



Self-review and feedback in virtual reality dialogues increase language markers of personal and emotional expression in an empathetic communication training experience

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ABSTRACT

Technological advancements have transformed how people communicate, work, and develop critical skills, especially in leadership. These changes will require nuanced skills, particularly empathetic communication, which is pivotal in managing teams and maintaining high performance in distributed work environments. Virtual reality has shown encouraging results in developing empathy and communication skills. Moreover, natural language processing techniques can provide a deeper understanding of communication patterns and nuances. However, there is still much to learn about how virtual reality can support active, empathetic communication training in the workplace. Hence, we first developed a virtual reality experience where participants could embody the manager and the employee in a performance review meeting. Then, we investigated the effects of reviewing one's performance and receiving feedback in a virtual reality perspective-taking task, compared to not reviewing or receiving feedback. The study was pre-registered and followed a pre-and post-test study design. One hundred nine participants were randomly assigned to one of the three conditions: perspective-taking, perspective-taking with self-review, or perspective-taking with self-review and feedback. Empathetic communication skills were measured through self-report measures, human-coded scoring of written and spoken behavior, and natural language processing. Results showed that receiving feedback while reviewing one's performance in a perspective-taking task increased emotional expressions in oral communication. Repeating the interaction a second time increased the use of the "I" pronoun and decreased the use of "you." Improvement in empathetic communication was not linked to feeling concern for others. We discuss implications for theories of learning via media and implications for practitioners.

1. Introduction

Technological advancements have transformed how people communicate, work, and develop critical skills, especially in leadership. Computer-mediated communication (CMC) has allowed for greater flexibility in collaboration, overcoming geographical and temporal barriers (Baym & Ellison, 2023; Fu & Barbour, 2024; Hernandez-de-Menendez et al., 2020; Hughes, 2021; Rampa & Agogué, 2021; Treem et al., 2020). This shift, however, has also heightened the need for leaders to develop nuanced communication skills, particularly

empathetic leadership, which plays a pivotal role in managing teams and maintaining high performance in distributed work environments (Chopra & Bhilare, 2020; Hughes, 2021; Rampa & Agogué, 2021). Empathetic leadership—defined as the ability to recognize, understand, and respond effectively to the emotional states of others—has been shown to enhance team trust, satisfaction, and overall productivity (Madlock, 2008; Wikaningrum et al., 2018; Yue et al., 2021).

As a result, new training methods targeting empathetic communication skills aligned with the demands of digital and hybrid work environments are crucial. One key component in developing

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communication skills is the role of feedback, which enables learners to gain insight into how others perceive their communication. By offering opportunities for self-reflection, feedback helps individuals recognize areas for improvement, particularly in how they express empathy during challenging conversations (Managheb et al., 2012; Wang et al., 2024).

Building on this, immersive virtual reality (VR) offers an innovative and practical approach to empathy training. VR has demonstrated significant potential in enhancing empathy by allowing users to embody different characters and step into another's perspective (i.e., perspective-taking), creating a deeper understanding of different emotional experiences (Martingano et al., 2021; Trevena et al., 2024; Ventura & Martingano, 2023). While a growing body of research compares VR to other media in terms of its effectiveness for empathy and communication training, the current study stands out by adding to the handful of studies uncovering the underlying processes of perspective-taking in VR.

By combining VR with reviewing and feedback mechanisms, leaders not only experience the emotional states of others but also review their communication through others' lenses and receive guidance on how to improve their empathetic communication in real-world scenarios. This study investigates how VR, coupled with recording, reviewing, and feedback, can be utilized to develop empathetic leadership skills through the practice of difficult conversations in a performance review setting. Participants embody both a manager providing feedback and an employee receiving it, enabling them to practice empathetic communication. This dual-role VR experience, coupled with feedback, is hypothesized to improve both linguistic and emotional aspects of empathetic leadership, contributing to developing empathetic leadership skills.

1.1. Why Could VR Be useful for empathetic leadership development?

Immersive VR, characterized by sensory immersion and user interaction, fosters a sense of presence that is particularly valuable for training in situations where real-world exposure is impractical, dangerous, counterintuitive, or expensive (Bailenson, 2018; Slater & Wilbur, 1997). Moreover, presence is particularly important for situations in which the emotional responses to the environment are important for the training at stake (Markowitz & Bailenson, 2021), such as in soft skills training.

Communication skills training typically involves exposure to interpersonal situations, role-playing, or individualized counseling or therapy to teach how to navigate both others' and one's own emotions (Ginting et al., 2020; Ritter et al., 2018). Effective feedback mechanisms play an essential role in increasing the efficacy of such training programs, providing learners with insights into their performance, facilitating self-awareness, and guiding skill refinement in real-world contexts.

The feedback type, channel (e.g., written, oral, video, audio, or computer-assisted), and timing can significantly vary, influencing its effects on learning (Blair, 2009; Silvervarg et al., 2022; Wisniewski et al., 2020). Wisniewski and colleagues meta-analyzed 435 studies targeting feedback effects. They suggested grouping the feedback types into three main categories based on the information provided in the feedback: reinforcement/punishment, corrective feedback, and high-information feedback (Wisniewski et al., 2020). While reinforcement and punishment aim to alter behavior through consequences, they offer minimal task-related information and lack details on process or self-regulation levels. Corrective feedback typically provides task-related information, including the answer and its accuracy, while addressing performance aspects.

Recording and reviewing someone's own communication performance, coupled with feedback, can be considered a form of providing high-information feedback (i.e., a type of feedback that includes the information described for corrective feedback and additional details on the process; J. Wang et al., 2024). Although studies have shown positive

effects of video feedback on communication skills (Managheb et al., 2012; Mills & Pace, 1989; Noordman et al., 2014; Wang et al., 2024; Wilhelm, 2014), most of these studies targeted second language acquisition, public speaking, or clinical communication skills. There is still a lot to learn on how those findings would translate to office settings.

