Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 7, No.1, January 2025, pp. 0250109-01 ~ 0250109-013
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v7i1.1011

Non-Verbal Cues in Interactive Systems: Enhancing Proactivity through Winking and Turning Gestures

Siti Aisyah binti Anas[1], Mazran bin Esro[1*], Ahamed Fayeez bin Tuani Ibrahim[1], Yogan Jaya Kumar[2], Vigneswara Rao Gannapathy[1], Yona Falinie binti Abd Gaus [3], R. Sujatha [4]

[1]Fakulti Teknologi dan Kejuruteraan Elektronik dan Komputer, Universiti Teknikal Malaysia Melaka, Jalan Hang Tuah Jaya, 76100 Durian Tunggal, Melaka

[2]Fakulti Teknologi Maklumat dan Komunikasi, Universiti Teknikal Malaysia Melaka, Jalan Hang Tuah Jaya, 76100 Durian Tunggal, Melaka

[3]Post Doctoral Research Associate, Department of Computer Science, Durham University, South Road, Durham, DH1 3LE, United Kingdom

[4]Department of Embedded Technology (IoT and sensors specialization), School of Electronics and Communication Engineering, Vellore Institute of Technology, Vellore-632014, India.
*mazran@utem.edu.my

Abstract. This investigation investigates the extent to which proactive behaviours in interactive objects—specifically animated eyes that exhibit behaviours such as blinking and turning—improve user interaction. Through a two-phase process, we investigate the influence of these behaviors on users' perceptions of proactivity in both physical and virtual environments. In Phase I, we conducted a real-world study using a tangible box with animated eyes to evaluate user responses to expressive behaviours in single- and multi-person interactions. The results indicate that blinking significantly improves perceptions of the box's intentionality and engagement, thereby fostering a more robust sense of proactivity. Phase II expands this investigation to a virtual environment, where 240 participants on Amazon Mechanical Turk (MTurk) participated, thereby validating the real-world findings. The online study confirms that perceived proactivity is consistently increased across contexts by blinking and turning. These findings indicate that integrating basic, human-like behaviors into interactive systems can enhance user engagement and provide practical advice for the development of sustainable, low-complexity interactive technologies. These discoveries facilitate the future development of resource-efficient and accessible human-computer interaction and robotic systems by simulating intentionality through minimal behavior.

Keywords: behavioral cues, interactive design, human-computer interaction, mechanical turk study, user experience design, robotics

(Received 2024-08-30, Accepted 2024-11-16, Available Online by 2025-01-06)

1. **Introduction**

The proactive behaviours demonstrated by interactive objects, such as looking, winking, blinking, or body rotation, are widely acknowledged as vital for improving user interaction and engagement. Proactivity in interactive systems refers to an object or interface's capacity to anticipate user needs or elicit reactions, creating a more intuitive and responsive user experience. This study examines the influence of proactive behaviours on user perceptions, particularly with simple objects augmented with animated eyes and body rotation. Such behaviours are becoming essential in domains such as robotics and human-computer interaction (HCI), as researchers seek to build systems that adapt to users in real-time, facilitating interactions that are perceived as natural and engaging [1][2]. These behaviours can improve user experiences by eliciting actions that promote user responses.

Recent advancements in AI have significantly influenced interactive technology, enabling objects and systems to exhibit proactive behaviors that respond to users in real time [3]. AI-driven systems in human-computer interaction and social robotics utilize gestures and expressions such as winking or nodding to simulate intentionality and enhance user engagement. Research has shown that such human-like cues can foster a sense of presence and relational depth, making interactions more meaningful and enjoyable [4][5]. By designing objects with simple, proactive behaviors like animated eye movements, this study aligns with these findings, demonstrating how even minimal AI-inspired actions can increase perceived interactivity and engagement [6]. These insights are valuable for developing AI-based interactive systems that are not only engaging but also adaptable to various contexts, contributing to sustainable, user-centered design [7]. Apart from that, prior research has also demonstrated that incorporating human-like characteristics in designs can lead to increased interaction and a stronger sense of connection from users [8][9]. For instance, robotic systems with anthropomorphic traits often stimulate more authentic, meaningful engagement, with users responding to even minor signals, such as eye movements, as if they were human cues [10]. Studies on digital avatars support this, indicating that subtle visual cues can significantly boost a user's sense of presence and emotional connection, suggesting that even simple proactive behaviors can yield substantial engagement benefits [11].

Animated behaviors have also shown promise in other areas, such as consumer products and social robots, where simple animations enhance both product appeal and perceived emotional intelligence in robots [12][13]. Research on social robots with animated eye movements has demonstrated that these behaviours enhance the objects' capacity to express emotions and establish connection with users [14][15]. Within public displays and interactive installations, lifelike movements capture user attention and foster intuitive, effortless interactions, leading to deeper user participation [16]. As these examples suggest, proactive, adaptive behaviors can make interactions more seamless, contributing to the system's overall user-friendliness. [17].

Beyond enhancing engagement, proactive behaviors also hold value in sustainable design and efficiency-oriented applications. For example, by automating actions that traditionally require manual intervention, such as traffic control or safety monitoring, systems can reduce the demand for constant human involvement, which conserves resources and increases operational resilience [18][19]. Demand-based automation systems also demonstrate how proactive, real-time adjustments can optimize complex operations, reducing the energy and resources needed to maintain efficiency [20][21][22]. Integrating proactive features into interactive technologies not only improves usability but aligns with sustainable design principles by potentially reducing the energy required for long-term operation and user training [23][24]. These examples illustrate how adaptive behaviors can significantly enhance both user interaction and overall system performance across different contexts.

