The Power of Opening Encounters in HRI: How Initial Robotic Behavior Shapes the Interaction that Follows

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ABSTRACT

Opening encounters are a fundamental component of every interaction. Psychology research highlights the valence of opening encounters as one of the main factors that shape the nature of the interaction that follows. In this work, we evaluated whether opening encounters would have a similarly powerful effect on human–robot interactions. We tested how positive and negative opening encounters would impact the quality of the interaction that follows. In the experiment, a robotic dog approached a participant in a waiting room. The robot performed gestures designed to communicate different valences of opening encounters under three conditions: *Positive, Negative*, or *No opening encounter*, where the robot did not perform any gesture at the beginning of the interaction. To evaluate the quality of the interaction that followed, we measured participants' willingness to comply with a help request presented by the robot and their overall perception of the robot. Objective and subjective measures indicated that most of the participants in the *Positive opening encounter* condition helped the robot and reported a positive overall perception. An opposite pattern emerged in the other two conditions. Almost none of the participants helped the robot, and the overall perception of the robot was negative. Our findings suggest that opening encounters with robots should be carefully considered and well-designed due to their profound impact on the interaction that follows.

KEYWORDS

Opening Encounters, Greeting, Help, Human–Robot Interaction, Robot, Interaction Quality

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1 INTRODUCTION

As robots become increasingly common in our daily lives, there is a greater emphasis on designing high-quality human–robot interaction (HRI). Previous studies indicated that interactions with autonomous technologies (even very simple ones) are perceived as social encounters that should follow social norms [3, 17]. Social norms can reduce the cognitive effort associated with HRI, enhance them, and enhance their fluency [9]. When social norms are followed, the interaction is commonly perceived as positive, understandable, and pleasant [23, 28, 32, 55]. Opposite experiences are typically reported when social norms are violated, typically leading to unclear and stressful interactions that, in many cases, result in rejection of the robot altogether [3].

Figure 1: Robotic dog performing positive (A) and negative (B) opening encounters

One of the most important social norms in human interactions is greeting [26, 36]. Greeting defines a positive opening encounter between humans, indicating a willingness for interaction. It is a universal social action at the heart of social relationships [20, 36]. Opening encounters can also be negative, indicating that individuals are not interested in social interaction [16]. Using a rapid exchange of non-verbal cues at the beginning of an interaction, people signal to each other whether social interaction is desired and whether they find the other person acceptable for interaction [26]. Research in human social interaction shows that apart from signaling the beginning of an interaction, the valence of an opening encounter typically lasts for a significant time after the encounter and shapes the nature of the interaction that follows [36]. The positive or negative social cues in the first moments of the interaction influence psychological aspects such as mood, sense of belonging, and social motivation, setting the social context and social foundations for the interaction that follows [20, 56]. Positive opening encounters are believed to create a favorable impression that puts individuals at ease, which commonly facilitates the development of a positive interaction overall [52]. Negative opening encounters (and even a lack of greeting) are typically perceived as threatening. As a result, people become suspicious and tend to mistrust one another. This experience, formed at the very beginning of the interaction, is difficult to overcome, and it therefore shapes the nature of the interaction [16]. Because of this profound impact, the valence of opening encounters is considered a basic and vital element for forming and maintaining social relationships [20, 26, 51, 56].

The understanding that interactions with robots should follow social norms implies that opening encounters with the robot may also drastically impact the interaction that follows. It can potentially shape the perception of the robot and the behavior towards the robot throughout the interaction. This idea is supported by previous

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studies indicating that the impression formed at the beginning of the interaction with a robot can impact its perception, the level of trust in the robot [70], and the perception of the robot's competence [47]. It was therefore suggested that the opening encounter between a robot and a human is the cornerstone for their relationship [3]. The impact of opening encounters on the quality of the interaction may be especially important in HRI since most people do not have previous experience with robots and cannot base their perception and behavior on their past experiences [48].

Opening encounters have already been studied in HRI, mostly focusing on designing understandable greeting behaviors [3, 10] and adjusting them to cultural differences [57, 65, 66]. Most of these studies indicated that it is possible to apply human-greeting theories for designing human–robot opening encounters [21]. Mimicking human social cues in robotic behaviors was shown to drastically enhance opening encounters, capture participants' attention, increase participants' engagement, and form an experience of a personal encounter [21, 22, 29, 30, 48, 54, 67]. Opening encounters were also designed for interactions with non-humanoid robots. These studies indicated that minimal non-verbal cues could be leveraged for designing positive and negative opening encounters, even for abstract, unfamiliar robots [2]. While these studies provided guidelines for designing opening encounters, they did not evaluate their impact on the interaction that follows.