Moreover, these types of training are often expensive and challenging to scale up as they require experienced trainers and frequent one-on-one interactions (Balcar, 2016). Because of VR affordances in triggering emotions and offering authentic learning simulations at scale, VR can be used in communication skills training, showing positive results (Akdere et al., 2023; Markowitz & Bailenson, 2021; Somarathna et al., 2023).

Recent systematic literature reviews and meta-analyses have explored how VR influences empathy, often trying to separate the effects of perspective-taking and immersion (Estrada Villalba et al., 2021; Lee et al., 2024; Martingano et al., 2021; Trevena et al., 2024). Those studies have revealed that rather than immersion, perspective-taking, and evocative storytelling have greater effects on empathy. The literature indicates that the activity experienced in VR is a key driver, rather than the medium itself, in influencing empathy (Barbot & Kaufman, 2020; Ventura & Martingano, 2023). For example, Yun and colleagues (2022) found that using a neutral or dramatic story was more effective in health behavior change than not telling a story when counseling with a virtual agent in VR (Yun et al., 2022).

Moreover, these effects and their duration seem to be specific to different types of empathy (Lee et al., 2024; Martingano et al., 2021; Ventura & Martingano, 2023). Experience storytelling seems to influence emotional empathy (i.e., feelings of care and concern about others) (Davis, 1983), while perspective-taking has increased effects on cognitive empathy (i.e., the ability to understand other's feelings) (Davis, 1983; Peck et al., 2013). Moreover, the effects on emotional empathy seem to be short-term, whereas long-term impact is observed on cognitive empathy (Lee et al., 2024).

To the best of our knowledge, no study has investigated the use of VR for developing empathetic leadership communication through perspective-taking, reviewing, and feedback tasks altogether. When targeting empathetic leadership communication, leaders need to show empathy through their behavior and communication. Studies using immersive experiences targeting empathy usually focus on storytelling, embodiment, and perspective-taking, with just a few providing reflective moments or users' performance feedback (Trevena et al., 2024). Among these few studies, Jütten and colleagues (2018) investigated the effectiveness of mixed reality experiences targeting informal caregiving of individuals with dementia. After embodying someone with dementia in mixed reality, participants engaged in a reflective activity, sharing their experiences in groups. Although no significant difference in empathy was found between the intervention and control groups, 76 % of the participants who had the mixed reality experience reported the experience positively changed their approach to caregiving. In these studies, the feedback was provided by humans after the VR experience, and no opportunity to review their actual behavior during the simulation was provided.

In addition, most studies targeting VR's effects on empathy did so through subjective measures (Lee et al., 2024; Trevena et al., 2024), with a few measuring impacts on behavior (Herrera et al., 2018; R. S. Rosenberg et al., 2013). Some studies examined the effects of VR on communication skills, specifically conflict communication skills with a close person (Kim et al., 2020; Yong et al., 2024). But to the best of our knowledge, no study has analyzed the discourse in empathetic leadership communication in VR.

In VR, users' movements and speech can be recorded, allowing the assessment of communication skills in an interaction that closely mirrors real-life situations employees may encounter. Moreover, diverse workplace simulations, particularly those representing situations that could be difficult to simulate in real life (Bailenson, 2018), can be created to both train the necessary skills and evaluate the impact of training on

behavior and discourse. This makes VR suitable for most of the methods used in training communication skills, such as recording and reviewing one's own speech, receiving guidance and feedback, and practicing the speech until the desired outcome is achieved (Henry et al., 2013). VR offers an opportunity for users to not only review their communication performance but also do it from the perspective of the message receiver. In that sense, leaders can practice how to interact with employees in difficult situations, record and review their performance, and then further practice it until they are satisfied with their communication skills.

Unlike role-playing or peer feedback, which involves observation and possible judgment of peers, VR allows users to go through the training in a private setting, which may reduce negative emotions related to the training process (Kluger & Adler, 1993). Negative emotions, such as stress and anxiety, can impair memory (e.g., Gagnon et al., 2019; Gagnon & Wagner, 2016); within the context of learning, such emotional states may disrupt the ability to draw on memory for critical training activities and targeted behavior, degrading skill acquisition and performance. Finally, VR also reduces the constraints of time and place of training and allows the collection of objective data on users' performance that can be automatically analyzed and used to provide personalized feedback.

1.2. Hypotheses and research questions

This study investigates how reviewing one's own interaction and receiving feedback when conducting difficult conversations in VR influences factors related to empathetic leadership, particularly other- and self-distress, empathetic concern, critical thinking disposition, growth mindset, interpersonal communication perception, and linguistic styles. We also explore the effects on variables related to immersion, such as social, environmental and self-presence. A pre-registered 3x1 pre- and post-test study design was conducted in which participants embodied a manager in VR and were prompted to conduct a performance review with an employee. Participants randomly assigned to one of the three conditions, during which their interactions in the VR environment were recorded (speech and body movement) and in which they subsequently (a) embodied the employee and reviewed their recorded communication and interactions (*self-review*, SR), (b) embodied the employee, reviewed their recorded communication and interactions, and also received feedback about empathetic communication (*self-review and feedback*, SRF), or (c) did not review their communications and interactions, nor receive feedback (*Control*).

Because participants in the SR and SRF conditions could reflect on their performance, similar to conventional communication skills training (Henry et al., 2013), while participants in the Control condition could not, we predicted that SR and SRF participants would perform better than Controls on post-performance measures of empathetic communication (written and oral) (H1a). In addition, building on previous studies showing that receiving feedback improved communication skills (Perera et al., 2010), we predicted that receiving feedback while reviewing their performance would have a further positive effect on participants' empathetic communication compared to not receiving feedback (H1b). That is, on post-performance measures of empathetic communication (written and oral), participants in the SRF were predicted to perform better than participants in the SR condition.

Moreover, based on previous studies showing positive effects of perspective-taking in VR on empathy (Ventura et al., 2020), we predicted that subsequently embodying the employee (SR and SRF) would have a positive effect on participants' empathetic concern (H2a). That is, on post self-reported empathy (empathetic concern), SR and SRF participants were predicted to report higher levels than Controls. Moreover, we predicted that SRF participants would report higher self-reported empathy (empathetic concern) relative to SR participants (H2b).

