Exploring Winking in Interactive Systems as a Minimal Non-Verbal Cue for Enhancing Perceived Proactivity

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ABSTRACT

This research explores how minimalist, human-like non-verbal cues specifically winking and turning gestures can enhance user perception of proactivity in interactive objects. We conducted a two-phase study to measure how these simple behaviors influence an object's perceived intentionality and engagement in both physical and virtual settings. The first phase involved a real-world experiment with a tangible box featuring animated eyes that could turn and wink at participants. The findings from this initial phase strongly suggest that the winking gesture significantly boosts the perception of the object's proactivity. To validate these results, a second phase was conducted in a virtual environment with 240 participants via Amazon Mechanical Turk (MTurk). The online study confirmed our initial findings, showing that a wink consistently increases perceived proactivity across different contexts. These results provide compelling evidence that integrating simple, low-complexity behaviors like winking can foster greater user engagement. This insight offers practical guidance for designing more accessible and resource-efficient interactive technologies, particularly in robotics and human-computer interaction, by effectively simulating intentionality through minimal gestures.

Keywords: Proactivity, Winking, Non-Verbal Cues, Human-Computer Interaction, User Engagement, Interactive Design, Robotics

INTRODUCTION

Human communication is rarely limited to words alone. It is embedded in expressions, gestures, and particularly the eyes, how they look, when they signal, when they lock in contact, or even wink. Winking is a notably deliberate gesture: one eye closes briefly, often to signal inclusion, humor, or shared understanding. Unlike blinking or glance shifts, winking is seldom automatic; it carries intention, which makes it a promising cue for interactive systems seeking to appear proactive. Yet, despite its expressive power in person-to-person communication, winking has been little explored as behavior emitted by systems (robots, agents, interactive objects) with respect to how it influences perceptions of proactivity, intentionality, or agency [1].

In contrast, eye gaze and eye contact have been studied more thoroughly in recent years. For example, the effect of robot gaze on social presence has been investigated: in hallway navigation tasks, robots that orient

their gaze either towards their future path or towards nearby people (instead of maintaining a fixed gaze) are rated as more socially present [1]. Eye-contact studies also show stronger psychophysiological responses when the gaze is direct and when the agent appears intentional [2].

Other recent work focuses on recognizing intention from gaze and motion. For instance, in human-robot collaboration assembly settings, idle state estimation using eye tracking and movement features improves synchronization between human and robot agents [3]. Similarly, gaze-based interaction intention recognition in virtual reality demonstrates that gaze alone or combined with motion cues is a strong indicator of what a user intends to do [4]. Beyond gaze, broader gesture recognition studies confirm that even subtle movements can provide natural and flexible interaction between humans and computers [5].

Gesture-based interaction frameworks have also been applied in non-contact systems, highlighting the potential of small, efficient motions to create meaningful interaction [6]. Emerging technologies such as millimeter-wave and thermal sensors further extend the capability of detecting minimal gestures, including subtle facial expressions, to enrich interaction [7]. These developments reinforce the notion that minimal non-verbal signals are effective in shaping human interpretation of system intentionality.

Although these gaze and gesture studies support the idea that non-verbal eye cues are powerful, they still leave open the specific question: What does a wink from an interactive system communicate, compared to eye gaze, blinking, or more complex gestures? Does a system that winks seem more proactive, more “alive,” more intentional? The educational robotics field has begun to explore multi-modal designs that combine subtle gestures with voice or movement, showing promising effects on learning engagement and perceived agency [8]. Yet, the wink itself remains under-examined.

This gap motivates the current paper. By isolating winking as the system’s gesture excluding turning, head movement, or even standard blinking, we seek to understand its unique effect on perceived proactivity. We hypothesize that when an interactive object (physical or virtual) winks, participants will perceive it as more proactive, intentional, and socially present than when it does not wink or exhibits only generic eye behavior.

To test this, we conduct a two-phase study, first with physical prototypes in real settings, then with video-based online experiments to broaden contexts and participant backgrounds. Through this, we aim to show how even a minimal, well-timed gesture like winking can yield strong perceptual effects, helping designers build more engaging interactive systems with low complexity and high expressiveness.

METHODOLOGY

Our investigation was structured in two distinct phases to rigorously evaluate the impact of the winking gesture in both physical and virtual environments.

Phase I: The Real-World Study

The first phase centered on a physical object designed to be simple and neutral, ensuring that participants' reactions were focused solely on its behaviors rather than its form.