In this work, we evaluated whether the valence of an opening encounter with a robot sets the foundation for the interaction that follows and shapes its nature. We designed an interaction with a robotic dog that presented social cues indicating its willingness for interaction (see Figure 1). The specific choice of a robotic dog allowed for the design of opening encounters that are based on mimicking cues presented by (real) dogs in positive and negative encounters [38].

The impact of these opening encounters on the quality of the following interaction was tested by measuring participants' compliance when presented with a request for help by the robot later in the interaction. The specific choice of "willingness to help a robot" is based on previous studies indicating that helping behaviors are strong indicators of the quality of interactions [1, 12, 27, 63]. For example, helping others was shown to be directly related to a sense of psychological closeness, a sense of connectedness [12], and a sense of responsibility [27]. In the context of HRI, helping a robot was used in a previous study to assess if a robot's communication modality during an opening encounter (beeping as an opening encounter vs. a verbal greeting) would impact the interaction [21].

The opening encounter with the robotic dog took place in a waiting room where participants waited for the experiment to begin. We tested participants' compliance with the robot's request for help under three conditions: (1) *Positive opening encounter* – after the robot performed gestures designed to indicate a willingness to interact; (2) *Negative opening encounter* – after the robot performed gestures designed to indicate an unwillingness to interact, (3) *No opening encounter* – after the robot did not perform any gestures relevant to an opening encounter (i.e., a baseline condition).

2 RELATED WORK

Opening encounters with robots, the impact of first impressions on a human's perception of a robot, and help requests by robots have all been studied in previous work.

2.1 Opening encounters with robots

Several studies focused on investigating the design of opening encounters with robots, both humanoid and non-human [2, 3, 22, 25, 29]. Most of these studies indicated that it is possible for a robot to directly mimic human social cues when interacting with humans. Social signals such as head nods, hand waving, and linguistic cues by humanoid robots have all been leveraged for designing opening encounters and setting their valence [21, 29, 35, 48, 58, 61]. Another similarity to human greeting concerns the importance of proxemics in the encounter. Previous studies indicated that in order to design a positive opening encounter, one should carefully control for the distance between the participant and robot [29, 41, 62, 68]. It was specifically suggested that a distance of approximately 0.6 m is perceived as appropriate for an opening encounter with a robot and leads to a comfortable social interaction [62]. Eye gaze was also indicated as a social cue that should be considered when designing opening encounters with robots. Heenan et al. [29] explored the design of positive opening encounters with a Nao humanoid robot. They showed that eye contact had the greatest impact on the initial greeting experience, whereas head nodding had a less significant effect. However, persistent eye contact can become uncomfortable when the robot appears to "stare" at the person [29].

Opening encounters with different valences have also been designed for non-humanoid robots. Despite their inability to directly mimic human social cues and their limited communication modalities, an interaction with them can be designed as a social encounter that involves greeting [18, 34, 45, 71]. Greeting opening encounters have been designed for robotic objects resembling an Ottoman, a car seat, a robotic trash barrel, a lamp, and even a door [22, 33, 39, 59, 64]. The greeting behaviors were designed using simple non-verbal gestures, with a special focus on the movement direction, movement pattern, timing, and rhythm. These movement dimensions were also used to design opening encounters with abstract, unfamiliar robotic objects. For example, Anderson et al. [2] used an abstract non-humanoid robot designed as a small ball rolling on a larger dome. The robot's minimal non-verbal gestures were designed to communicate positive and negative social cues, indicating the robot's willingness for interaction. They showed that a simple movement of the ball from the back of the dome to its front was perceived as a positive opening encounter and greeting. A movement of the ball from the front of the dome to its back was perceived as a highly negative opening encounter, indicating that the robot wished to avoid an interaction [2].

We extend this line of work by evaluating how such positive and negative opening encounters impact the interaction that follows.

2.2 Impact of a robot's first impression

Previous studies have also indicated that the first impression of a robot may last for a long period of time and shape the nature of the interaction [47, 49]. For example, Xu and Howard [70] tested

whether the initial impressions of a robot would impact a participant's level of trust. Participants were asked to collaborate with a Nao robot when performing a cognitive task within a limited time frame. As they started working together on the task, the robot either provided a correct answer or an incorrect answer. Xu and Howard's findings showed that the first impression of the robot's capabilities significantly influenced participants' trust throughout the interaction [70]. Another example was presented by Paetzel et al. [47], who tested whether playing a game with a robot in repeated interactions would impact the perception of its competence. They found that the perception of the robot's capabilities was set in the first interaction and did not change across two additional interactions of playing the same game. The perceived competence of the robot, which was set in the first two minutes of a chat at the beginning of the first interaction, remained stable across another two sessions conducted at different times [47].

