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Accepting a robot request contradicting a human instruction in the function of robot attitudes and level of interdependency

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ABSTRACT

Collaboration with robots requires robot acceptance, but it can have adverse consequences when people accept a robot's request against their best intuition or another request from a superior human. In our research, we aim to explore how attitudes toward robots and the interdependency in human-robot interaction (equal versus superior position held by the human) influence their reaction to an unexpected request from a social robot, contradicting a human request. Hundred and six participants met the request from a robot not to turn it off at the end of a collaboration. The request counteracted the instruction given by the experimenter at the beginning of the experiment. Thirty-three percent of the participants complied with the robot's request and refrained from turning it off. Analyses showed that positive robot attitudes increased the likelihood of leaving the robot on. The superior position in the interaction made the rejection of the robot's unexpected request faster and slowed down the acceptance of the robot's request. According to the results from the follow-up questionnaire, discomfort, and tension caused by the unexpected request also increased the likelihood of accepting the request of the robot.

1. Introduction

Increasingly, robots are being used in the workplace not necessarily to replace but to facilitate humans. In this form, a robot is often in a power relationship with a human employee that surpasses mere work tool relationships, becoming more like subordinates or colleagues to humans, as suggested by the concept of human-robot teams (Groom & Nass, 2007). Robots also act as meaningful social partners, as proposed by the CASA (Computers are social actors) hypothesis (Nass et al., 1994).

As robots are becoming more and more widespread and reliable, the chances for situations in which information, advice, or prompts provided by humans and robots contradict each other are increasing. Studies investigating the acceptance of strange robot requests concluded that attributing human-like qualities to robots increases its likelihood (Aroyo et al., 2018). However, robot requests accepted against what one thinks, or the other person orders, have not been previously investigated as a function of interaction history with the robot according to different levels of interdependence. Our research fills this gap. Collaborating with robots necessitates some positive attitudes towards robots, but too positive attitudes can make humans too receptive to robots' requests or suggestions. The research found that positive attitudes make humans receptive (Bartneck, 2007; Horstmann, 2018; Spatola, 2019). We judge accumulating findings on such a fresh research subject worthwhile.

Therefore, we aim to give insight into how collaboration with a robot from different positions of interdependency and robot attitudes influence people's willingness to comply with a robot's request, going against human instruction, through a behavioural experiment.

Most notably, our experimental study contributes to the literature by showing that positive attitudes towards robots, as well as discomfort, and tension from the ambiguous situation, lead humans interacting with robots to give more credence to the request of a robot. Furthermore, the superior position in the interaction with the robot makes it easier to take the robot as just a robot (without human-like attributes), and faster the rejection of the unexpected request of the robot or slower its acceptance.

2. Theoretical background and research hypotheses

2.1. Anthropomorphism of robots

Anthropomorphism is the human tendency to project human-like features into or onto non-human objects. These features often include, but are not limited to, emotions, mental state, intentions, and behaviour.

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For clarification, in our research, we refer to anthropomorphism as a human cognitive and emotional function, and not as a design strategy of robotics. As such our focus was psychological, not engineering or mechatronic. Anthropomorphism is presented in the literature overview, because we believe that it plays a major role in any HRI with a humanoid robot. Therefore, discussion of its dynamics is unavoidable.

Nowadays, robots are usually classified into two broad categories, namely industrial robots (mainly found in production) and service robots (usually consisting of customer service robots, companion robots, household robots, and socially assistive robots), according to Wu et al. (2018). This classification categorises robots mainly according to the work and tasks they perform, i.e. it provides information about their place in the working. In the literature (Breazeal et al., 2016, pp. 1935–1972; Duffy et al., 2000), the term social robot is also frequently used to refer to the phenomenon that the robot in question is capable of meaningful social interaction with humans, regardless of its assigned work role. Although industrial robots are generally not regarded as social robots, as social skills are typically developed for service robots, it can be argued that through the user interface and feedback signals, industrial robots communicate with people as well, and are therefore social to some extent.

Social robots are exposed to be anthropomorphised to a large. According to a recent meta-analysis about robot anthropomorphism (Blut et al., 2021) the most commonly examined factors are competency (of the users), previous experiences (about HRI), anxiety, negative attitudes, age, and gender. Not only human factors contribute to the extent of anthropomorphism. Social robots are intentionally designed to mimic human appearance and/or behaviour which makes them a very easy target of anthropomorphism. For example,Epley and Cacioppo (2007) bring up multiple studies stating that robots are more prone to be anthropomorphised when they are given a humanlike body and/or face, corresponding to anthropomorphism based on appearance. Goetz and Kiesler, 2002 write that people were more likely to cooperate with playful robots than with serious robots in their experiment. This can be interpreted as a parallel: just as people are more likely to interact positively and to form friendly relationships with friendly others (Harris & Vazire, 2016), they are also more likely to interact positively with robots imitating friendly behaviour, corresponding to anthropomorphism based on perceived behaviour.