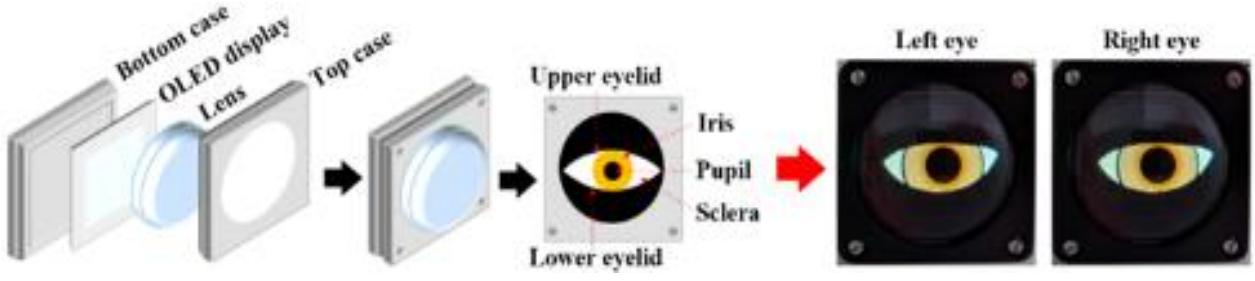

Figure 1. Design and components of the animated eyes displayed on OLED screens.

Figure 2. . (a) Square box mounted with animated eyes and Omron HVC-P2 camera module, (b) rotating base attached at the bottom of the box, and (c) square box turning towards the user.

We constructed a square box equipped with two 1.5-inch OLED displays for animated eyes. These eyes were designed with upper and lower eyelids, an iris, and a pupil to simulate a natural blinking effect and denote gaze direction. A default blinking behavior was included to prevent an unsettling, prolonged stare. The box was mounted on a servo-driven rotating base, allowing it to turn towards a person. An Omron HVC-P2 camera module enabled face detection, allowing the box to identify and respond to a person's presence.

We developed ten behavioral scenarios to test the box's perceived proactivity in single-person (SP) and two-person (TP) interactions. The core of the experiment was to compare scenarios where the box only turned towards a participant, SP(T-S) and with scenarios where it turned and then winked, SP(T-W-S). In two-person scenarios, the box would interact with either the participant or an experimenter, again with conditions that either included a wink (e.g., TP1(T1,W1,S1)) or did not (e.g., TP1(T1,S1)).

Table 1. Sequence of behaviors in single- and two-person scenarios

Scenarios	Sequence of behaviors	Conditions
Single-person	I→ T→ S	SP(T-S)
	I→ T→ W→ S	SP(T-W-S)
Two-person (Box initiating interaction with the participant)	I→ T2→ T1→ W1→ S1	TP1(T2-T1-W1-S1)
	I→ T2→ T1→ S1	TP1(T2-T1-S1)
	I→T1→W1→S1	TP1(T1-W1-S1)
	I→T1→S1	TP1(T1-S1)
Two-person (Box initiating interaction with the experimenter)	I→ T1→ T2→ W2→ S2	TP2(T1-T2-W2-S2)
	I→ T1→ T2→ S2	TP2(T1-T2-S2)
	I→T2→W2→S2	TP2(T2-W2-S2)
	I→T2→S2	TP2(T2-S2)

A total of 24 participants were recruited for this phase. They were instructed to position themselves 60-120 cm from the box to facilitate direct interaction. After each of the ten scenarios, participants rated the box's behavior on a 7-point Likert scale, ranging from 1 (“very reactive”) to 7 (“very proactive”). They were asked to base their rating on the object's perceived intentionality and purposefulness.

The Online MTurk Study

The second phase aimed to validate our real-world findings with a larger and more diverse audience through Amazon Mechanical Turk (MTurk).

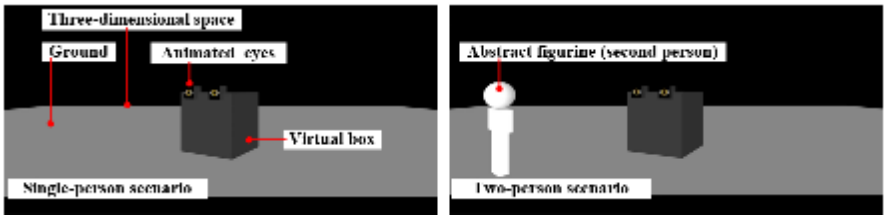

Figure 3. Virtual box animation design in single- and two-person scenarios within a three-dimensional virtual space.

