

Effects of Gestural Politeness on Comfort and Social Perception During Command-Based Interaction with Virtual Agents in Augmented Reality

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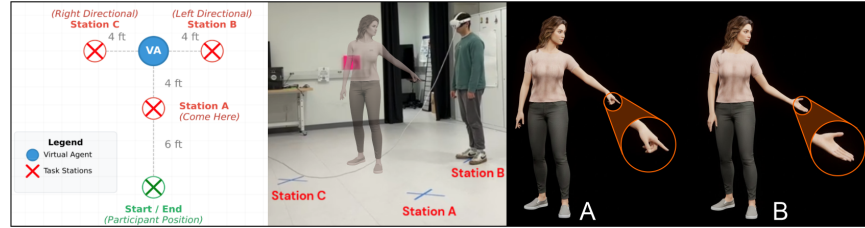


Figure 1: (Left) Experimental layout with stations and distances. (Center) Participant at Station B following a left directional command from the virtual agent. (Right) Comparison of (A) impolite finger-pointing and (B) polite open-palm left gestures.

ABSTRACT

Nonverbal communication influences human-agent interaction, yet research in augmented reality (AR) remains limited. This within-subjects study ($N = 22$) investigated how gestural politeness (open-palm versus finger-pointing) affects psychological comfort and social perception during command-based interaction with virtual agents. Participants received polite or impolite directional commands while other variables remained constant. Polite gestures significantly increased comfort, warmth, and willingness to re-engage, whereas impolite gestures increased perceived dominance, with medium to large effect sizes, demonstrating that gesture design functions as a meaningful social signal in AR agent development.

Index Terms: Augmented reality, virtual agents, gestural politeness, nonverbal communication.

1 INTRODUCTION

As virtual and augmented reality technologies integrate into education, healthcare, and everyday applications, understanding human-agent social dynamics grows increasingly important. Virtual agents (VAs) now act as instructors, assistants, and collaborators in immersive environments [8], yet research on nonverbal agent behavior largely focuses on VR, with limited attention to mixed reality and AR contexts [9]. Gesture plays a central role in human communication [7], and gesture style and expressivity [10] have been shown to influence perceived personality, social presence, and user judgment of VAs [2]. However, little work examines how gestural politeness, such as open-palm versus finger-pointing gestures, affects user comfort when receiving commands from VAs in immersive AR. To address this gap, we conducted a within-subjects study in which 22 participants received directional commands from a VA using polite (open-palm) or impolite (finger-pointing) gestures, with verbal content held constant. We hypothesized polite gestures would increase comfort and warmth, and examined how impolite gestures shaped users' perceptions during interaction.

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2 METHODS

2.1 Study Design and Procedure

This IRB-approved within-subjects study (Protocol: ET00048813) examined gestural politeness effects (open-palm vs. finger-pointing) on user perception in AR. 22 participants (mean age = 21.18, $SD = 2.06$; 16 males, 5 females, 1 undisclosed) with normal or corrected-to-normal vision completed two counterbalanced sessions. In each session, a VA issued commands using one gestural style (open-palm or finger-pointing), with verbal content, tone, and facial expressions constant and gesture order randomized.

2.2 Measures and Tasks

Participants completed 7-point Likert-scale measures after each session assessing psychological comfort, agent perception, and gesture quality. Psychological comfort included: overall comfort, comfort receiving commands, interaction naturalness, communication appropriateness, and willingness to re-engage [3]. Agent perception was assessed along warmth and dominance dimensions [5]. Gesture quality evaluated clarity, naturalness, and verbal-gestural congruence as a manipulation check. Open-ended responses provided qualitative context for comfort and perceived interaction quality.

2.2.1 Tasks

Participants began each trial at a marked floor position facing the VA (Fig. 1). Three extra markers were positioned relative to the agent: one directly ahead, one left, and one right.

In each session, participants completed three types of gestural commands issued by the VA: left, right, and center directional gestures. For each command, participants walked to the indicated marker and returned to the starting position before the next command. Each command type was presented twice per session, with presentation order randomized to control for order effects.

2.3 System Design

The study was implemented in Unreal Engine 5.5 using MetaHuman characters for realistic VA representation. Participants wore a Meta Quest 3 head-mounted display in passthrough mode, allowing them to see the physical environment and the VA simultaneously. The VA's gestures were animated using QuickMagic, an AI-powered tool that converts 2D videos of human movement into 3D skeletal animation data [1]. Its markerless motion capture approach enabled the creation of fluid, natural gesture animations that enhanced the realism of the interaction.

3 RESULTS AND DISCUSSION

Paired-samples t-tests compared polite and impolite gesture conditions in a within-subjects design, using one-tailed tests reflecting a priori directional hypotheses favoring polite gestures. Significant differences emerged between polite and impolite conditions across several perceptual dimensions (See Table 1).