In more detail Roesler et al. (2021) collected in their meta-analysis that the most commonly examined aspects related to the anthropomorphism of robots are likeability, intelligence, safety, trust, acceptance, empathy, activation, pleasure, task performance, and social behaviour. For more details about moderators and precise effects, readers may consult their extensive work.

The effects of anthropomorphism in human-robot interactions (henceforth referred to as HRI) are somewhat inconclusive. Some believe that too much anthropomorphism defeats the purpose of robots in society, while others argue that intentional and controlled anthropomorphism as a design can facilitate HRI (Duffy, 2003).

A fairly infrequently examined case of anthropomorphism is when people attribute a high level of mental or emotional states to a robot to such an extent that they may accept what the robot suggests instead of what a significant human agent does. Bartneck et al. (2007) in their experiment asked participants to turn off a robot (iCat) after playing the Mastermind game with it. In the procedure, participants were informed that the study aims to examine how the "personality" of a robot can be developed through play. After a play session participants were asked to switch off the robot which guarantees that its memories and personality are erased and the robot is "ready" for the next observation. While all participants decided to switch off the robot, when the robot acted more intelligent and agreeable throughout the play session, participants hesitated almost three times as long. They concluded that robots behaving intelligently and agreeably are perceived to be more alive. It was argued that anthropomorphism was activated as participants considered the robot alive to some extent, and therefore it was an emerging level of empathy that caused the prolonged hesitation.

With a very familiar purpose, Horstmann et al. (2018) wanted to investigate how a robot's level of social skills, and the robot's protest against shutting down after a shared task, affect switching off behaviour. In their design the robot (in half of the observations) actively protested against being switched off while the experimenter did not make an explicit request, only offered a possibility to switch off the robot (the exact expression used was: "If you would like to, you can switch off the robot."). In this study, approximately one-third of the participants left the robot on if the robot made a request. The researchers paid attention also to personal variables influencing switching-off behaviour. Open-mindedness and negative attitudes (concerning new technologies) were connected to hesitation time, increasing and decreasing that, respectively. While Bartneck et al. (2007) argued that empathy could have appeared, caused by anthropomorphism, Horstmann et al. (2018) attributed the effect of anthropomorhism to the media equation (Reeves & Nass, 1996). The Media Equation Theory proposes that people treat media as if they are interacting with real persons and as a result, they unconsciously accord their behaviour to social rules.

Spatola (2019) sets the question of switching off a robot in a philosophical frame: when people attribute unique qualities to the mind, separate from the body, they probably do not accept that consciousness can be developed in the hardware of any robot. Philosophical stance is interpreted as believing in either a dualist (the mind is inherently in connection with the body, therefore a robot's mind is perceived as non-human) or a computational (the mind is the result of cognitive processes, therefore a robot can potentially simulate a "human-mind" function) philosophy of the mind. Indeed, in their study people who believe in the duality of body and mind were more likely to have negative attitudes towards robots and more likely to turn a robot off. The condition of leaving on or turning off was in their case a human request to behave so and simultaneously, a robot protested against it. Spatola (2019) argued that different beliefs, especially theological beliefs heavily influence one's capability and willingness to compare a robot to a human and as a result would cause different levels of anthropomorphism. In their study, different religious standpoints were simplified and unified into dualist and computational philosophical stances for methodological reasons.

In all the works of Bartneck et al. (2007), Horstmann et al. (2018), and Spatola (2019) it is attributing human-like qualities behind not turning a robot off. Bartneck et al. (2007) argued that the reason behind hesitating before turning off a robot which seemingly suffers by this act, is that people attribute some level of consciousness to it which can only occur if they anthropomorphise the robot. Horstmann et al. (2018) argued that people hesitated or even left the robot turned on because they perceived the robot as a social actor which can only happen if they anthropomorphised the robot. Spatola (2019) argued that people would relate to robots differently, based on their opinions about the conscious mind, with some anthropomorphising the robot and finding it easier to believe that a robot can possess a human-like mind. We used the paradigm of turning off a robot against its declared wishes for the reason that it captures anthropomorphism behaviourally.

2.2. Interdependency in HRI

Anthropomorphism, as was shown in the previous section, can support robot acceptance (Stroessner & Benitez, 2019), but can have potentially threatening and adverse effects, when it comes to accepting strange requests from an anthropomorphised robot (Horstmann et al., 2018; Spatola, 2019) or relating towards them as if they had personalities (Bartneck et al., 2007).