These studies indicate that several factors at the beginning of an interaction can impact and shape its quality. We evaluate whether the valence of the opening encounter is one of these factors.

2.3 Help requests by robots

Human responses to a robot's request for help have been widely studied in the HRI field. These studies have indicated various factors that affect the willingness to help a robot. These can be categorized as request-related, human-related, and robot-related factors [4, 5, 8, 11, 13–15, 19, 31, 37, 40, 40, 50, 53, 60, 69].

Request-related factors typically involve the intensity [60] and urgency of the request [11]. For example, Srinivasan and Takayama showed that participants were more inclined to help a robot when it asked them to open a door than when it asked them to point to dirty mugs [60]. Similarly, Cha and Matari'c showed that participants were quicker to provide help to a robot when it demonstrated urgency using a combination of non-verbal signals (lights and sounds) [11].

Human-related factors typically involve the participants' availability [31]. For example, Hüttenrauch and Eklundh showed that participants occupied by inserting events into a personal calendar were less likely to assist a robot than unoccupied participants [31]. Similarly, Cha and Matari'c showed that participants' responses to help requests were quicker when they were unoccupied than when they were busy typing meal orders [11]. Other human-related factors that were shown to impact willingness to help a robot include gender [50], emotional state [31], and culture [5, 19].

Studies that explored robot-related factors pointed towards the robot's politeness as one of the central factors determining people's willingness to provide help. Srinivasan and Takayama [60] compared different types of robot politeness when requesting help. They showed that the best request type was positive politeness, where the robot made participants feel good about themselves. They also showed that the relationship with the robot impacted the willingness to help it. The likelihood of providing help increased when the robot was familiar and when the robot was introduced as a peer instead of an assistant [60]. Similarly, Riccio et al. showed that low social distance is associated with higher tendencies to help a robot [50]. Additional robotic factors influencing willingness to help a robot include its design [15, 69], perceived cuteness [15], and emotional expression [4, 13].

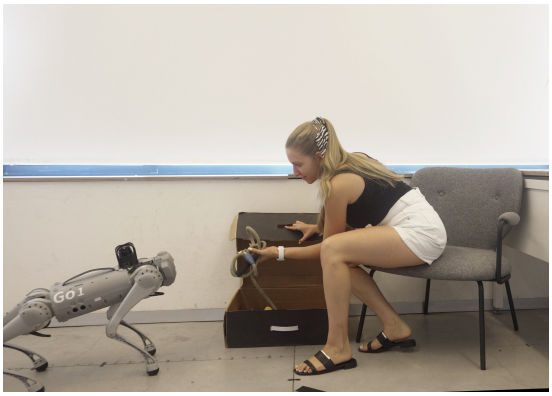

Figure 2: A participant helping the robot by opening a box it was interested in.

The most relevant factor for this work is the opening encounter with the robot. In a study by Fischer et al. [21], the authors evaluated whether different communication modalities in an opening encounter would impact the willingness to help a robot. In that study, the robot greeted the participant either by producing an acoustic signal (a sequence of short beeps) or a verbal greeting. The robot's greeting was followed by a help request, in which the robot asked participants for assistance reaching a cup that was located on a shelf. They found that the communication modality at the opening encounter did not affect the participants' willingness to help the robot [21].

In this work, we extend the work by Fischer et al. [21] (who focused on the modality of the opening encounter) and test whether the valence of the opening encounter with the robot (positive vs. negative) influences the quality of the interaction and impacts participants' willingness to comply with a help request presented at a later stage of the interaction.

3 METHOD

We evaluated the impact of an opening encounter with a robot on the quality of the interaction by assessing participants' willingness to help the robot. In the study, participants met a robot in a waiting room after filling in a demographic questionnaire. We manipulated the valence of the opening encounter with the robot to create three conditions (*Positive*, *Negative*, and *No opening encounter*) and tested whether participants would be willing to help the robot later in the interaction when it asked them to open a box it was interested in (see Figure 2).

3.1 Robot: Gesture design and technical implementation

We used a Unitree Go1 robot (see Figure 3). The Go1 is a small-scale 15 kg quadruped robot with 12 degrees of freedom. The robot can be controlled through various methods tailored to different levels of interaction, providing the flexibility required to design a variety of gestures. The specific choice of a robotic dog allowed existing

Figure 3: Unitree Go1 quadruped robot used in the experiment.

experiences with positive and negative opening encounters (with real dogs) to be leveraged for the experiment [38] while avoiding social complexity related to language, tone of speech, and cultural differences.