However, understanding the effectiveness of proactive behaviors often requires examining how different designs and contexts impact user engagement [25]. This research explores the effectiveness of proactive behaviors by examining how designs and contexts influence user engagement. Conducted in two phases, the study's first phase involved a real-world test using a physical box equipped with animated eyes to observe user responses to various behaviors in both single- and multi-person interactions. Insights from this phase informed the development of a virtual version of the object, designed to replicate the same behaviors. In the second phase, a video-based study using Amazon

Mechanical Turk (MTurk) involved 240 participants, allowing for a broader evaluation of these behaviors in a virtual environment.

By combining results from both real-world and virtual studies, this research highlights how simple, proactive behaviors, such as winking and body rotation, can meaningfully shape user experiences. These findings offer valuable insights for designing sustainable, interactive systems that leverage proactive behaviors to boost user engagement and resource efficiency across diverse contexts.

2. Phase I: Real-World Study

2.1. Design and Development of Proactive Object

The initial phase of this study focusses on the development and evaluation of a physical object intended to captivate individuals through fundamental yet intentional dynamic behaviours, particularly eye movements and orientation towards the individual. Eyes were selected for their inherent ability to attract attention, enable nonverbal communication, and elicit emotional reactions [26], while the turning behaviour was incorporated to replicate a sense of awareness and active involvement with the individual [27]. Figure 1 depicts the design of the animated eyes utilised in the investigation. Each eye was showcased on a 1.5-inch full-color Organic Light-Emitting Diode (OLED) display and animated with a Teensy 3.2 microcontroller. The design featured upper and lower eyelids to simulate a natural blinking effect, along with an iris, pupil, and sclera to denote gaze direction. Blinking was established as a default to prevent prolonged staring, which may be regarded as disconcerting or unresponsive, thereby reducing user interest [11].

As shown in Figure 2, the animated eyes were mounted on the front face of a square box, chosen for its simple and neutral geometry. This design allowed the focus to remain on the behaviors of the eyes without the influence of any complex or anthropomorphic shapes. The square box served as a minimalistic platform, ensuring that participants' attention was directed towards the eyes' movements and their interactions, rather than the shape of the object itself. To enhance interaction, a servo motor was attached to the bottom of the box, enabling it to turn towards the engaging person. The object was equipped with an Omron HVC-P2 camera module, which natively supports face detection and gaze direction. This allowed the object to detect the presence of a person in front of it, identify their engagement, and respond accordingly.

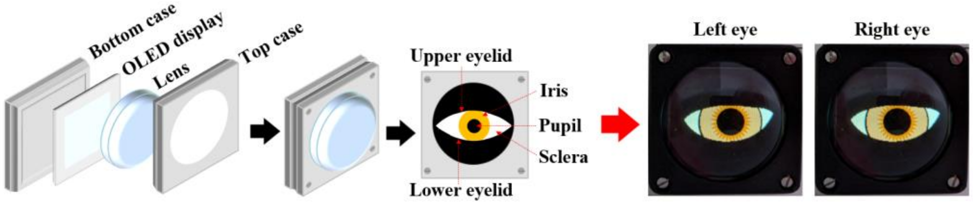

Figure 1. Design and components of the animated eyes displayed on OLED screens.

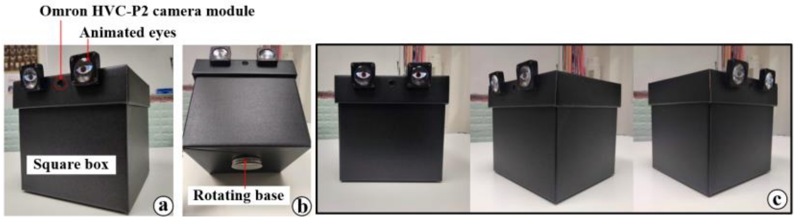

Figure 2. (a) Square box mounted with animated eyes and Omron HVC-P2 camera module, (b) rotating base attached at the bottom of the box, and (c) square box turning towards the user.

2.2. Experimental Design and Behavioral Scenarios

Ten scenarios were developed to evaluate the proactive behaviors of a square box equipped with animated eyes. Each scenario involved the box performing different Motion-Gaze expressions to show its intention in both single-person and two-person interactions. In the two-person scenarios, the participant was paired with an experimenter acting as a second person. The simple, non-human shape of the square box allowed the focus to remain on the Motion-Gaze expressions themselves. The box's Motion-Gaze expressions included Turning (T), and Winking (W), tested in both Single-Person (SP) and Two-Person (TP) scenarios. In the SP scenarios, the box aimed to engage directly with the participant. Two conditions were tested: (1) SP(T,S), where the box turned towards the participant without winking, and (2) SP(T,W,S), where the box turned and winked. Both conditions were followed by a stare (S) to maintain engagement.