Although some studies investigating empathy have shown positive correlations between critical thinking disposition and empathy (Arslan,

2018; Jeong, 2015), no study that we are aware of has investigated the relationship between those factors while interacting with virtual agents in VR, or the effects of practicing difficult conversations on those factors. Hence, aiming to better understand the factors driving empathetic communication while training in VR simulations, we asked the following research question (RQ1): What are the relationships between the training conditions, critical thinking, and empathetic concern?

Moreover, we examined how previous practice, measured by how often participants lead teams, relates to empathetic communication by asking RQ2: What are the relationships between participants' real-world team-leading frequency and team size and their empathetic communication?

Finally, recent studies reveal correlations between how people perceive their own and others' flexibility to change (i.e., one's *growth mindset*, Yeager & Dweck, 2020) and positive leadership styles (Chan, 2016; Dweck, 2006). Hence, to investigate whether subsequently embodying the employee in VR and reviewing their own manager-embodied communication and interaction and receiving feedback affects how people perceive their flexibility to change, we asked RQ3: What are the relationships between the training conditions and growth mindset perception?

2. Methods

2.1. VR experiences and experimental conditions

The VR experiences were developed to allow participants to undergo an authentic simulation of a performance review meeting. The prompts, dialogues, and feedback were created based on the literature (M. B. Rosenberg & Chopra, 2015; Zaki, 2019) and reviewed by human resources experts, educators, psychologists, and VR scholars. The researchers shared the experience script with various domain experts and met with them several times to discuss its content, flow, and adequacy to the study goals. The resulting experience script is shown in Table 1.

The experiences were created using the Strivr® content creator platform, which provided the assets for customizing the environment, the agent, and animation options. The Strivr software synced the verbal content with the agent's lip movements (lipsync). The experiences' length ranged from 7 to 12 min, depending on the condition and participant's speech investment. The participant-agent interaction followed a dialogue, with the participant and the agent taking turns. Participants pressed a button every time they started talking and again when they finished talking so that the system would record their speech and start the agent's talking turn after the participants were done talking.

The agent's verbal behavior, detailed in Table 1, was used to guide the agent's non-verbal behavior. The agent's non-verbal behavior was designed to mimic free-form speech, albeit in a pre-recorded format. It involved programming the agent's avatar with a range of facial expressions, lip movements (lipsync), gestures, and body movements aligned with the verbal content of the interaction. For instance, when the avatar expressed disagreement or skepticism, such as saying, "What? I can't entirely agree with this performance review," its non-verbal cues would include raising its arms, slightly tilting its head, and frowning to create a more realistic interaction. Fig. 1 shows some examples of the agent's gestures and facial expressions.

The first interaction round was identical across all conditions. In this phase, participants assumed the role of a manager conducting a performance review meeting with an employee in an office-like setting. Instructions about the meeting's goals and prompts for interaction were provided in virtual whiteboards on the left side of the employee (Table 1, see visuals in Fig. 2). Participants' voices, hands and head movements were recorded while they interacted with the employee.

The second round of interaction varied depending on the condition. In the Control condition, participants repeated the same interaction as in the first phase, receiving the same prompts and employee responses. In the SR condition, immediately following the first round of interaction,

Table 1
VR experience script.

Action	Content
Instructions	Today you will conduct a conversation with Brad, an essential team member.
Instructions	You have noticed that your team is overwhelmed with work, but you need them to keep performing. And Brad is one of your team members that, although dedicated, is showing signs of demotivation and exhaustion.
Instructions	With recent layoffs, Brad's responsibilities increased significantly. Since then, he has delayed some deliverables.
Instructions	You want Brad to fully understand the performance goals, and work on strategies to achieve better performance. Click Okay to start the conversation.
Instructions	
Agent Interaction	<i>Hi, nice to see you.</i>
Instructions	You have two goals for your opening comments. You want to both greet Brad, and you want to share the meeting's purpose.
Participant's verbal interaction	
Agent Interaction	<i>Hum, ok, go ahead.</i>
Instructions	Inform Brad that your team fell behind in some performance metrics during the recent progress report. Let Brad know that a few of them were related to Brad's recent performance.
Participant's verbal interaction	
Agent Interaction	<i>What? I can't entirely agree with this performance review. I have always delivered everything in my charge.</i>
Instructions	Talk with Brad about performance improvement.
Participant's verbal interaction	
Agent Interaction	<i>I don't understand. I'm working as much as possible, up to late at night. What can I do if I had to assume projects from people who were laid off?</i>
Instructions	Ask Brad to improve his performance.
Participant's verbal interaction	
Agent Interaction	<i>I can't have the work done in the time the company expects. For that, I need to be in charge of fewer projects.</i>
Instructions	Encourage Brad to bring up a plan and discuss with you how he wants to navigate his future workload.
Participant's verbal interaction	
Agent Interaction	<i>I will do that. But will this impact my performance review and career progression?</i>
Instructions	Answer his question and how this might relate to Brad's future performance review and career progression.
Participant's verbal interaction	
Agent Interaction	<i>Ok, I understand.</i>
Instructions	End the conversation.
Participant's verbal interaction	
Agent Interaction	<i>I will let you know if I have questions. Thank you.</i>

participants reviewed their conversation from the employee's perspective. During the review, the frames per second were identical to the original experience. Participants could see a light-blue representation of their own head, which moved according to their head movements during the initial interaction. They heard the recording of their initial conversation (Fig. 2). While not necessarily natural, the light-blue head representation was intentionally chosen as a neutral visual stimulus, ensuring consistency across participants regardless of their physical appearance. This approach mitigated potential biases related to variations in individual features and avatar representation limitations (DeVeaux et al., 2023).

After reviewing their interaction, participants engaged with the employee once more, again in the role of the manager. The prompts and employee's responses remained the same as in the first phase.

In the SRF condition, participants also reviewed their conversation from the employee's perspective right after the first round of interaction.