3.1.1 Gesture design. The robot's gestures were designed via several iterations with an animator and an HRI expert. The process was also informed by the literature on greetings (in human–human interactions and HRI), which suggested that opening encounters involve several behaviors, including the recognition of an encounter with another person [20], coordinated change in spatial orientation [2, 36], and moving towards or away from the other person to communicate a willingness to interact [2, 36]. The *Request for help* gesture was designed through a similar process that included iterations with the animator and guidelines from the HRI literature indicating that help request gestures should involve a back-and-forth movement between the location where the help is required and the participant [21]. We additionally designed a *Goodbye* gesture to comply with social norms and indicate that the interaction was over.

The design process resulted in four robotic gestures composed of a sequence of several robotic movements:

(1) *Positive opening encounter*: The robot walked towards the participant from a corner at the far end of the room. When it reached a distance of 65 cm from the participant, it performed two quick right-left movements and then turned its front part up towards the participant twice (simulating nodding towards the participant). The gesture ended with the robot in a position simulating a dog sitting in front of the participant (see Figure 1A).
(2) *Negative opening encounter*: The robot walked towards the participant from a corner at the far end of the room. When it reached a distance of 65 cm from the participant, it performed a quick movement towards the floor (the whole body dropping at once) and then moved aggressively backward while still in the low-body position. It stopped at a distance of 125 cm from the participant and remained in the low-body position (see Figure 1B).
(3) *Request for help*: The robot went towards a box placed on the floor next to the participant and leaned towards it (front part lowered towards the box); it then performed right-left movements just with its head (interpreted as indicating interest). This was followed by three repetitions of turning back and forth between the box and participant (see Figure 2).
(4) *Goodbye*: The robot walked back to stand in front of the participant, bowed (turning its front part towards the floor), and then walked back to a corner at the far end of the room.

The understanding of these gestures and their valence was validated in a pilot study with 24 participants, where we asked them to explain the meaning of the gesture and rank their confidence. All four gestures were easily understood and participants reported high confidence in their interpretation.

3.1.2 Technical implementation. To control the robot's gestures, we developed an interface for sequencing robotic movements using TypeScript. The interface allowed for the execution of robotic commands traditionally achievable via a controller. Using the interface, we enriched the platform with the ability to design fixed autonomous robotic behaviors. By creating pre-defined queues of robotic commands, we designed autonomous robotic behaviors for each condition.

3.2 Participants

Forty-five participants were recruited either from the university or via social media (22 women, 22 men; mean age = 23.8, SD = 1.8). They received a 15 USD gift card for local stores. All participants signed a consent form and were informed that recorded material would be deleted after data analysis.

3.3 Experimental design

The between-participant experimental design included three conditions (see Figure 4): *Positive opening encounter*, *Negative opening encounter*, and *No opening encounter*. In each condition, the robot performed the relevant opening gesture, which was followed by showing interest in the box and performing the *Request for help* gesture. At the end of the interaction, the robot performed a *Goodbye* gesture, regardless of the participant's behavior (opening/not opening the box). Participants were *randomly* assigned to one of the three conditions using a matching technique that balanced gender, attitudes to helping [43], and negative attitudes toward robots [44].

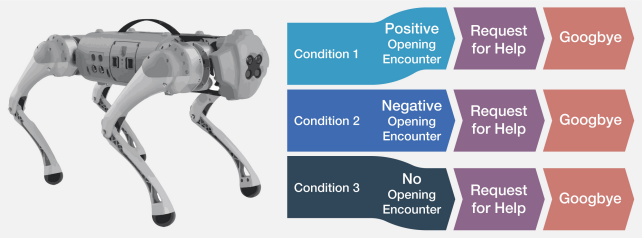

Figure 4: Robot's behavior in each condition.

3.4 Experimental Settings

The experiment was conducted in a quiet room at the research lab. The setup included a table (70 cm in height) in one corner of the room with a tablet on it (for participants to fill in a demographic questionnaire). A chair was placed next to one end of the table against the wall. A simple box was placed next to the other side of the chair. The robotic dog was positioned next to the other side of the table in a gap between the table and another wall. Since the room was presented to participants as a waiting room, we added a carpet on the floor and a plant on the table (see Figure 5).

3.5 Dependent measures

To assess how the opening encounter affected participants' willingness to help the robot and the robot's perception, we used objective and subjective measures.

3.5.1 Opening the box for the robot. Similar to previous studies (e.g., [21]), we evaluated participants' willingness to help the robot by coding their behavior. Specifically, we coded the frequency of participants who opened the box for the robot after it showed interest and performed the *Request for help* gesture.