In the TP scenarios, the box interacted with either the participant (TP1) or the experimenter (TP2). The number 1 in each condition signifies that the box displays behavior towards the participant, whereas the number 2 indicates that the behavior is directed towards the experimenter. The tested conditions included: (1) TP1(T1,S1) and TP2(T2,S2), where the box turned towards the intended person without winking, and (2) TP1(T1,W1,S1) and TP2(T2,W2,S2), where the box turned, winked and stared towards the intended person. Additionally, some scenarios tested how people reacted when the box first turned to the other person before engaging with the intended participant, resulting in eight conditions overall. For each scenario, the timing of the box's behaviors is shown in Table 1, with the box remaining idle (I) for 3 seconds and each turn, wink, and stare lasting one second before stopping. Figures 3 and 4 provide visual representations of the proactive box interacting in single-person (SP) and two-person (TP) scenarios.

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 and divided into two equal groups of 12, labeled Group A and Group B. Group A interacted directly with the box, which initiated engagement with them, while Group B observed the box initiating interaction with an experimenter. To control for between-group ordering effects in the Single-Person (SP) and Two-Person (TP) conditions, six participants in each group experienced the SP(T-S) condition first, and the remaining six participants in each group started with the SP(T-W-S) condition before proceeding through the other conditions listed in Table 1. Before beginning, participants were given instructions outlining the purpose of the study and explaining the concepts of proactive and reactive behavior. They were also instructed to position themselves 60–120 cm from the box to enable eye-to-eye interaction and engagement. After each interaction, participants recorded their responses before moving on to the next condition.

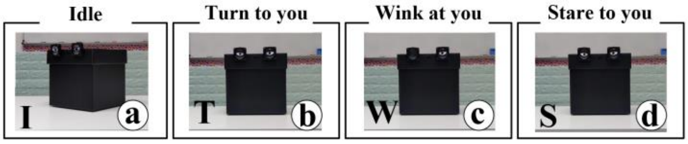

Figure 3. Real-world study for single-person (SP) scenarios.

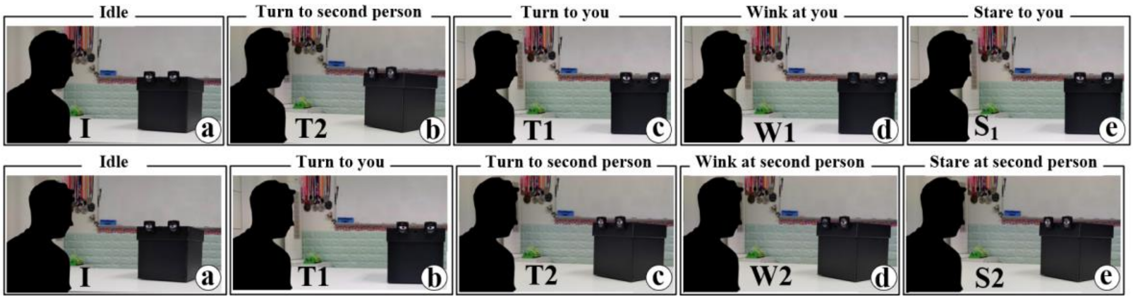

Figure 4. Real-world study for two-person (TP) scenarios. The experimenter (on the left side) is the second-person.

2.3. *Proactivity Measurement and Scoring Mechanism*

Participants rated the perceived proactivity of the box in each scenario using a 7-point Likert scale, where a score of seven indicated "very proactive" and one indicated "very reactive." Proactivity was defined in terms of the object's apparent intentionality and engagement in response to the participants' presence and actions. Participants were instructed to consider the object's responsiveness and purposeful actions when scoring, aiming to capture their subjective perceptions of proactivity. Average scores across participants were calculated for each scenario, providing a quantified measure of the box's perceived proactivity.

2.4. *Results*

A summary of the real-world study results is presented in Figure 5 and Table 2. This section details the quantitative results obtained from the proactive-reactive measures.

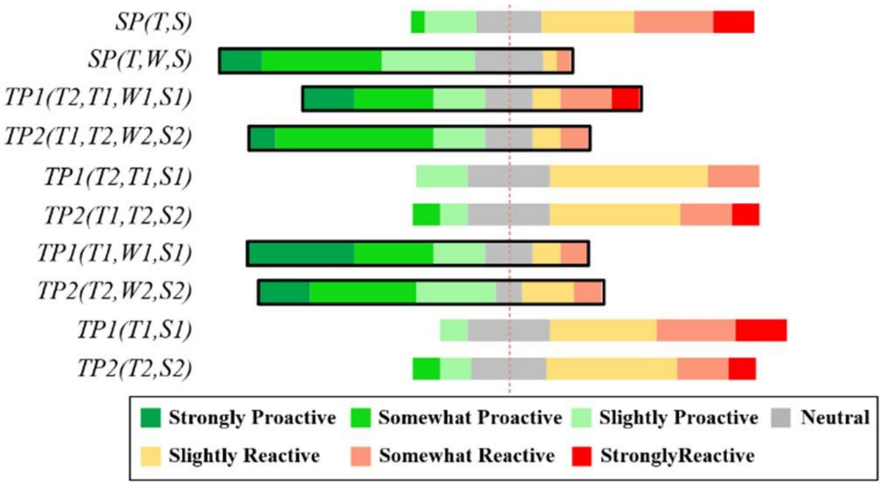

Figure 5. Diverging stacked bar chart of participants' responses to the seven-point Likert proactive-reactive measure. The results related to the wink behavior have been highlighted with a bold frame.