In addition, they answered six questions, one after each dialogue fragment composed by one turn of participant (leader) – agent (employee) exchange, regarding their adherence to elements of an empathetic, communicative approach (e.g., whether they maintained objectivity when introducing the meeting's purpose). Answer options were 'yes' or 'no' and were not included in the analyses. These questions were only displayed in the reviewing phase of the SRF condition. After responding to those questions, they then received feedback about elements of an empathetic conversation. Once the review and feedback phase were completed, they engaged with the employee once more, again in the role of the manager, receiving the same prompts and responses as in the first phase of interaction. In this manner, the second round of interaction remained identical across all conditions, serving the purpose of assessing changes in participants' communication. Fig. 2 shows visuals of the experience.

2.2. Instructions, questionnaires, and subjective measures

Right after giving consent to participate in the study, participants received written information about empathetic communication. The acronym 'LIVES' was employed to denote the five elements of empathy in communication: listen, incisive, validate, express, and support. Participants read about how to include these elements in a conversation. Following the instructions, tests were administered via a Qualtrics link on a computer or tablet. All participants completed the same set of tests. The pre-test encompassed the consent form, demographic information (age, gender, race), questions regarding prior VR experience, leadership frequency, team sizes. The experiment procedure flow is shown in Fig. 3.

The post-test initial question prompted participants to imagine themselves leading a team of researchers. They were presented with contextual information regarding the workplace situation and an e-mail received from an employee detailing challenges in team relationships and seeking assistance. The contextual information and the topic of the e-mail were defined after piloting the task with university students (all textual materials are available in Supplementary Material). To assess empathy in written communication and evaluate the transferability of the empathetic communication skill practiced in the VR environment to a written form of communication, participants were tasked with composing a response to the e-mail.

Subsequently, participants responded to questionnaire items assessing social, environmental, and self-presence (three questions about each, adapted from Han and colleagues [2023]), empathetic concern (five questions adapted from Batson and colleagues [1997]), self- and other-distress (two questions about each, adapted from Batson and colleagues [1997]), interpersonal communication (nine questions adapted from Rubin and Martin [1994]), critical thinking disposition (seven questions adapted from Sosu [2013]) and growth mindset (six questions adapted from Dweck and colleagues [1995]).

Finally, participants shared their opinions about the experiment and their thoughts concerning the study's purpose in two open-ended questions. These responses were not included in the data analysis. Examples of the post-test questions, their respective coding, and each composite reliabilities are shown in Table 2.

2.2.1. Empathetic communication measures

We used the transcripts of the oral communication in VR and the written content in the post-test e-mail to assess empathetic communication.

Written communication. We analyzed participants' e-mail content in three ways. First, two independent coders, blinded to condition, scored the answers based on a rubric we developed to assess the five elements of empathetic communication that participants learned during the experiment (see complete rubric at Supplementary Material). Scores ranged from 0 (absence of the element) to 1 (partial presence of the element) to 2 (satisfactory presence of the element). For example, understanding was assessed as how the participant e-mail showed to pay



Fig. 1. Agent's facial expressions and gestures.



Fig. 2. VR experience visuals.

Note. Visuals of three scenes of the virtual reality experience depicting an office environment. **A:** Scene in the first phase of interaction, encountered by participants in all conditions; **B:** Scene in the reviewing phase of the SR and SRF conditions, when participants embodied the employee; **C:** Scene in the reviewing phase of the SRF condition, when participants received feedback about empathetic communication.

attention to what the person was saying and tried to understand their perspective without judgement and focusing on the main message. A zero score reflected the absence of understanding, while a score of one represented a partial demonstration of understanding on the e-mail the participant wrote. Finally, a score of two was given when the e-mail content showed that the participant understood the situation in detail. The inter-rater reliability for each element was: understanding (Cohen's Weighted Kappa $K_w = 0.97$), objectivity ($K_w = 0.93$), validation ($K_w = 0.96$), expression ($K_w = 0.94$), and support ($K_w = 1$). A composite was calculated by averaging the five constructs ($\alpha = 0.87$). Second, we automated the discourse analysis using natural language processing (NLP) to analyze the e-mails' content, extracting word frequencies using the software LIWC® (Language Inquiry and Word Count; Pennebaker et al., 2001). We analyzed the word categories used in previous studies investigating empathy in language (i.e., total pronouns, personal pronouns, impersonal pronouns, I, you, we, she/he, they; Ireland & Pennebaker, 2010; Meinecke & Kauffeld, 2019) and the categories related to emotions (total emotions, positive emotions, negative emotions, positive

tone, negative tone, anger, anxiety) (Table 3; See Boyd et al., 2022 for a complete list of words associated with each emotion).

Oral communication. We analyzed the transcripts of participants' communication during the first and second rounds of interaction in the VR experience, using the same NLP analysis procedures applied to the written (e-mail) communication.

2.3. Design and procedure

The Institutional Review Board approved the procedures and materials for this study. Participants were recruited via e-mails sent to listservs targeting students, faculty and staff of a university in the U.S. Participants received \$25 for their participation, which typically took between 45 min and 1 h.

Upon arriving at the study site, participants completed a consent form and the pre-test using a computer or tablet. Participants were then randomly assigned to one of the three conditions and were directed to a room where a researcher explained how to use the VR headset (model