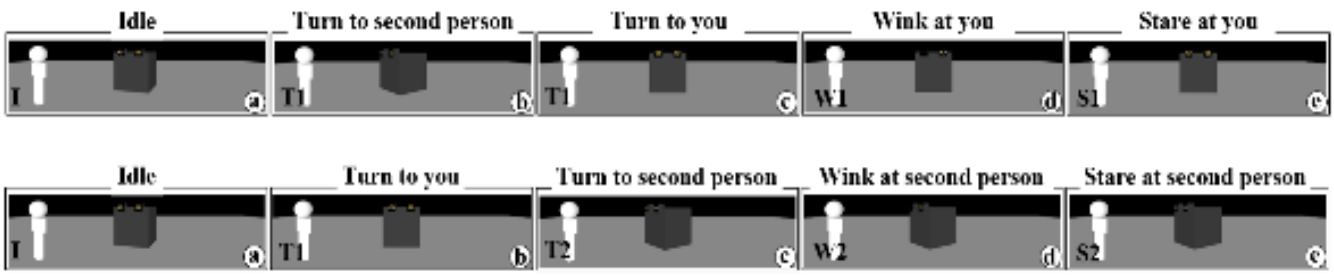

Figure 4. Online MTurk study for two-person (TP) scenarios. Abstract figurine (on the left side) acts as the second-person.

We created ten pre-recorded videos that precisely replicated the behavioral scenarios from Phase I. The virtual box was designed to look identical to its physical counterpart, situated in a simulated 3D space from a first-person perspective. For the two-person scenarios, an abstract figurine was used to represent the second person.

We recruited 240 MTurk participants, who were evenly divided into two groups. The procedure mirrored the real-world study. participants watched the videos and, after each one, rated the virtual box's behavior on the same 7-point proactive-reactive Likert scale.

RESULTS

Across both the real-world and online studies, the results consistently demonstrated that the winking gesture had a significant and positive impact on the perceived proactivity of the object.

Real-World Findings

In physical interactions, the inclusion of a wink was the key factor that elevated proactivity ratings.

Table 2. Sequence of behaviors in single- and two-person scenarios.

Scenarios	Mean (M)	Median (Mdn)	Standard Deviation (SD)
SP(T-S)	3.15	3	1.35
SP(T-W-S)	**5.19**	**5**	**1.21**
TP1(T2-T1-W1-S1)	**5.15**	**6**	**1.68**
TP2(T1-T2-W2-S2)	**5.08**	**6**	**1.38**
TP1(T2-T1-S1)	3.38	3	0.92
TP2(T1-T2-S2)	3.31	3	1.26
TP1(T2-W1-S1)	**5.31**	**6**	**1.65**
TP2(T1-W2-S2)	**5.00**	**5**	**1.58**
TP1(T1-S1)	2.85	3	1.21
TP2(T2-S2)	3.31	3	1.32

Winking vs. No Winking: Scenarios featuring a wink received consistently higher proactive scores. The single-person scenario where the box turned and winked, SP(T-W-S), earned a mean score of 5.19, which was dramatically higher than the 3.15 mean score for the scenario where the box only turned, SP(T-S). This stark contrast shows that participants interpreted the wink as a clear, deliberate signal of engagement.

Reinforcing Intentionality: The combination of turning and winking proved to be the most effective pairing. Scenarios that included both actions, such as SP(T-W-S) and TP1(T1-W1-S1), were among the highest-rated for proactivity, with mean scores of 5.19 and 5.31 respectively. In contrast, scenarios with turning alone were perceived as more reactive or passive. This suggests that while turning indicates awareness, the wink communicates active intent.

Effectiveness in Multi-Person Scenarios: Even in more complex two-person interactions, the wink retained its power to convey proactivity. For instance, when the box turned to the experimenter and winked (TP2(T1-T2-W2-S2)), it still received a high mean score of 5.08, indicating that the gesture successfully communicated purposefulness even when not directed at the primary participant.

Online MTurk Validation

The online study with 240 participants validated the findings from the real-world experiment, confirming the wink's role as a powerful proactive cue.

Table 3. Sequence of behaviors in single- and two-person scenarios.