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

Effectiveness of winking as a proactive behavior: The wink behavior consistently received higher ratings on the proactive scale across various scenarios, as highlighted in the bolded rows of Table 2 and emphasized with the bold frame in Figure 3. Specifically, scenarios that involved a wink, such as SP(T-W-S), TP1(T2-T1-W1-S1), TP2(T1-T2-W2-S2), and TP1(T1-W1-S1), showed higher mean and median scores, indicating that participants perceived these conditions as more proactive. The distinct preference for the wink behavior over non-wink scenarios (e.g., SP(T-S) and TP1(T1-S1)) further supports the conclusion that the wink was effectively recognized as a proactive gesture by the participants. The inclusion of a wink significantly enhanced the perception of the box's intentionality. Participants were more likely to interpret the wink as a deliberate and purposeful action aimed at initiating interaction. This behavior effectively communicated a sense of agency and engagement, making the box seem more proactive.

Effectt of turning and winking combined: The scenarios that involved both turning and winking (e.g., SP(T-W-S), TP1(T2-T1-W1-S1), TP1(T1-W1-S1)) consistently received higher proactivity ratings. These scenarios are highlighted with bold values in Table 2, showing mean scores above 5.00, indicating that participants generally perceived these behaviors as more proactive. The combination of turning towards the participant and winking appears to reinforce the perception of intentionality and engagement from the box, making it seem more proactive in initiating interaction. This is evident from the scenarios like SP(T-W-S) and TP1(T1-W1-S1), which scored among the highest in terms of perceived proactivity. Whereas, in scenarios where the box turned without winking (e.g., SP(T-S), TP1(T2-T1-S1)), the proactivity ratings were generally lower. For example, SP(T-S) has a mean score of 3.15, and TP1(T2-T1-S1) has a mean score of 3.38, indicating that these behaviors were perceived as more reactive compared to the scenarios involving a wink. Turning alone, without the additional cue of winking, seems less engaging and less intentional. Participants may have interpreted the behavior as more passive or less directed, resulting in lower proactivity ratings. This suggests that the wink is a critical component in signaling proactive intent.

Proactivity in multi-person scenarios: In multi-person scenarios, where the box interacts with both the participant and the experimenter, the inclusion of a wink helps maintain a strong sense of proactivity. Even though the box's attention is divided between two people, the wink makes the interaction feel more intentional and directed. For example, in the TP2(T1-T2-W2-S2) scenario, where the box turns towards the experimenter and winks, the mean score of 5.08 shows that participants still view the box's behavior as proactive. This indicates that the wink is a key factor in keeping the interaction engaging and purposeful, even in more complex settings with more than one person.

3. **Phase II: Online MTurk Study**

3.1. Design and Implementation

The second phase of the study extends the investigation to an online environment using Mechanical Turk (MTurk) to validate and further confirm the results obtained from the real-world study. This phase aims to ensure that the findings regarding the proactive behaviors demonstrated by the object, particularly the impact of winking is consistent across different settings and participant demographics by leveraging a larger and more diverse participant pool through MTurk. To achieve this, ten pre-recorded videos were created, each featuring a proactive virtual box equipped with animated eyes, performing various Motion-Gaze to convey its intentions (Figure 6). The virtual box was designed to closely resemble the physical box used in the real-world study, ensuring continuity in design and behavior. However, unlike the physical box, the virtual version's expressions were pre-recorded, eliminating the ability to detect and respond to a user's presence in real-time. The videos assumed that the viewer's gaze was centered on the screen, placing the virtual box in a simulated three-dimensional space from a first-person perspective. For scenarios involving two person, an abstract figurine was included to represent the second person, allowing for the evaluation of interactions in multi-person settings. This design enabled the study to assess the virtual Box's proactive behaviors in a controlled, yet diverse, online environment, providing a comprehensive comparison to the real-world interactions.

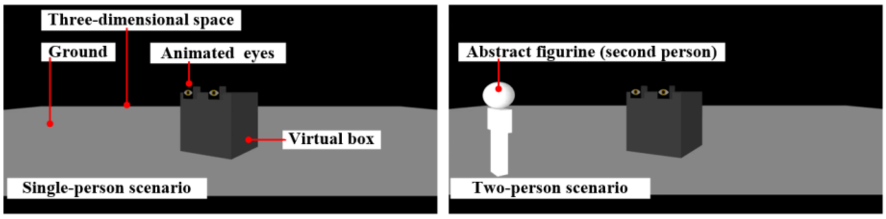

Figure 6. Virtual box animation design in single- and two-person scenarios within a three-dimensional virtual space.

3.2. Experiment Design and Setup

A total of 240 participants were recruited from Amazon Mechanical Turk for the online study. The participants were evenly divided into two groups of 120: Group A and Group B. Group A interacted with the virtual box that initiated engagement with them directly, while Group B interacted with the virtual Box that focused its engagement on a second entity, represented by an abstract figurine. Ten videos were created based on the scenarios outlined in Table 1, with eight videos specifically designed for the TP scenario. These were further divided into two sets: one where the virtual box initiated interaction with the participant (TP1) and another where the interaction was initiated with the second person (TP2). Figures 7 and 8 provide visual representations of the proactive virtual box interacting in single-person (SP) and two-person (TP) scenarios. Similar with the real-world study, for each condition, participants were asked to assess the box's behavior as either proactive or reactive using a 7-point Likert scale, where a score of seven indicated 'very proactive' and one indicated 'very reactive'. The online MTurk study closely followed the task, stimuli, and measurement methods used in the real-world study, ensuring consistency across both phases.