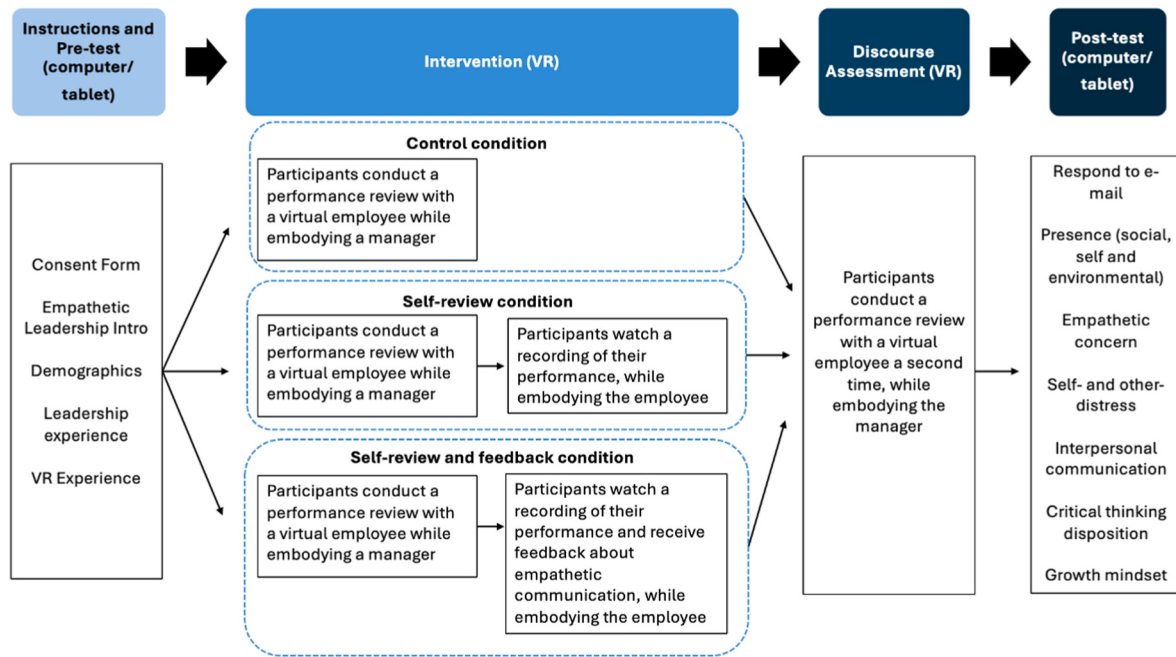


Fig. 3. Experiment flow.

Note. Figure showing the experience flow, materials, and procedures employed in the study.

Table 2
Post-test variables and composites' reliability.

Variable	Question example	Options range (score)	Reliability (α)
Social Presence	To what extent did you feel like Brad was in the room with you?	Not at all (1) - Extremely (5)	0.76
Environmental Presence	To what extent did you feel like you were inside the virtual world?	Not at all (1) - Extremely (5)	0.72
Self-Presence	To what extent did you feel that when something happened to your avatar, you felt like it was happening to you?	Not at all (1) - Extremely (5)	0.74
Empathetic Concern	To what extent did you feel softhearted while interacting with Brad?	Not at all (1) - Extremely (5)	0.86
Self-distress	To what extent did you feel directly distressed, as you might when you personally have a bad experience?	Not at all (1) - Extremely (5)	0.86
Other-distress	To what extent did you feel distressed for Brad?	Not at all (1) - Extremely (5)	0.86
Interpersonal Communication	I let Brad know that I understood what they said.	Almost never (1) - Always (5)	0.62
Critical Thinking disposition	How often were you thinking about the bigger picture during the conversation?	Never (1) - Always (5)	0.68
Growth Mindset	Everyone, no matter who they are, can significantly change their basic characteristics.	Strongly disagree (1) - Strongly agree (5)	0.84

Note. Cronbach's alpha (α) was used to calculate composites' reliability.

PicoNeo 3) and what to expect from the VR experience. The researcher instructed participants to remove the headset if they needed assistance and that she would observe them through a glass door.

The researcher selected the VR experience corresponding to the condition assigned to the participant, assisted participants in putting on the headset, and then left the room. Once participants completed the VR

Table 3
Word examples for each emotion category analyzed (Boyd et al., 2022, pp. 1–47).

Emotions categories	Words examples
Positive emotions	good, love, happy, hope
Negative emotions	bad, hate, hurt, tired
Positive tone	good, well, new, love
Negative tone	bad, wrong, too much, hate
Anger	hate, mad, angry, frustr*
Anxiety	worry, fear, afraid, nervous

experience, they were guided to another room where they answered the post-test using a computer or tablet.

2.4. Statistics

We estimated parameters using several linear regression models to test the pre-registered hypotheses and investigate the research questions. These models included the conditions as predictors and controlled for gender, age, race, prior VR usage, and leadership experience. For the discourse analyses, we ran regression models including each word category score in the second round of interaction as outcome, condition as predictor, and controlling for the scores of the same word category in the first round of interaction and demographics. The analyses were performed in RStudio, utilizing the 'lmerTest' package, which provides Satterthwaite approximations for degrees of freedom and p-values (Kuznetsova et al., 2015). ANOVA tests were run on the linear model outputs to investigate general condition effects. Partial eta squared (η_p^2) with a 90 % confidence interval (CI; Lakens, 2013) was computed using Sums-of-Squares (Ben-Shachar et al., 2020). Contrast analyses of the least-squares mean were run on the regression outputs to compare pairs of conditions, adjusted by the Bonferroni method, using the "emmeans" package in RStudio (Lenth & Lenth, 2018).

3. Results

3.1. Sample and descriptive analyses

A priori power analysis of the linear multiple regression models, including a medium effect size of Cohen's f squared = 0.15, alpha probability error of 0.05, seven predictors, and 80 % power, showed a sample size of 109 participants. We collected data from 111 participants, to target the 109 sample of valid data as one participant left the experiment before going through the VR experience, and data from another participant were not correctly recorded. Participants' mean age was 28.81 years old ($SD = 10.55$, $min = 18$, $max = 68$), and did not significantly differ across conditions ($\chi^2(2, 109) = 0.99$, $p = 0.610$). Regarding gender, 66 (61 %) participants described themselves as women, 40 (37 %) as men, two participants (1.8 %) as non-binary, and one participant (0.9 %) preferred not to say. Fisher's Exact tests revealed no significant differences across conditions for the gender distribution ($p = 0.889$) or race ($p = 0.550$). Participants' race and ethnicities are shown in Table 4.