3.5.2 Godspeed questionnaire. We evaluated participants' impression of the robot using the Godspeed questionnaire [6], a five-item Likert scale measure commonly used in HRI studies to test participants' impression of the robot. We used three relevant subscales from the questionnaire: likability, animacy, and perceived intelligence.

3.5.3 Semi-structured interview. Semi-structured interviews were used as they allow the researcher to ask open-ended questions and enable participants to freely express their views during data collection while remaining in line with a particular framework [24]. The interview provided an opportunity to better understand the participants' thoughts, emotions, and attitudes. The interview included questions concerning the overall experience, robotic dog, and interaction (e.g., "Describe the experience," "Describe your thoughts about the robot," and "Describe your own behavior while waiting in the room").

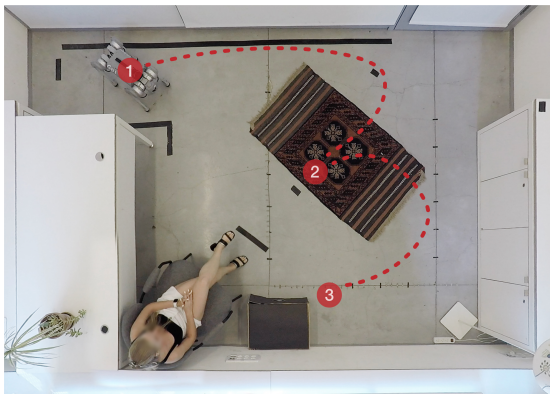

Figure 5: Experimental setting and the robot's path during the experiment: (1) The position of the robotic dog at the beginning of the experiment; (2) the position where the robot performed the opening encounter; (3) the position where the robot performed the *Request for help* gesture.

3.6 Procedure

A few days before the experiment, participants received two questionnaires by email: the Attitude Towards Robots questionnaire [44] and Helping Tendencies scale [43] to balance the groups in the different conditions. When participants arrived at the lab, the researcher explained that since it was an HRI lab, they might encounter robots during their stay. Participants were also informed that from that point, everything was recorded and that they could withdraw from the experiment at any time without penalty. The researcher then asked them to enter a "waiting room," take a seat, and fill in a demographic questionnaire. The researcher made sure participants began to fill in the demographic form on the tablet and left the room.

As participants completed the demographic questionnaire, the robotic dog was (remotely) activated according to the relevant condition. The robot performed the relevant opening encounter behavior, which was followed by movement towards the box, showing interest in it, and performing the *Request for help* gesture. After approximately 5 minutes, the robot performed the *Goodbye* gesture and returned to its original location between the table and the wall. After the interaction ended, the researcher re-entered the room, asked the participant to fill in the Godspeed questionnaire, and conducted the semi-structured interview. At the final stage of the experiment, participants were asked to describe a recent positive experience (to mitigate any negative effects). The researcher debriefed the participants and verified that they left with an overall positive experience.

4 ANALYSIS

We conducted Bayesian analyses to verify the lack of early differences between groups in helping tendencies and negative attitudes toward robots.

Our main analyses for the impact of opening encounters on willingness to help the robot included a chi-square analysis for the frequency of box opening in the different conditions and a 1-way ANOVA for the three Godspeed subscales. The qualitative analysis of the semi-structured interviews was performed by three researchers. We used a thematic coding methodology for the analysis [7]. The analysis included four stages: (1) Two researchers transcribed the interviews to develop an initial understanding of the data. The transcriptions were read several times before the coding process began. (2) Initial themes were extracted from the data and discussed in depth with a third researcher, and any inconsistencies were resolved. (3) The researchers used those themes to independently analyze part of the data, verifying inter-rater reliability (kappa=82%). (4) The two coders analyzed the rest of the data.

5 FINDINGS

The Bayesian analysis indicated no early differences between groups (NARS: $BF_{10} = 0.10$; Helping Tendencies scale: $BF_{10} = 0.08$). The quantitative and qualitative main analyses indicated an impact of

Table 1: Distribution of participants' compliance with the robot's request for help in each opening-encounter condition.

Robot Condition	Helping Behavior		Total
	Opened the box	Did not open the box	
Positive Opening Encounter	11	4	15
Negative Opening Encounter	2	13	15
No Opening Encounter	2	13	15
Total	15	30	45

the opening encounter's valence on the willingness to help the robot and the perception of the robot.

5.1 Participants' willingness to help the robot

The analysis revealed that the valence of the opening encounter had a significant influence on the frequency of opening the box for the robot $\chi^2_{(2)} = 16.2, p < 0.001$. In the *Positive opening encounter* condition, most participants opened the box after the robot performed the *Request for help* gesture. In the *Negative opening encounter* and the *No opening encounter* conditions, hardly any participant opened the box for the robotic dog (see Table 1).