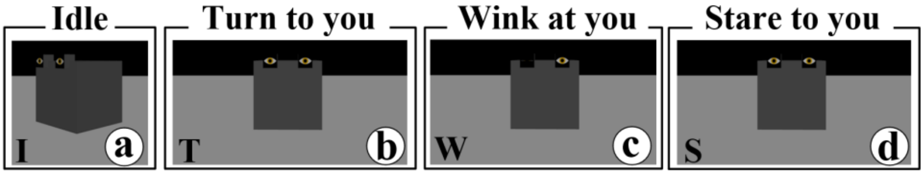

Figure 7. Online MTurk study for single-person (SP) scenarios.

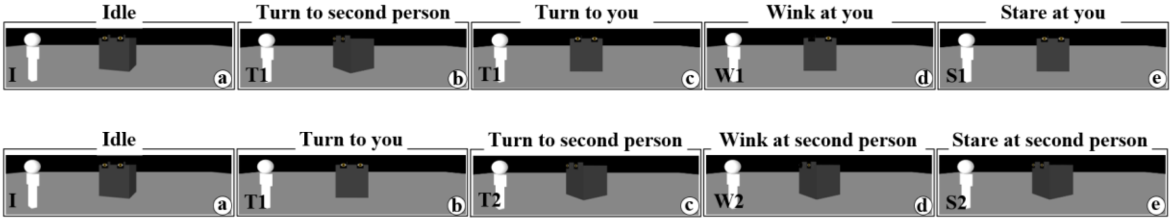

Figure 8. Online MTurk study for two-person (TP) scenarios. Abstract figurine (on the left side) acts as the second-person

3.3. *Results*

A summary of the online MTurk study results is presented in Figure 9 and Table 3. This section details the quantitative results obtained from the proactive-reactive measures.

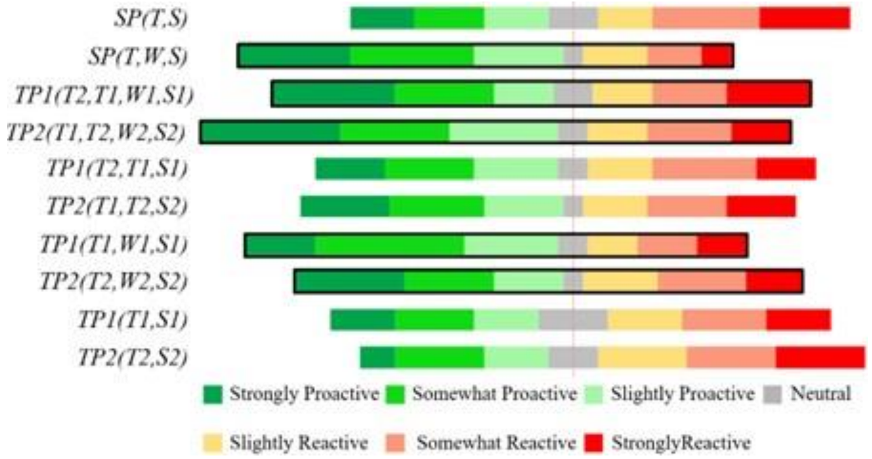

Figure 9. Diverging stacked bar chart of online MTurk participants' responses to the seven-point Likert proactive-reactive measure. The results related to the wink behavior have been highlighted with a bold frame.

Table 3. The online MTurk participants' responses to the seven-point scaled Likert proactive-reactive measure. Wink-related results are highlighted in bold font.

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

Validation of the wink as a proactive behavior: Scenarios involving winking, such as SP(T-W-S), TP1(T2-T1-W1-S1), TP1(T2-W1-S1), and TP2(T1-W2-S2), exhibit higher mean scores on the proactive-reactive measure, suggesting that the presence of a wink significantly enhances the perception of the virtual box's behavior as proactive. For instance, the SP(T-W-S) scenario, with a mean score of 4.71, one of the highest among all scenarios illustrates that when the virtual box winks during a single-person interaction, participants are more likely to perceive it as taking initiative or being proactive. Winking seems to act as a clear signal of intentionality. In the context of the experiment, winking may be interpreted as a deliberate and communicative gesture, which is perceived as the virtual box taking a proactive step in the interaction. When compared to scenarios where the virtual box only turns without winking, those that include a wink are consistently rated as more proactive. This difference suggests that winking adds a layer of intentionality that turning or moving alone cannot convey.

Comparison of single-person vs. two-person scenarios: The comparison between Single-Person (SP) and Two-Person (TP) scenarios reveals that winking is a key factor in enhancing the perception of proactivity. In both SP and TP scenarios, those involving winking consistently receive higher mean scores, indicating that this gesture is universally seen as a proactive behavior. Single-person scenarios, particularly those involving a wink, are rated highly for proactivity, suggesting that simple, direct interactions can effectively convey the virtual box's intentionality. In contrast, the presence of a second person in TP scenarios introduces more complexity to the interaction. While winking still maintains a strong sense of proactivity in these cases, the absence of winking leads to lower scores, especially in multi-user contexts. This indicates that more complex social dynamics in TP scenarios may require deliberate gestures, like winking, to uphold the perception of proactivity. Overall, winking significantly impacts how the virtual box's behavior is perceived, with its effect being evident across both single and multi-user interactions.