3.2. Pre-registered hypothesis testing

Written communication. No significant effects of condition were found on the composite of the five empathy elements in e-mail content ($F(2, 84) = 0.85$, $p = 0.432$, $\eta_p^2 = 0.02$, $CI [0.00, 0.08]$). Linear regression models showed that participants in the SRF condition used the pronoun "they" significantly less frequently ($\beta = -0.49$, $SE = 0.24$, $t(62) = -2.03$, $p = 0.046$) in their written communication than participants in the Control condition. Means and standard deviation of the empathy measures and word category frequency in the written communication are shown in Tables 5 and 6, respectively.

Oral communication. Significant condition effects were found on the total use of pronouns ($F(2, 61) = 3.68$, $p = 0.031$, $\eta_p^2 = 0.11$, 90 % $CI [0.01, 0.23]$), personal pronouns ($F(2, 61) = 3.78$, $p = 0.028$, $\eta_p^2 = 0.11$, 90 % $CI [0.01, 0.23]$) and "you" pronoun ($F(2, 61) = 4.95$, $p = 0.010$, $\eta_p^2 = 0.14$, 90 % $CI [0.02, 0.27]$). However, none of the planned contrast analyses revealed significant differences between individual pairs of conditions after applying a Bonferroni correction for multiple comparisons. This suggests that the overall effect of condition may be due to subtle differences across all three groups, rather than strong effects between specific pairs.

There were significant effects of condition on the frequency of words associated with emotions in general ($F(2, 61) = 4.87$, $p = 0.011$, $\eta_p^2 = 0.14$, 90 % $CI [0.02, 0.26]$), with participants in the SRF condition scoring higher than participants in the Control condition ($\beta = 0.66$, $SE = 0.21$, $t(61) = 3.13$, $p = 0.007$). Specifically, there were condition effects on the frequency of words associated with negative tone ($F(2, 61) = 6.12$, $p = 0.004$, $\eta_p^2 = 0.17$, 90 % $CI [0.04, 0.30]$) and anxiety ($F(2, 61) = 5.14$, $p = 0.009$, $\eta_p^2 = 0.14$, 90 % $CI [0.02, 0.27]$). Contrast analyses revealed that participants displayed a significantly more negative tone in the SRF condition compared to both the Control ($\beta = 0.64$, $SE = 0.17$, $t(61) = 3.68$, $p = 0.001$), and SR conditions ($\beta = 0.40$, $SE = 0.15$, $t(61) = 2.68$, $p = 0.025$). Participants also used more words associated with anxiety in the SRF condition compared to both the SR ($\beta = 0.20$, $SE =$

Table 4

Participants' race and ethnicity distribution.

Race	N (%)
African, African-American or Black	5 (4.6 %)
Asian or Asian-American	40 (37 %)
Decline to answer	2 (1.8 %)
Hispanic or LatinX	21 (19 %)
Indigenous/Native American, Alaska Native, First Nations	1 (0.9 %)
Middle Eastern	3 (2.8 %)
More than one race	9 (8.3 %)
White	28 (26 %)

Table 5

Written communication empathy measures' mean and standard deviation per condition.

Variables	Conditions					
	Control		SR		SRF	
	M	SD	M	SD	M	SD
Understanding	1.15	0.74	1.32	0.70	1.40	0.60
Incisive	1.27	0.62	1.17	0.68	1.27	0.45
Expression	1	0.85	0.89	0.86	1.08	0.72
Validation	1.09	0.79	0.92	0.78	1.13	0.75
Support	1.18	0.76	1.16	0.72	1.40	0.55
Empathy Composite	1.14	0.63	1.09	0.63	1.26	0.48

Table 6

Word category frequency (LIWC) means and standard deviation per condition in the e-mail content.

	Control		SR		SRF	
	M	SD	M	SD	M	SD
Total pronouns	17.35	3.28	17.71	3.21	17.40	3.59
Personal pronouns	12.40	2.87	12.10	2.31	12.28	2.91
I	4.28	1.75	4.22	1.40	4.51	1.75
We	1.80	1.72	1.92	1.15	1.93	1.14
You	5.64	1.89	5.37	2.45	5.47	1.99
She/he	0.00	0.00	0.08	0.26	0.08	0.26
They	0.63	1.14	0.45	0.67	0.20	0.38
Impersonal pronouns	4.95	1.84	5.61	2.28	5.12	1.71
Emotions in general	1.80	1.38	1.83	1.07	1.90	1.47
Positive Emotions	1.59	1.30	1.61	1.00	1.43	1.02
Negative Emotions	0.13	0.29	0.17	0.36	0.28	0.56
Positive Tone	6.36	2.51	6.90	1.62	6.17	2.14
Negative Tone	1.19	0.89	0.94	0.86	1.21	1.04
Anger	0.05	0.19	0.06	0.18	0.12	0.32
Anxiety	0.05	0.20	0.03	0.15	0.08	0.26

0.08, $t(61) = 2.42$, $p = 0.048$) and Control conditions ($\beta = 0.25$, $SE = 0.09$, $t(61) = 2.66$, $p = 0.023$). Means and standard deviation of each word category frequency in each round of interaction in VR are shown in Table 7.

These findings partially support H1a and H1b, revealing nuanced effects of the intervention on participants' oral and written communication. Reviewing and receiving feedback tended to increase emotional expressions in oral communication compared to perspective-taking only (without the opportunity to review and receive feedback). Meanwhile, receiving feedback showed to increase the use of words associated with anxiety and the negative tone of the language.

There were no condition effects on empathetic concern ($F(2, 94) = 0.443$, $p = 0.643$, $\eta_p^2 = 0.01$, $CI [0.00, 0.05]$) thus, H2a and H2b were not supported. Moreover, while a linear model regression predicting empathetic concern from training condition and critical thinking, and controlling for demographics, revealed a significant effect of critical thinking on empathetic concern ($F(1, 83) = 23.24$, $p < 0.01$, $\eta_p^2 = 0.22$, 90 % $CI [0.10, 0.34]$), there was no condition effect ($F(2, 83) = 1.20$, $p = 0.306$, $\eta_p^2 = 0.03$, 90 % $CI [0.00, 0.10]$). Mediation analyses also showed no mediation effect of critical thinking between training condition and empathetic concern ($ACME = 0.07$, $p = 0.31$; $ADE = -0.08$, $p = 0.61$; $total\ effect = -0.01$, $p = 0.91$). These outcomes indicate that VR condition did not relate to critical thinking nor empathetic concern (RQ1). Means and standard deviation of the subjective measures are shown in Table 8.