Participants reported greater comfort during interactions with polite VAs ($M = 6.18$, $SD = 0.96$) compared to impolite VAs ($M = 5.73$, $SD = 1.42$), $t(21) = 1.87$, $p = .038$, $d_z = 0.40$, 95% CI [-0.05, 0.96]. Participants reported greater comfort receiving commands from polite VAs ($M = 6.00$, $SD = 1.11$) than from impolite VAs ($M = 5.45$, $SD = 1.50$), $t(21) = 1.74$, $p = .048$, $d_z = 0.37$, 95% CI [-0.11, 1.20]. Participants also expressed a greater willingness to re-interact with polite VAs ($M = 5.91$, $SD = 1.44$) than with impolite VAs ($M = 5.14$, $SD = 1.49$), $t(21) = 2.11$, $p = .023$, $d_z = 0.45$, 95% CI [0.01, 1.53].

Significant differences were observed for social perception measures. Polite VAs were perceived as significantly warmer ($M = 4.55$, $SD = 1.79$) than impolite VAs ($M = 3.86$, $SD = 1.61$), $t(21) = 2.35$, $p = .014$, $d_z = 0.50$, 95% CI [0.08, 1.28]. Conversely, impolite VAs were perceived as significantly more dominant ($M = 5.41$, $SD = 0.85$) than polite VAs ($M = 4.59$, $SD = 1.05$), $t(21) = -3.15$, $p = .002$, $d_z = 0.67$, 95% CI [-1.36, -0.28].

Gestures produced by polite VAs were rated as significantly more natural ($M = 5.41$, $SD = 1.14$) than those produced by impolite VAs ($M = 4.45$, $SD = 1.60$), $t(21) = 2.37$, $p = .014$, $d_z = 0.50$, 95% CI [0.12, 1.79]. No significant differences were observed for perceived interaction naturalness, friendliness, gesture clarity, or gesture-verbal command matching (all $ps > .05$).

No significant differences were found for participants' comfort in receiving or giving commands to a VA in the additional command-related measures ($ps > .05$). Open-ended responses echoed the quantitative findings, with participants frequently describing polite gestures as more natural and approachable, and impolite gestures as dominant or "bossy," helping to contextualize the observed comfort and dominance effects.

Beyond statistical significance, the results indicate meaningful design implications for VAs in immersive environments. Medium to large effect sizes across comfort, warmth, dominance, and gesture naturalness show subtle differences in gestural politeness can systematically shape users' affective and social perceptions. While politeness was operationalized through open-palm and pointing gestures, these gestures also differ in perceived dominance and familiarity, which may jointly contribute to the observed effects. This clarity-politeness tradeoff aligns with multimodal gesture research [12]. Increased comfort and willingness to re-engage suggest polite gestures may promote sustained interaction and acceptance in contexts such as training, education, and assistive systems. Conversely, strong dominance from impolite gestures shows gestural style can unintentionally signal authority or threat, potentially undermining trust. Overall, these findings position gesture design as a social signaling mechanism with measurable perceptual impact.

4 CONCLUSION AND FUTURE WORK

This study examined how gestural politeness in AR VAs shapes user perception during interactive encounters in immersive environments. In a within-subjects design, we found polite gestures increased perceived comfort, warmth, and naturalness, whereas impolite gestures increased perceived dominance. Medium to large effect sizes indicate that gestural politeness functions as a meaningful social signal rather than pure stylistic variation.

These findings align with theories of politeness and social signaling [4, 7] and prior work demonstrating the influence of nonverbal cues on social presence and user judgment [3, 2]. Our results extend this literature by showing that contrasts in gestural politeness cues alone can modulate affective and social evaluations of VAs.

Table 1: Significant differences between polite and impolite VA gestures (one-tailed paired-samples t-tests, $df = 21$).

Measure	Polite	Impolite	t	p	d_z
Comfort during interaction	6.18	5.73	1.87	.038	0.40
Comfort receiving commands	6.00	5.45	1.74	.048	0.37
Comfort interacting again	5.91	5.14	2.11	.023	0.45
Warmth	4.55	3.86	2.35	.014	0.50
Dominance	4.59	5.41	-3.15	.002	0.67
Gestures felt natural	5.41	4.45	2.37	.014	0.50

The observed warmth and dominance effects are consistent with models of social perception [6] and embodiment research highlighting the impact of subtle behavioral variations on user interpretation [11]. However, because politeness was operationalized through open-palm versus pointing gestures only, user perceptions regarding those gestures may have been disproportionately amplified. Moreover, these effects may reflect a combination of cultural norms, politeness, perceived dominance, and gesture familiarity rather than politeness alone. The reliance on self-reporting also limits interpretation. Future work could examine other behavioral outcomes, such as task compliance and hesitation in movement.

Future work should examine whether these effects persist over longitudinal interactions, particularly in training, education, and assistive contexts [3], and how cultural and contextual factors shape interpretations of polite and impolite gestures [4]. Beyond isolated gestures, future studies should explore multimodal politeness strategies and evaluate behavioral and task-level outcomes such as compliance, trust calibration, learning, and collaboration.

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