Does turning alone convey intentionality?: Turning alone can contribute to the perception of the box being proactive, but its impact is generally less pronounced compared to scenarios that include winking. In the experiment, scenarios where the box only turns without winking, such as SP(T-S) and TP2(T2-S2), receive lower mean scores on the proactive-reactive measure compared to those that include winking. This suggests that while turning can be perceived as a proactive gesture, indicating that the box is responding or directing attention towards something, it doesn't convey the same level of intentionality or communicative purpose as winking does. Turning may be interpreted as a more neutral or responsive action rather than a deliberate and proactive one. It shows that the box is aware of its surroundings and is capable of changing its orientation, which could be seen as a basic level of interaction. However, without an additional gesture like a wink, turning alone might not strongly convey the box's intention or initiative to the same extent. In two-person scenarios, turning without winking further reduces the perception of proactivity, possibly because the social complexity of interacting with multiple individuals requires more explicit signals of engagement. Therefore, while turning does play a role in making the box appear responsive and somewhat proactive, it is the combination of turning with winking that significantly enhances the perception of the box as a proactive entity in the interaction.

4. Discussion

The results of this study highlight how nonverbal actions, especially winking and turning, help to define how individuals view proactivity in interactive objects. One important realization is the universal reaction to winking as a cue of intentionality, implying that winking is generally recognized as a proactive, deliberate movement. This probably results from the human inclination to understand some facial expressions as deliberate communicative actions. Winking, being a rare and intentional gesture in human encounters, may have sent a deliberate cue to participants, causing them to regard the box as more proactive. This result suggests that since winking consistently expresses agency and can improve user involvement, it can be a very effective design technique for interactive system developers.

Context, especially in single- vs. multi-person situations, helps to emphasize even more the importance of these actions. Winking by itself clearly expresses intentionality in single-user environments; participants responded favorably to this simple action. Turning alone seems less successful, though, in two-person situations when social relations grow more complicated. Turning maintained a strong sense of proactivity even in multi-user environments when combined with winking, implying that further cues are necessary for communicating deliberate participation in such environments. This could mean that people rely on several behavioral signals to evaluate intention in socially complicated situations. This suggests to designers the possibilities of layered gestures in interactive systems, especially in multi-user contexts where they could replicate human-like interactions.

The influence of context, specifically in single- versus multi-person scenarios, further highlighted the significance of these behaviors. In single-user settings, winking alone effectively conveyed intentionality, with participants responding positively to this straightforward gesture. However, in two-person scenarios, where social dynamics become more complex, turning alone appeared less effective. When combined with winking, however, turning maintained a strong perception of proactivity even in multi-user contexts, suggesting that additional cues are essential for conveying intentional engagement in such settings. This may indicate that in socially complex scenarios, people rely on multiple behavioral cues to assess intent. For designers, this points to the potential of layered gestures in interactive systems, particularly when simulating human-like interactions in multi-user environments.

Cultural and cognitive factors undoubtedly have an essential effect on how winking is perceived across different circumstances. Winking is widely viewed as a meaningful social cue, with cultural connections that enhance its intentionality, friendliness, or even familiarity. This broader cultural context may have contributed to the constant beneficial effect of winking on proactivity scores. Cognitively, there's a known human inclination to anthropomorphize things demonstrating typical social behaviors, which may have magnified participants' view of the box as purposeful and proactive. This corresponds with past research indicating that individuals assign human-like traits to things that exhibit socially identifiable behaviors. By utilizing these cognitive biases, designers might potentially boost user engagement, making systems appear more relatable and deliberate. A further step might be to study how different cultural contexts or age groups receive non-verbal cues like winking, ensuring the design of future interactive systems appeals broadly across diverse consumers.

In practical terms, these findings offer several implications for interactive system design, particularly in roles where the simulation of intentionality is beneficial. Social robotics, virtual assistants, and customer service systems are just a few examples where proactive gestures could help systems appear more engaging and responsive. For instance, a customer service bot that "winks" or otherwise directs attention towards a user could be perceived as inviting and engaging, potentially improving user interaction quality. In settings where clarity of intent and communication are critical, like healthcare or education, incorporating such gestures could make the system feel more human-centered and approachable, enhancing trust and user experience.

The challenges of multi-user interactions, however, present unique design considerations, as these contexts often require more nuanced behaviors to effectively convey proactivity. This study's results suggest that a combination of cues, such as turning paired with winking, can better convey proactivity in multi-user scenarios. When multiple users interact with a system, deliberate gestures help manage user attention and foster a sense of connection, even when the system's attention is divided. Designers could consider layering gestures in these settings to create more engaging, personalized experiences. For example, social robots or virtual environments that navigate multi-user dynamics may benefit from adding cues that convey intentionality, helping each participant feel individually acknowledged and engaged.

The choice to use Amazon Mechanical Turk (MTurk) in Phase 2 brought its own considerations, with both benefits and potential biases. MTurk's broad and diverse sample allowed for a wider range of perspectives, but participants tend to be tech-savvy, which could impact their interpretation of proactive behaviors. This familiarity with technology might make MTurk users more receptive to interactive objects and perhaps more likely to interpret the box's gestures as proactive. Future studies could consider diversifying participant pools to include users with varying technological exposure levels, helping to assess the generalizability of these findings. Such diversity would also clarify how the perception of cues like winking might differ between individuals who are more familiar with digital interactions versus those who are not.