To investigate the relationships between participants' real-world team-leading frequency and team size with empathetic communication (RQ2), linear regression models predicting written empathetic communication, including team size and team-leading frequency as predictors and controlling for conditions and demographics, were run and showed no significant effects of team size ($F(1, 84) = 0.52$, $p = 0.718$,

Table 7

Word category frequency (LIWC) means and standard deviation per condition in each round of interaction in VR.

	First round						Second round					
	Control		SR		SRF		Control		SR		SRF	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total pronouns	21.96	2.66	21.84	2.84	21.56	2.52	21.43	2.14	22.09	2.44	20.93	2.51
Personal pronouns	14.67	2.00	14.61	2.20	14.17	2.32	14.04	1.91	14.48	2.25	13.77	1.97
I	3.45	1.26	3.38	1.50	3.15	1.41	3.61	1.77	3.63	1.38	3.43	1.40
We	3.68	1.16	3.01	1.38	3.72	1.33	3.21	1.29	3.13	1.27	3.47	1.23
You	7.23	1.37	7.80	2.30	6.90	2.09	6.99	1.18	7.31	2.04	6.44	1.54
She/he	0.03	0.10	0.02	0.09	0.07	0.19	0.01	0.05	0.04	0.10	0.07	0.17
They	0.27	0.25	0.37	0.48	0.28	0.31	0.21	0.32	0.35	0.39	0.33	0.35
Impersonal pronouns	7.29	1.93	7.23	2.33	7.39	2.02	7.39	1.31	7.60	1.81	7.16	1.86
Emotions in general	0.88	0.65	1.21	0.84	0.91	0.72	0.72	0.47	1.13	0.75	1.25	0.76
Positive Emotions	0.60	0.53	0.92	0.79	0.66	0.55	0.51	0.41	0.86	0.71	0.80	0.59
Negative Emotions	0.24	0.30	0.23	0.34	0.25	0.37	0.15	0.20	0.24	0.39	0.38	0.38
Positive Tone	4.17	1.34	4.53	1.72	4.35	1.50	3.82	1.33	4.14	1.53	4.33	1.90
Negative Tone	0.58	0.53	0.50	0.48	0.54	0.64	0.34	0.33	0.48	0.57	0.83	0.68
Anger	0.00	0.02	0.02	0.08	0.02	0.09	0.03	0.11	0.04	0.15	0.01	0.05
Anxiety	0.16	0.23	0.11	0.28	0.16	0.29	0.10	0.16	0.14	0.31	0.33	0.36

Table 8

Subjective measures' mean and standard deviation per condition.

Variables	Conditions					
	Control (n = 34)		Self-review only (SR) (n = 38)		Self-review and feedback (SRF) (n = 37)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Empathetic concern	3.12	0.79	3.11	0.71	3.20	0.78
Other distress	2.94	0.85	3.01	0.75	2.73	1.11
Self-distress	2.75	0.94	2.64	0.86	2.39	1.14
Growth mindset	3.29	0.85	3.33	0.67	3.19	0.78
Interpersonal communication	3.68	0.51	3.54	0.54	3.63	0.54
Critical thinking disposition	3.63	0.40	3.74	0.51	3.57	0.55
Social presence	3.31	0.86	3.01	0.77	3.19	0.81
Self-presence	2.68	0.88	2.40	1.06	2.78	0.92
Environmental presence	3.05	1.06	3.12	0.75	3.20	0.73
Team size	2.18	1.06	2.16	0.79	2.19	0.81
Leadership frequency	3.03	0.94	3.00	1.01	2.81	1.00

$\eta_p^2 = 0.02$, 90 % CI [0.00, 0.06]) or team-leading frequency ($F(1, 84) = 1.22$, $p = 0.271$, $\eta_p^2 = 0.01$, 90 % CI [0.00, 0.08]) on written empathetic communication. Finally, linear regressions predicting growth mindset from the conditions (RQ3), controlling for demographics, revealed no significant effects of conditions on growth mindset ($F(2, 88) = 0.97$, $p = 0.385$, $\eta_p^2 = 0.02$, 90 % CI [0.00, 0.08]).

3.3. Exploratory analyses

3.3.1. Practice effects

To investigate the effect of practice, i.e., repeating the conversation with the agent in VR on oral communication, we ran linear mixed-effect regression models predicting each of the categories of pronouns and emotions. Time (first or second round of interaction) was included as a predictor, and the models were controlled for condition main effects, demographics and random individual effects. Results showed that participants increased the use of “I” ($\beta = 0.28$, $SE = 0.14$, $t(83) = 2.01$, $p = 0.047$, $\eta_p^2 = 0.05$, 90 % CI [0.00, 0.14]) and decreased the use of “you” ($\beta = -0.41$, $SE = 0.17$, $t(84) = -2.36$, $p = 0.020$, $\eta_p^2 = 0.06$, 90 % CI [0.01, 0.16]) in the second VR interaction. No effects of repeating the conversation in VR were found on emotions expressed in oral communication (see Supplementary Material for complete data analyses).

4. Discussion

This study investigated the effects of review, feedback, and practice

when conducting a performance review meeting in VR on factors related to empathetic leadership, such as empathetic communication, empathetic concern, critical thinking disposition, growth mindset, and interpersonal communication perception. Results indicated that receiving feedback while reviewing one's own performance in VR had effects on written and oral communication.

Participants in the SRF condition used the pronoun “they” less than participants in the control condition in their written communication after the intervention. Studies identified that the use of the pronoun “they” indicates less personal involvement than the use of first-person pronouns (such as “I” and “we”; [Stirling & Manderson, 2011](#)). According to the authors, when a speaker uses first-person pronouns in a conversation, he/she includes him/herself in the situation, while when using “they,” the speaker is excluding both him/herself and the addressee. In this context, our finding suggests that participants in the SRF condition were more personally involved than participants in the control condition. Although we do not have data to support further explanations about this finding, perhaps the opportunity to review and receive feedback on the interaction in the SRF condition increased participants' engagement with the situation. Future studies should investigate which elements of this VR intervention influence personal involvement.