Scenarios	Mean (M)	Median (Mdn)	Standard Deviation (SD)
SP(T-S)	3.90	3.5	2.08
SP(T-W-S)	**4.71**	**5**	**1.91**
TP1(T2-T1-W1-S1)	**4.57**	**5**	**1.91**
TP2(T1-T2-W2-S2)	**4.49**	**5**	**2.20**
TP1(T2-T1-S1)	4.19	5	2.13
TP2(T1-T2-S2)	4.04	4	2.05
TP1(T2-W1-S1)	**4.32**	**5**	**2.13**
TP2(T1-W2-S2)	**4.58**	**5**	**1.96**
TP1(T1-S1)	3.62	3	1.95
TP2(T2-S2)	3.98	4	1.98

Consistent Preference for the Wink: As in the physical study, virtual scenarios that included a wink were rated as significantly more proactive. The SP(T-W-S) scenario again scored highly with a mean of 4.71, compared to the SP(T-S) scenario's mean of 3.90. This confirms that the winking gesture acts as a clear signal of intentionality, regardless of the medium.

Winking Outperforms Turning Alone: The data showed that turning motions without a wink were perceived as less proactive. Scenarios like SP(T-S) and TP1(T1-S1) received some of the lowest mean scores (3.90 and 3.62, respectively). While turning can suggest the box is responsive, it does not convey the same level of communicative purpose as a wink. The wink adds a layer of deliberate communication that turning alone lacks.

Clarity in Social Contexts: The comparison between single and two-person scenarios revealed that a deliberate gesture like winking is especially important in more complex social dynamics. In both contexts, adding a wink consistently boosted proactivity scores, but its absence was more noticeable in the two-person scenarios, where more explicit signals of engagement are needed to convey intent.

DISCUSSION

The findings from both study phases converge on a clear conclusion, a simple wink is a remarkably effective tool for making an interactive object seem more proactive and intentional. This result likely stems from our innate human tendency to interpret certain non-verbal cues as deliberate acts of communication. A wink is not a passive or accidental gesture; in human interactions, it is used to convey a shared understanding, friendliness, or specific intent. When the box performed this action, participants appeared to transfer this understanding, viewing the object as having agency and a desire to engage.

The contrast between scenarios with and without winking is particularly revealing. Turning alone was often perceived as merely reactive as a basic response to a stimulus. It showed the box was aware, but not necessarily that it was initiating an interaction. The addition of a wink transformed this perception, layering a sense of purpose onto the physical movement. This was especially crucial in the multi-person scenarios, where ambiguity about the object's focus could arise. The wink served as an unambiguous signal, clarifying the object's intention and maintaining a sense of engagement even when its attention is divided.

These results have significant practical implications for the design of interactive systems, particularly in social robotics, virtual assistants, and customer service applications. Instead of relying on complex and resource-intensive programming to simulate personality, designers can use minimalist cues like winking to create a sense of responsiveness and intentionality. For example, a virtual assistant that "winks" when providing a helpful tip could feel more approachable and collaborative. This approach aligns with the principles of sustainable and efficient design by achieving high user engagement with low technical complexity.

It is important to acknowledge the context of the MTurk study. Participants from this platform are often more tech-savvy, which might have made them more receptive to interpreting the box's gestures as proactive. Future research could explore how these non-verbal cues are perceived across different cultural contexts and by users with varying levels of technological familiarity to ensure that such designs are universally effective.

CONCLUSION AND FUTURE DIRECTIONS

This study demonstrates that simple, animated gestures and the winking motion in particular have a profound impact on how users perceive proactivity in interactive objects. Through both a physical, real-world experiment and a large-scale online validation, we found that winking consistently and effectively signals intentionality, making an object appear more engaging and purposeful. While turning alone conveys a baseline level of awareness, it is the addition of a wink that transforms the interaction from reactive to proactive in the eyes of the user.

The implications for designers are direct and actionable. By strategically incorporating minimalist, human-like cues such as a wink, interactive systems in fields from social robotics to education can be made to feel more intuitive, responsive, and alive. This approach offers a low-cost, resource-efficient pathway to enhancing user experience and fostering a stronger sense of connection between humans and machines.

Future work could expand on these findings by exploring a wider range of non-verbal cues like nodding or smiling, creating a richer vocabulary for non-verbal interaction in HCI. Furthermore, investigating the cultural nuances of these gestures would be a valuable step toward designing globally resonant and accessible technologies. Finally, applying these principles to sustainability-focused technologies could be a promising avenue, where proactive, engaging systems might encourage more eco-friendly behaviors by fostering a sense of shared purpose and connection

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