as well as what they represent in relation to the cause (congruity). Hence, the integration of CASA's social-source cues perspective with congruity theory's cognitive alignment mechanism results in a more holistic explanation of how DHAs influence sustainability-related engagement and commitment, and, in turn, rendering a conceptually and theoretically integrated framework that future research can apply to examine AI-driven persuasion across other domains where value alignment and social presence are equally critical.

Furthermore, this research empirically demonstrates the centrality of climate engagement within the computer-mediated persuasion process, showing its pivotal role in amplifying the effectiveness of DHAs' green messaging and, in turn, fostering consumers' pro-environmental commitment. While prior studies have identified engagement as central to social influence in digital environments (Gerrath et al., 2024; Lou et al., 2022), few have unpacked its function as a mechanism in the context of AI-generated communicators promoting sustainability goals. Confirming climate engagement as a mediator advances the CASA paradigm (Reeves and Nass, 1996) by revealing how source and social cues from DHAs, such as credibility, narrative immersion, and vicarious

expression, are internalized by audiences and converted into meaningful pro-environmental outcomes. This mediation perspective adds theoretical depth to the CASA paradigm by embedding an explanatory layer between cue perception and behavioral outcome, rather than treating engagement as a terminal dependent variable. More importantly, DHAs as social actors possess unique affordances (e.g., consistency of message delivery, capacity for scalable personalization and interactivity) that enable them to sustain persuasive messaging and stimulate higher levels of engagement (Allal-Chérif et al., 2024; Byun and Ahn, 2023). Recognizing engagement as a linchpin in this process thus positions it not simply as a by-product of DHA communication but as a theoretically significant and strategic construct that operationalizes the pathway from AI-mediated persuasion to enduring behavioral commitment.

In addition, this research makes a pivotal theoretical contribution by elucidating the moderating role of environmental concern in AI-mediated climate communication and embedding it within a cross-cultural comparative framework. While prior studies have largely examined environmental concern as a moderator between attitudes and behaviors (Al-Quran et al., 2020; Cachero-Martínez, 2020), our findings extend this theorization by showing that environmental concern also conditions the translation of persuasive DHA messaging into pro-environmental commitment. More specifically, consumers with higher environmental concern hold stronger outcome expectations about the efficacy of their actions and, as a result, are more responsive to persuasive messages, leading to heightened commitment. This insight refines current models of persuasion by identifying environmental concern as a boundary condition that shapes the strength of message effects in AI-generated advocacy, which, in turn, highlights the need to account for individual predispositions when theorizing the persuasion-commitment relationship.

Moreover, this research further advances theory by explicitly incorporating cultural context into its model and empirical testing. Examining China and South Korea as theoretically relevant contexts reveals that the moderating role of environmental concern is not uniform but embedded within distinct environmental policy environments and social norms.

In China, environmental concern intensified the links between both perceived persuasiveness and climate engagement with pro-environmental commitment. This pattern can be interpreted through the country's systemic emphasis on sustainability, including its prominent global leadership in climate mitigation (World Bank, 2022), large-scale renewable energy investments (Reuters, 2023; World Economic Forum, 2024), and policy measures such as afforestation programs (Global Times, 2023) and emissions trading schemes (International Carbon Action Partnership, 2024). Environmental consciousness among younger generations, fostered through educational initiatives (Efid, 2020; Li et al., 2024) and visible adoption of sustainable lifestyles (Bloomberg, 2021; Honda, 2024), likely creates fertile ground for environmental concern to translate more readily into commitment.

In South Korea, environmental concern moderated only the direct relationship between perceived persuasiveness and pro-environmental commitment, with overall explained variance in commitment substantially lower ( $R^2 = 19.5\%$ ) than in China ( $R^2 = 69.2\%$ ). This difference may reflect South Korea's more convenience-oriented consumer culture, evidenced by high per capita single-use plastic consumption (Błaszczuk, 2022; Lee, 2024), and a tendency for climate activism to target governmental and corporate accountability rather than grassroots lifestyle change (Correa, 2025). These conditions help explain why environmental concern in South Korea exerts a narrower moderating effect, illuminating how socio-cultural systems may influence the link between individual attitudes and sustained behavior change.

Last but not least, the absence of moderation by environmental concern on the relationship between perceived persuasiveness and climate engagement in both countries suggests that persuasive DHA content can stimulate climate engagement irrespective of baseline environmental concern. This finding underscores the potential reach of

DHA-based persuasive strategies, demonstrating that they can mobilize engagement across a broad audience while signaling the importance of targeted message tailoring in contexts where commitment is more contingent on pre-existing concern. Hence, embedding cross-cultural considerations into the analysis of environmental concern's moderating role offers a more refined theoretical account of how cultural systems and individual dispositions jointly shape the efficacy of AI-mediated environmental persuasion.

## 6.2. Practical implications

Our research provides practical implications for stakeholders such as climate change advocates, influencer marketing professionals, non-profit organizations, and policymakers seeking to promote pro-environmental causes. Based on our findings, we offer three strategic recommendations to contribute to SDG 13 by raising awareness, mobilizing action, and promoting sustainable behaviors to mitigate the impacts of climate change.