The absence of significant differences between conditions for the empathy measures in the written communication may indicate that the effects of the intervention were brief, subtle, and more related to language styles than conceptual changes. Although we do not have data to expand on this explanation, future studies should investigate if more intense changes in the language style (e.g., larger effect sizes and number of word categories influenced) would result in the perception of changes in the empathetic communication by human-coders. Moreover, future studies should investigate if a longer or more frequent exposure to the VR intervention would lead to those more intense changes, to the point that the differences in the message would be noticed by human-coders and not only by automated methods.

In oral communication, participants in the SRF condition expressed more emotions after the intervention than participants in the control condition, in particular, anxiety and words associated with a negative tone. Collectively, these results indicate that answering prompts to think about own communication and receiving contextualized feedback about empathetic communication while going through this review had a positive effect on emotion expressions in speech, compared to conditions where no prompts or feedback was provided (i.e., SR and control).

Focusing on learning, the Social Cognitive Theory ([Bandura, 1986](#), pp. 23–28) states that individuals learn through observation, imitation, and reinforcement. The intervention's review-feedback process in the

SRF condition likely facilitated language changes by encouraging self-reflection and supporting observational learning and reinforcement compared to the SR and Control conditions. It suggests that reviewing one's communication and receiving feedback about empathetic communication contributed to the changes found as participants in the SRF condition were able to observe their communication behaviors and compare them with the feedback provided.

From the communication perspective, the Theory of Relevance (Sperber & Wilson, 1986) states that individuals seek to convey relevant and informative information in their discourse. Deriving from this theory and specifically targeting the link between language elements and cognition and emotions, Schiffrin (1987) proposed the study of discourse markers, such as pronouns and adjectives use, and their role in guiding interpretation, signaling shifts in topic or discourse and marking the speaker's attitude or emotions in cognitive, expressive, social and textual domains.

The VR experience in this study placed participants in a difficult conversation in which the agent expressed negative emotions and distress. The literature shows that in these situations (negative), participants tend to use words related to negative emotions, in particular, anxiety (Gibson et al., 2015), in an attempt to overcome the stressful situation (Zhou et al., 2021). For example, in therapeutic settings, Gibson and colleagues (2015) found a positive correlation between the therapist's use of words related to anxiety and empathy when discussing the feelings of the client.

Together, our results suggest that receiving feedback while reviewing one's communicative performance in VR may have increased participants' personal involvement in the written communication and emotional involvement in the oral communication.

Additionally, we found that as participants had the opportunity to repeat the interaction and practice their communication skills in the VR experience, they increased the use of "I" and decreased the use of "you" in the second round of interaction compared to the first round. In view of Packard and colleagues' work (2018), which showed that the use of pronoun "I" can indicate the speaker's emotional and behavioral involvement, and Stirling and Maderson's (2011) findings that third person pronouns indicate less personal involvement than first-person pronouns, these results suggest that practicing in VR may have contributed to increase participants' involvement in the conversation, influencing linguistic aspects of empathetic communication. Although the findings combined indicate that the training method used in this study increased participant's personal and emotional involvement in the situation, how exactly these aspects relate to empathetic communication was not investigated.

Notably, most discourse marker studies are based on written or face-to-face interactions, while participants in this study interacted with a virtual agent in a VR simulation. This novel context may have influenced the participants' discourse. Although our findings can contribute to the investigation of social interactions in digital spaces, we must take these findings with caution, and more studies are needed before generalizing these results.

Finally, the absence of significant effects of conditions or practice (time) in VR on empathetic concern (subjective measure) but significant effects on language, suggests that how participants communicate were not related to how participants felt about the agent in the simulation. These findings align with Schrooten and De Jong's (2017) findings of a disconnection between medical providers' empathetic communication and sensitivity to the client's perspective. These results indicate that empathy as a mental state does not necessarily result in empathetic communication. In this context, more studies are needed to better understand the relationship between la and empathetic communication, as well as the effects of having meaningful conversations in VR on empathetic communication skills development.

5. Limitations

Although the present study was thoughtfully designed in collaboration with a multidisciplinary team of scholars, it has important limitations. First, the study recruited a convenient sample that included university students, staff, and faculty. Second, the intervention consisted of only one VR session, targeting one topic, so caution is needed when trying to generalize our finding to other contexts and populations. Third, participants may have perceived the experience as less natural due to the on-screen questions presented during the SRF condition's review phase. Finally, participants may have paid more attention to the virtual whiteboard with the instructions than to the agent. Future studies should collect participant's gaze information, to identify the time spent gazing each element of the experience.

6. Conclusions and future directions

In this study, reviewing and receiving feedback on one's communications when conducting a performance review in VR improved aspects of participant's empathetic communication, compared to not reviewing or receiving feedback. Results also showed that empathetic concern did not relate to empathetic communication, indicating that empathetic communication training does not necessarily influence how participants feel about who they are interacting with.

The VR experience used in this study yielded positive results in empathetic communication skills after brief interventions of a few minutes (around 10 min). Given the multifaceted aspects of communication, future studies should consider multiple sessions, topics and cultural differences, long-term impacts, and investigate the psychological mechanisms underlying empathetic communication.

CRedit authorship contribution statement

Anna C.M. Queiroz: Writing – review & editing, Writing – original draft, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jeremy N. Bailenson:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Conceptualization. **Kristen Pilner Blair:** Writing – review & editing, Validation, Supervision, Resources, Methodology, Data curation, Conceptualization. **Daniel L. Schwartz:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization. **Candace Thille:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Anthony D. Wagner:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used Grammarly and Gemini in order to proof-read the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Anna C. M. Queiroz reports financial support was provided by Stanford Accelerator for Learning. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A Supplementary data

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