Looking to future applications, the connection between proactivity in technology and sustainable design emerges as an area worth exploring. Proactivity could be a powerful trait in sustainability-focused technologies, where systems that guide or encourage eco-friendly behaviors could foster longer-term engagement. Interactive systems designed to convey intentionality might also foster a sense of shared responsibility, making users feel more connected to sustainable actions. By investigating how specific non-verbal cues in proactive technologies influence users' behavior, designers can better support sustainable interactions and habits. Such work would enhance the relevance of this study to fields aiming to combine interactive design with environmental impact.

In conclusion, this study shows that easy animated actions like winking and turning can be used to make people more interested in both virtual and real worlds. By putting these clues together, interactive systems can look more deliberate and sensitive, which makes users feel like they are connected to them. This information is useful in many areas, from social robotics to digital assistance, where making exchanges clear and useful is still very important. Also, learning more about the cognitive and cultural factors that affect how gestures are understood will help make technology that is more engaging and available for everyone. These results make it possible to keep looking into how nonverbal cues in design can improve the user experience in a wide range of interactive apps.

5. Conclusion and Future Direction

This study reveals the important influence that simple non-verbal behaviors, such winking and turning, have in molding impressions of proactivity within interactive virtual objects created to simulate human-like intentionality. Through both real-world and MTurk studies, winking emerged as a very effective gesture for signaling intentionality, consistently drawing participants' attention and conveying a proactive presence. In comparison, turning alone seemed as likemore passive activity, showing attentiveness rather than a clear purpose to interact. The difference in participant responses to these gestures illustrates the importance of understanding how certain non-verbal cues can be employed to generate a sense of participation and agency in interactive systems. Moreover, these findings indicate that layering gestures—particularly in multi-user environments—strengthens the illusion of purposeful participation, which can be essential in making virtual or robotic systems look more dynamic and active.

The implications of these ideas are broad and relevant across numerous fields in interactive system design. For instance, adding gestures like winking into social robotics, virtual assistants, or customer service interfaces could increase user experience by imparting a feeling of responsiveness and intentionality to these systems. In situations where clear and engaging communication is vital, such as healthcare or education, non-verbal cues could help users feel understood and attended to, possibly enhancing interaction quality and user happiness. This method gives a chance to design systems that feel more suited to human behaviors and are, therefore, easier and more fun for users to engage with.

Looking forward, there are various possibilities for expanding on this research. Cultural factors, for example, certainly play a crucial part in how gestures like winking are interpreted, and researching these cultural variances could lead to globally resonant design methods. The application of proactive behaviors in sustainability-focused technologies also emerges as a potential field. Interactive technologies that portray intentionality may not only boost user engagement but also encourage the adoption of sustainable habits by promoting a sense of shared responsibility and connection. Future research could further examine this topic, studying how non-verbal cues might direct users toward eco-friendly activities in both virtual and real-world environments. Additionally, researching a larger range of non-verbal cues such as nodding, smiling, or pointing could enable designers to construct richer, more nuanced interactive experiences, broadening the repertory of actions that make virtual systems feel more lifelike and responsive.

In conclusion, this study offers essential knowledge to the expanding field of human-computer interaction, particularly in understanding how subtle, well-chosen non-verbal gestures can make interactive systems feel more engaging and genuine. By exploiting these indications, designers may build user experiences that resonate on a human level, boosting the attractiveness and effectiveness of both virtual and physical interactive technology.

Acknowledgements

We would like to express my sincere gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for their invaluable support and resources that made this research possible. Their encouragement and assistance have been instrumental in the successful completion of this work.

References

[1] Agyemang B, Ren F, Yan J. Proactive Agent Behaviour in Dynamic Distributed Constraint Optimisation Problems. Information 2024, Vol 15, Page 255 2024;15:255. https://doi.org/10.3390/INFO15050255.

[2] Sirithunge C, Jayasekara AGBP, Chandima DP. Proactive Robots With the Perception of Nonverbal Human Behavior: A Review. IEEE Access 2019;7:77308–27. https://doi.org/10.1109/ACCESS.2019.2921986.

[3] Alexander Obaigbena, Oluwaseun Augustine Lottu, Ejike David Ugwuanyi, Boma Sonimitiem Jacks, Enoch Oluwademilade Sodiya, Obinna Donald Daraojimba, et al. AI and human-robot interaction: A review of recent advances and challenges. GSC Advanced Research and Reviews 2024;18:321–30. https://doi.org/10.30574/gscarr.2024.18.2.0070.

[4] Alia PA, Kartika Sari D, Azis N, Gunawan Sudarsono B, Agus Sucipto P. Implementation Artificial Intelligence with Natural Language Processing Method to Improve Performance of Digital Product Sales Service. Advance Sustainable Science Engineering and Technology 2024;6:0240301. https://doi.org/10.26877/asset.v6i3.521.

[5] Dewantara AS, Aryanto J. Implementation Of A Web-Based Chatbot Using Machine Learning For Question And Answer Services In Universities. Advance Sustainable Science, Engineering and Technology 2023;6:0240106. https://doi.org/10.26877/asset.v6i1.17590.

[6] Ghiglino D, Willemse C, Tommaso D De, Bossi F, Wykowska A. At first sight: robots' subtle eye movement parameters affect human attentional engagement, spontaneous attunement and perceived human-likeness. Paladyn 2020;11:31–9. https://doi.org/10.1515/pjbr-2020-0004.