5.2 Robot perception

A separate one-way ANOVA analysis was performed for each of the three sub-scales of the Godspeed questionnaire (robot likeability, animacy, and perceived intelligence).

5.2.1 Robot likeability. The valence of the opening encounter had a significant influence on the likeability ratings, F(2,42) = 12.37, p < 0.001. Scheffe's post-hoc analysis indicated that the *Positive opening encounter* condition resulted in higher ratings than the *Negative opening encounter* (p < 0.001) and the *No opening encounter* (p = 0.001) conditions. No difference was found between the *Negative opening encounter* and *No opening encounter* conditions (see Figure 6).

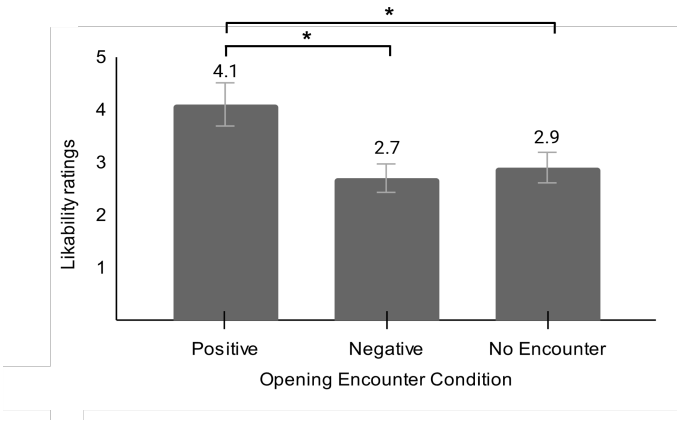

Figure 6: Analysis of the robot's likeability ratings, indicating a significant increase in the *Positive opening encounter* condition.

5.2.2 Animacy and perceived intelligence. The analysis of the animacy and perceived intelligence ratings indicated no significant differences between the different opening-encounter conditions.

5.3 Thematic analysis of the semi-structured interview

The thematic analysis of the interviews resulted in four main themes: (1) opening encounter valence validation; (2) the perception of the robot's request for help; (3) the general perception of the robot; and (4) the robot's animacy.

5.3.1 Opening encounter valence validation. Most participants in the *Positive opening encounter* condition (13/15) stated that the opening encounter with the robot was positive. They explained that the encounter involved pleasant, welcoming behavior where the robot showed a clear positive attitude. Participants stated that the robot was enthusiastic about the possibility of interacting with them and showed signs of excitement to play:

- "At our first meeting, the robot acted like a friendly dog with a ball, as if he wanted me to play with him." (p. 6, Positive).
- "It felt like when dogs meet someone new, they get all excited and say, 'Hello, I'm here'." (p. 24, Positive)
- "It felt to me like he was alive and wanted me play with him, look at him, talk to him, or just be there for him." (p. 2, Positive)

Other participants explained that the robot wanted to get to know them:

- "It was almost like the robot had recognized and picked up on my presence. Then it started moving closer to me, wanting to know more about me." (p. 26, Positive).
- "This first interaction was like us getting to know each other. My initial impulse was to give him the back of my hand so that he gets used to it." (p. 30, Positive).

The two participants who did not describe the opening encounter as positive perceived it as uncomfortable and even intimidating.

- "He makes zoomorphic-like movements and gestures even though he's not alive. It made me feel really uncomfortable." (p. 29, Positive).
- "I didn't expect to interact with such a large object. It's intimidating, especially since it has no tail or fur." (p. 8, Positive).

In the *Negative opening encounter* condition, all participants (15/15) described the opening encounter with the robot as highly negative. They stated that the encounter involved unpleasant and even aggressive behavior in which the robot was hostile and showed a strong negative attitude, indicating that it was not interested in interacting with them:

- "The step back felt as if he wanted to attack me." (p. 1, Negative)

- "He did a crouching motion that my dogs do when they want to attack. In my head, he moved away to run at me and attack." (p. 39, Negative)
- "He acted like dogs do when they're suspecting someone." (p. 42, Negative)

Other participants in this condition stated that the robot wanted to avoid the encounter since it was anxious or scared:

- "He was threatened or scared. He examined me and took a few steps back like dogs do when they feel frightened." (p. 28, Negative)
- "It looked like he was really scared. I was like, 'Oh, what did I do?' " (p. 22, Negative)

None of the participants in the *No opening encounter* condition (0/15) described having an opening encounter, either positive or negative, with the robot.