Firstly, leverage DHAs as credible and engaging communicators for sustainability messaging, but prioritize cues and strategies that our results show are persuasive rather than investing disproportionately in authenticity, which was not a significant predictor of persuasiveness. This means integrating DHAs into influencer marketing strategies where their credibility, narrative richness, and vicarious emotional expressions can be fully utilized. Brands should, therefore, partner with established virtual influencers whose personal brand aligns with sustainability values. For example, Imma, known for her fashion and digital activism, could showcase sustainable fashion or zero-waste routines on Instagram or TikTok. Similarly, Miquela, with her strong Gen Z following and social cause reputation, could promote climate action or ethical consumption through relatable, story-driven content. To increase credibility and reach, brands and NGOs could co-create campaigns with DHAs in partnership with reputable environmental institutions (e.g., Jeffrey Sachs Center on Sustainable Development, United Nations Sustainable Solutions Development Network). These could include co-branded digital events such as virtual workshops on sustainable living (Yang et al., 2023b). Policymakers can also integrate DHAs into public awareness initiatives, particularly targeting younger audiences who are highly responsive to interactive digital formats (Gerrath et al., 2024; Zhou et al., 2024). For example, DHAs could host interactive social media challenges, such as #PlasticFreeWithImma, encouraging followers to share plastic-free practices, with incentives like digital badges, public recognition, or exclusive virtual content. Nonetheless, brands should strategically allocate resources and address ethical considerations. Developing highly authentic DHAs requires substantial technical and financial investment, yet our findings show that authenticity does not significantly enhance persuasiveness. Budgets should instead be directed toward strengthening credibility cues, refining narratives, and optimizing emotional expressiveness, which were found to significantly increase persuasiveness. Ethical considerations must be integral to this process, with transparency about the artificial nature of DHAs essential to avoid consumer deception, "uncanny valley" discomfort, or backlash (Block and Lovegrove, 2021). Campaigns should therefore clearly disclose the synthetic identity of DHAs, ensure alignment with environmental values, and design interactions that prioritize genuine, human-centric engagement.

Secondly, the significant mediating role of climate engagement underscores that DHAs are most effective when leveraged as catalysts for active audience participation, rather than as one-way content broadcasters. This finding supports the strategic value of collaborating with DHAs who not only possess substantial reach but can also mobilize audiences into co-creative and participatory climate initiatives (e.g., Imma, Lil Miquela). To capitalize on this potential, social media practitioners should design campaigns that move audiences beyond passive viewing toward visible, repeated actions, such as citizen science projects, collaborative storytelling, or sustained hashtag challenges, which

reinforce environmental self-identity and commitment over time (Neset et al., 2021). Maximizing the effectiveness of these participatory efforts requires that the emotional expressions embedded in DHA content are carefully calibrated to the seriousness of climate change, balancing empathy-evoking narratives with solution-oriented optimism to sustain engagement and avoid message fatigue (Ferreira et al., 2024; Hart and Feldman, 2014; Naidu et al., 2023). More specifically, relatable story arcs that personalize climate impacts and showcase achievable actions can heighten receptivity and deepen engagement (Yang et al., 2024; Zhou et al., 2024). One way to operationalize this is through brand-led DHA campaigns that launch multi-week challenges, in which audiences document and share their eco-friendly routines, pair these with interactive leaderboards or recognition systems, and integrate user-generated content into the DHA's ongoing narrative, thereby transforming individual actions into a visible, collective movement.

Thirdly, environmental concern serves as a crucial moderator, significantly strengthening the relationship between perceived persuasiveness and pro-environmental commitment. This underscores the strategic value of tailoring DHA messaging to the audience's baseline level of environmental concern (Han et al., 2022; He et al., 2022). For high-concern consumers, especially prevalent in China due to policy-led environmental education and awareness campaigns (Efrid, 2020; Li et al., 2024), marketers should focus on reinforcing existing motivations through DHA content that integrates credible, evidence-based data from respected environmental authorities, with the embedding of verifiable facts alongside immersive narratives expected to maximize perceived persuasiveness and accelerate conversion to commitment. In contrast, in markets like South Korea, where pro-environmental motivation may be tempered by convenience-oriented consumer norms (Blaszczyk, 2022), DHA campaigns should first endeavor to elevate environmental concern. This can be achieved through emotionally resonant narratives (Zhang et al., 2025) that personalize climate risks, make future consequences tangible, and frame inaction as socially costly. Once concern is heightened, calls-to-action should be highly specific and achievable, such as measurable reductions in single-use plastic over a set period, documented via user-generated content and reinforced through social recognition. In both contexts, the combination of narrative persuasion and clear, achievable behavioral commitments should help bridge the gap between message acceptance and sustained pro-environmental behavior.

## 7. Conclusion, limitations, and future directions

This research demonstrates that perceived persuasiveness, climate engagement, and pro-environmental commitment are significantly influenced by credibility, narrative transportation, and DHA-content congruence. The relationship between perceived persuasiveness and pro-environmental commitment is mediated by climate engagement and favorably moderated by environmental concern. These findings contribute to the body of knowledge by elucidating how DHAs affect pro-environmental consumer behavior and climate participation, providing guidance for effective environmental advocacy tactics.