[7] Hadiyanto MY, Harsono B, Karnadi I. Zonation Method for Efficient Training of Collaborative Multi-Agent Reinforcement Learning in Double Snake Game. Advance Sustainable Science, Engineering and Technology 2023;6:02401011. https://doi.org/10.26877/asset.v6i1.17562.

[8] Buyukgoz S, Grosinger J, Chetouani M, Saffiotti A. Two ways to make your robot proactive: reasoning about human intentions, or reasoning about possible futures 2022. https://doi.org/10.48550/ARXIV.2205.05492.

[9] Kim S, Kang D, Choi J, Kwak SS. Who's on First: The Impact of the Proactive Interaction on User Acceptance of the Robotized Object. RO-MAN 2022 - 31st IEEE International Conference on Robot and Human Interactive Communication: Social, Asocial, and Antisocial Robots 2022:1377–84. https://doi.org/10.1109/RO-MAN53752.2022.9900757.

[10] Wu J, Du X, Liu Y, Tang W, Xue C. How the Degree of Anthropomorphism of Human-like Robots Affects Users' Perceptual and Emotional Processing: Evidence from an EEG Study. Sensors 2024;24:4809–4809. https://doi.org/10.3390/S24154809.

[11] Ichino J, Ide M, Yoshiki T, Yokoyama H, Asano H, Miyachi H, et al. How Gaze Visualization Facilitates Initiation of Informal Communication in 3D Virtual Spaces. ACM Transactions on Computer-Human Interaction 2023;31:1–32. https://doi.org/10.1145/3617368.

[12] Anas SAB, Rauterberg M, Hu J. Designing elements for a gaze sensitive object: Meet the coffeepet. HAI 2017 - Proceedings of the 5th International Conference on Human Agent Interaction 2017:223–31. https://doi.org/10.1145/3125739.3125745.

[13] Tuazon BJ, Dizon JRC. Additive Manufacturing Technology in the Furniture Industry: Future Outlook for Developing Countries. Advance Sustainable Science Engineering and Technology 2024;6:02403024. https://doi.org/10.26877/asset.v6i3.908.

[14] Wang X, Li Z, Wang S, Yang Y, Peng Y, Fu C. Enhancing emotional expression in cat-like robots: strategies for utilizing tail movements with human-like gazes. Front Robot AI 2024;11. https://doi.org/10.3389/FROBT.2024.1399012.

[15] John A, Van Opstal J, Bernardino A. A Cable-Driven Robotic Eye for Understanding Eye-Movement Control. 2023 9th International Conference on Automation, Robotics and Applications, ICARA 2023 2023:128–33. https://doi.org/10.1109/ICARA56516.2023.10126021.

[16] Song J, Gao Y, Huang Y, Chen L. Being friendly and competent: Service robots' proactive behavior facilitates customer value co-creation. Technol Forecast Soc Change 2023;196. https://doi.org/10.1016/J.TECHFORE.2023.122861.

[17] Li D, Liu C, Xie L. How do consumers engage with proactive service robots? The roles of interaction orientation and corporate reputation. International Journal of Contemporary Hospitality Management 2022;34:3962–81. https://doi.org/10.1108/IJCHM-10-2021-1284.

[18] Jinglu L, Sun X. Exploring Proactivity in Human-Vehicle Interaction: Insights for proactive interaction Design. AHFE International 2023;95. https://doi.org/10.54941/AHFE1003804.

[19] Bérubé C, Nißen M, Vinay R, Geiger A, Budig T, Bhandari A, et al. Proactive behavior in voice assistants: A systematic review and conceptual model. Computers in Human Behavior Reports 2024;14:100411–100411. https://doi.org/10.1016/J.CHBR.2024.100411.

[20] Kumar S, Rao G, SubramonianSivarao, Hamid H. Automated traffic light system for road user's safety in two lane road construction sites. WSEAS Transactions on Circuits and Systems 2010. https://doi.org/10.5555/1852308.1852309.

[21] Automated system and process for providing personal safety (2016) | Bean Charles Alfred | 10 Citations n.d. https://typeset.io/papers/automated-system-and-process-for-providing-personal-safety-3xv90bpayk (accessed August 23, 2024).

[22] Proactive safe driving for an automated vehicle 2019.

[23] Subramaniam S, Esro M. Self-Algorithm Traffic Light Controllers for Heavily Congested Urban Route 2012.

[24] Wang W, Zong F, Yao B. A Proactive Real-Time Control Strategy Based on Data-Driven Transit Demand Prediction. IEEE Transactions on Intelligent Transportation Systems 2021;22:2404–16. https://doi.org/10.1109/TITS.2020.3028415.

[25] Maulana Prawiro W, Rosi Subhiyakto E. User-Centered Design Approaches to Enhance Employee Attendance Applications. Advance Sustainable Science Engineering and Technology 2024;6:02403025. https://doi.org/10.26877/asset.v6i3.798.

[26] Onnasch L, Schweidler P, Schmidt H. The potential of robot eyes as predictive cues in HRI—an eye-tracking study. Front Robot AI 2023;10. https://doi.org/10.3389/FROBT.2023.1178433/PDF.

[27] Durán J, Vidarte F, Vega A, Bustos P, Núñez P. A Novel Human-Awareness Solution for Person-Following Robot's Behavior Problem Based on Proxemics 2022. https://doi.org/10.3233/AISE220017.