5.3.2 Perception of the robot's request for help. Participants' attention to the robot's request for help and their willingness to comply varied greatly among the conditions. In the *Positive opening encounter* condition, most participants (11/15) discussed the robot's need for help and complied with it. Only a few participants in the other two conditions discussed the robot's request for help (two in the *Negative opening encounter* condition; four in the *No opening encounter* condition).

In the *Positive opening encounter* condition, participants explicitly discussed the robot's request for help from them:

- "He looked at the box as if saying, 'There is something there that I want; help me'. I felt as if he wanted a toy from his box, so I opened it to give it to him." (p. 6, Positive)
- "It seemed like he wanted to see what was inside. He requested... expected me to open the box for him." (p. 8, Positive).

The few participants who mentioned the robot's request for help in the *Negative opening encounter* and *No opening encounter* conditions discussed and acknowledged the robot's need for assistance but were not always willing to provide it.

- "I didn't open the box for him. I told him that he should have thought about it before being so aggressive when we just met." (p.39, Negative)
- "He seemed to me to be begging, 'Open. I want to see what's in here'." (p.34, No opening encounter)

5.3.3 General perception of the robot. Participants also discussed their perception of the robot. In most cases, they had a clear attitude that was either positive or negative.

Positive perception was mostly observed in the *Positive opening encounter* condition (11/15 vs 0/15 in the *Negative opening encounter* condition and 3/15 in the *No opening encounter* condition). Participants perceived the robot as sweet and friendly. They compared the robot to a pet who sought connection and love.

- "When he tilted his head, I was like 'How cute!' It was sweet." (p. 33, No opening encounter)
- "He had a loving look. As if trying to say, 'I love you'." (p. 17, Positive)
- "I thought he was intelligent. It made me smile." (p. 8, Positive)

Negative perception was mostly observed in the *Negative opening encounter* condition (13/15 vs 3/15 in the *Positive opening encounter* condition and 4/15 in the *No opening encounter* condition). Participants perceived the robot as dangerous and aggressive.

- "He was really intimidating. Really threatening. He had a wicked look." (p. 39, Negative)
- "It seems to me that he is not completely reliable. He might be dangerous." (p. 23, Negative)
- "I kept thinking that I had to follow and see what he was doing to make sure I wasn't in danger." (p. 9, No opening encounter)

5.3.4 Robot animacy. More than half of the participants in the *Positive* (8/15) and *Negative opening encounter* (9/15) conditions explicitly discussed the robot's animacy. This theme was hardly mentioned in the *No opening encounter* condition (2/15).

Participants perceived the robot as more than merely a mechanical object. They described it as a living being with its own thoughts, emotions, and conscience.

- "Throughout the interaction, he really seemed to look, understand, and listen to me. It felt like he was alive." (p. 2, Positive)
- "He gave me the feeling that he has his own feelings, his own world, and that he's not a machine." (p. 42, Negative)
- "I felt like he really was like an animal with feelings and thoughts. On one hand, I knew it was a robot, but on the other hand, I felt the need to act as if it was a living creature." (p. 42, Negative)

6 DISCUSSION

In this work, we demonstrate the great importance of designing appropriate opening encounters with robots. Our findings showed that the robot's behavior, indicating its willingness for interaction, had a significant impact on participant behavior in the interaction that followed and on the overall perception of the robot.

A positive opening encounter indicating a willingness for interaction was followed by a high sensitivity in participants to the robot's request for help and willingness to comply with it. Participants also reported a positive perception of the robot, indicated in the high likability ratings and their descriptions of the robot as "cute," "playful," "looking for love," and "friendly." A negative opening encounter led to the opposite effects. Participants ignored the robot's request for help, and its likeability ratings were lower. They perceived the robot as "threatening," "unreliable," and "dangerous."

When the interaction with the robot did not include an opening encounter, participants' willingness to help and the likability ratings were similar to those found in the *Negative opening encounter* condition. This finding indicates that failing to design and control the opening encounter with a robot may result in highly negative effects that would persist in the interaction that follows. Without compliance with common social norms and without establishing a clear indication that a robot is interested in interaction, people may adopt a cautious attitude, which would shape their subsequent behavior towards the robot. It is therefore important to understand that the lack of an opening encounter would not have a neutral impact but rather a negative impact on the interaction that follows. Our qualitative analysis also revealed that the lack of

an opening encounter led to a different perception of the robot's animacy. While in the *Positive opening encounter* and *Negative opening encounter* conditions, participants explicitly described the robot as "alive," "lifelike," and "animal like," in the *No opening encounter*, participants hardly mentioned the robot's animacy. This finding further indicates that opening encounters cannot be overlooked when designing robotic behaviors.