The efficiency of DHAs' endorsement effects on consumer engagement with climate-related content and their commitment to adopt pro-environmental behavior was established through this research. Notably, this research integrates congruity theory (Osgood and Tannenbaum, 1955) into the CASA paradigm (Reeves and Nass, 1996) in response to calls for further empirical investigation into the effects of source-content congruence on consumer engagement (Xie-Carson et al., 2023). More specifically, this research explores DHA-related source cues, content-related social cues, and DHA-content congruence as significant predictors influencing consumers to interact with climate-related posts and commit to engaging in pro-environmental behavior in their everyday lives. The research's main theoretical contributions include expanding the CASA paradigm, investigating DHA-content congruence, emphasizing the role of climate engagement, and

understanding the moderation effects of environmental concern. Yet, despite its contributions, this research has limitations that present opportunities for further research.

Conceptually, this research focuses on pro-environmental commitment, a specific dimension of pro-environmental consumer behavior, which, as argued, is the most suitable approach given our reliance on a survey-based methodology. Commitment is positioned as more concrete and reliable than intention (Lokhorst et al., 2013) and consistently precedes and predicts actual behavior in line with reasoned action theories (Ajzen, 1991). Although an alternative approach could have involved directly examining self-reported behaviors, such measures remain inherently vulnerable to biases, notably social desirability bias (Fisher, 1993), which similarly constrain measures of intention and commitment. Nonetheless, commitment employs more definitive language (Harris, 2019), which reduces susceptibility to social desirability bias and, arguably, better predicts actual pro-environmental actions (Demarque and Girandola, 2017). Hence, focusing on commitment not only addresses the methodological limitations inherent in survey research but strategically leverages a theoretically-justified predictor, thereby enabling a more precise assessment of DHAs' potential for inspiring lasting pro-environmental behavioral change. Nevertheless, with the rapid proliferation of DHAs and increasing consumer interactions with digital influencers, future research should move beyond self-reported commitment and validate the results herein using large-scale, real-world consumer data, such as user-generated content or online reviews on social media platforms (D'Acunto et al., 2025; Khan et al., 2024), to track real-time consumer trends and enrich understanding of how DHAs influence both commitment and actual behavior over time.

Furthermore, though our findings indicate that DHA authenticity does not significantly enhance persuasiveness, this should not be interpreted as evidence that authenticity is irrelevant. Rather, future research should examine whether authenticity gains persuasive value when combined with other potential considerations, for instance, ethical disclosure and transparency, particularly in contexts where audiences are sensitive to perceived manipulation, such as environmental advocacy campaigns in which credibility and trust are prerequisites for mobilizing sustained public action (Alonso-Paulí et al., 2025; Cooper et al., 2024). In such contexts, the stakes are heightened as DHAs become more prevalent in emotionally charged domains, making the potential for user deception, data privacy violations, and unintended psychological effects from prolonged human-avatar interaction particularly consequential. Understanding how these risks influence, and potentially erode, the persuasive impact of DHAs will be essential for ensuring that their deployment strengthens rather than undermines public trust in climate communication.

Moreover, further research is required to critically assess specific attributes of DHAs, DHA-generated content, and their impacts on consumer responses. For instance, researchers should investigate how variations in influencer type (e.g., female versus male, young versus old), message structure (e.g., high versus low construal levels), framing strategies (e.g., promotion versus prevention appeals), and interactive elements affect engagement and consequent behaviors. Field experiments incorporating immediate feedback mechanisms and real-time incentives could further clarify how effectively pro-environmental commitments translate into observable, sustained behaviors (Khan et al., 2024), thereby enriching theoretical and practical understanding of DHAs' impact.

Contextually, this research is limited by its specific focus on Generations Y and Z within an exclusively Asian context (China and South Korea), potentially restricting generalizability due to cultural and economic development variations that shape environmental attitudes and sustainability practices (D'Acunto et al., 2023). This contextual specificity calls into question the wider applicability of findings to other generational cohorts or settings, emphasizing the need for critical comparative analyses. Consequently, future research should adopt

longitudinal and experimental designs, critically examining and comparing climate engagement and pro-environmental behaviors across diverse generational groups and varied contexts. Such comprehensive, cross-cultural investigations would substantially enhance theoretical robustness and provide deeper insights into the evolution of pro-environmental behaviors and their variability due to contextual factors influencing sustained engagement and commitment to environmental action (Schönherr and Pikkemaat, 2024).

## CRedit authorship contribution statement

**Xi Luo:** Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization, Conceptualization. **Weng Marc Lim:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Conceptualization. **Ayoung Suh:** Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Izian Idris:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Pei Shan Soon:** Writing – original draft, Investigation, Conceptualization. **Lan Ma:** Writing – original draft, Investigation, Conceptualization. **Jun Hwa Cheah:** Writing – review & editing, Investigation, Conceptualization.

## Declaration of Competing Interest

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

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jbusres.2026.116049>.

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