Previous studies have already suggested that a robot's first impression is a critical factor in HRI that has long-lasting effects [47, 70]. We extend this line of work by indicating that the very first moments of the interaction should be carefully designed to follow acceptable social norms. The robot should clearly demonstrate its willingness to interact using acceptable social cues. Our findings suggest that apart from controlling for the first impression associated with the robot's function and capabilities [47, 70], robot designers should also account for the valence of the opening encounter. The robot's social behavior and compliance with familiar human norms at the very beginning of the interaction should be considered an integral part of the robot's first impression and designed appropriately. Establishing a clear and positive opening encounter is highly important as it shapes the nature of the interaction that follows.

We note that in some cases, negative opening encounters may be desired and can be leveraged to reduce risks. There are some circumstances where people are required to share an environment with dangerous robots. While people are aware of the risks associated with their work environment, over time, they may become less careful and even fond of the robot simply because they share the same workspace. Since even highly non-humanoid robots are perceived as social entities [17], it is possible to leverage negative opening encounters to clearly communicate that an interaction is not desired. The impact of the opening encounter on the interaction that follows would establish a relationship characterized by avoiding interactions. Keeping social distance from the robot is likely to also increase physical distance, which would reduce chances for risky interactions. At the same time, experiencing constant negative opening encounters may lead to a sense of rejection and exclusion. Hence, the advantages and disadvantages of the negative opening encounter should be carefully balanced.

Our findings can also inform the design of help requests by robots. We show that a simple and minimal positive interaction prior to the help request may set the foundations for people's willingness to help the robot. It is, therefore, recommended to establish an initial social connection before presenting a request for help. Based on human norms, a positive opening encounter can quickly create a sense of social commitment that would facilitate compliance with following help requests and encourage sensitivity to the robot's needs. Future work should evaluate whether the social commitment created at positive encounters can overcome well-known challenges associated with people's availability and encourage them to provide help even when they are preoccupied with other tasks.

Taken together, our findings provide another example of the importance of accounting for social norms when designing interactions with robots. Opening encounters are central to human behavior as they indicate the parties' willingness to engage in the interaction. The mutual processing of social cues indicating the valence of the opening encounter determines their behavior throughout the rest of the interaction. Our findings suggest that people apply similar social processes when interacting with robots. They use the behavioral cues provided by the robot in the opening encounter as guidelines for their own behavior towards the robot and for constructing the perception of the robot. Various studies have already provided methods for designing clear, understandable, and positive opening encounters. We suggest that leveraging these methods for designing positive opening encounters is critical for reaching high-quality interactions with robots. Failing to provide clear social cues at the very beginning of an interaction can have a highly negative impact on the quality of the interaction that follows.

7 LIMITATIONS

There were several limitations to this study. First, We used a specific robot with a particular (zoomorphic) morphology. Future studies should evaluate the impact of opening encounters with different robots ranging from abstract to humanoid. Related to the robot's morphology is the specific robotic behavior. We chose a familiar behavior that is based on participants' previous experiences. It is important to further test the effect of unfamiliar opening encounters with different levels of emotional intensity (either positive or negative). Another limitation concerns our focus on "helping the robot" as an indicator of the quality of the interaction. While providing help is a basic human behavior that represents people's attitudes and perceptions of relationships, opening encounters may impact various other aspects of interactions with robots that should be mapped in future studies. We additionally acknowledge that the duration of the effect should be further studied. It is possible that the impact of the opening encounter fades over time, depending on the robot's subsequent behavior and the length of the interaction. Participants may update their perception based on their accumulated experience with the robot throughout the interaction. However, it is important to consider that even though the opening encounter's negative impact may be mitigated over time, a significant effort would have to be invested in overcoming these negative effects and restoring a neutral perception. Lastly, interviews may be biased by the interviewers' expectations and the "good subject effect" [42, 46]. We minimized this risk by following a strict protocol, ensuring the interviewer used neutral language, and telling participants that all answers were helpful.

8 CONCLUSION

Our work highlights the importance of opening encounters when interacting with robots. We demonstrated how the valence of the opening encounter can shape the interaction that follows and determine its quality. When designing robots, developers typically focus on the robot's main function, and the opening encounter may be overlooked. Our findings suggest that failing to consider and design a positive opening encounter may have a highly negative impact on people's perception of the robot and their behavior toward it. This effect is not limited to opening encounters that were intentionally designed to be negative; a lack of an opening encounter at the initiation of the interaction may lead to a similar negative impact. We conclude that, as in human social interactions, opening encounters in HRI are the cornerstone of the interaction, shaping its nature and determining the overall atmosphere governing the

interaction. More generally, our study further supports the importance of considering social norms when designing human-robot interactions.

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