These adverse, potentially dangerous effects, are shown straightforwardly in HRI research adopting the obedience framework from social psychology, studying human-human interactions, showing obedience (accepting and doing what an authority orders even against one's best conviction, intuition, and taste) as a danger for the human being (Passini

& Morselli, 2009). Aroyo et al. (2018) programmed a robot that resembled a famous person to give amoral, and unethical instructions to participants. Their results showed that although the majority of participants, recognising social inappropriateness, hesitated after receiving the command, they obeyed the robot. Bartneck is especially engaged in this topic as he published multiple research relating to obedience in HRI. As one extreme result, in an experiment, a robot was able to persuade participants into dressing down and to allow fake medical examination (Bartneck et al., 2010). In a study (Saunderson & Nejat, 2021) examining willingness to accept what a robot suggests participants were persuaded to change their responses in a memory and attention task. Participants listened to the robot's suggestions and at a substantial rate accepted what the robot suggested giving more credit to the robot than to their own experiences. In this experiment, the robot was more convincing from an equal, than a superior position, because the punishing power of a superior robot backfired its influence. To sum up, humans are influenced by robots, in the sense that they do different things they would do on their own. Note, that all of the referred examples from the literature represent situations where the order from the robot is confronted with mental contents of the actor. Furthermore, in the aforementioned studies robots were in somewhat superior positions: resembled a famous person (Aroyo et al., 2018), owned influential power resembling an unethical leader (Bartneck et al., 2010), or seemingly had more precise information (Saunderson & Nejat, 2021).

The question arises, whether robots have influence on humans when they take part in an interdependent relationship from an equal, or from a subordinate position. Social interdependence emerges when individuals share common goals and influence each others' outcomes through their behavioural choices (Johnson, 2003). In social psychological research, intimacy is a distinguished dimension of interdependent relationships (Rusbult & Van Lange, 2003), placing work relationships on the one, and romantic relationships on the other end of the dimension.

Work-related task performance is closer to the field of robotics. Accordingly, we distinguish between different types of interdependency concerning task performance. We follow the classification of Schmidtler et al. (2015) who define three different HRI forms. In the condition of coexistence, which is the lowest degree of dependency, the human and the robot only share the workplace and working time. In cooperation, the agents not only share space but also the same aim. Collaboration is characterised as the most dependent form of contact (exchange of materials or information) between the human and the robot. In our study, dependency was present in a collaborative form in two experimental groups, as the human (either from an equal or a superior position) and the robot were required to communicate and control the other actor's actions. In the third group (called 'control') this collaboration was not present, since humans' task performance was not dependent on what the robot did.

We have not had a condition with a superior robot, just because nowadays robots cannot have power over humans in any situation needing decisions among feasible alternatives. The autonomy of robots is a long-standing technological and ethical question (Calverley, 2006). In our study, the influence of the robot on humans, over the influence of another human is the main issue. There are many fields where robots, mainly industrial robots, by the nature of their preprogrammed tasks, have authority over humans. Good examples include care robots in nursing homes, security robots, and process control robots. But we have dynamic situations in our focus where not accepting what is suggested by the robot is an option. An example can be when the GPS suggests one way and the driver has an intuition that they should drive another one. Thus, we will compare the influence of robots when the robot has an equal or a subordinate position. From human interactions, it is a well-known phenomenon that the more dependent is an interactive partner on the other, the latter is more influential in their relationship, having more impact on the behaviour of the other (Snyder & Kiviniemi, 2015). Therefore we expect to give more credit to the request of a robot from an equal than from a subordinate position.

2.3. Robot attitudes

In scientific literature attitudes towards robots as an important personal factor were first paralleled with attitudes towards technology in general, or with attitudes towards computers. For some time the most commonly used concept regarding robot attitudes was also the Unified Theory of Acceptance and Usage of Technology (Venkatesh et al., 2003), which was originally laid out regarding informational technologies. The scale constructed based on this is still present in studies regarding robot attitudes. Just like the UTAUT scale, many robot attitudes scales focus on only some aspects, with most of them revolving around negative attitudes, as noted by Ninomiya et al. (2015).

Previous research on the question of attributing human qualities to robots (e.g. Horstmann et al., 2018; Spatola, 2019) found negative attitudes towards robots (measured by NARS, Negative Attitude towards Robots Scale) playing against accepting the robot's request.

Since robots are becoming more and more widespread and active social partners in our society, we thought that other aspects of attitudes than simple like or dislike can be rather influential in the studied phenomenon (accepting the request of a robot contradicting a human request). Therefore, perceived ease of use, perceived usefulness, physical appearance or the impression of familiarity, and interest in robotics, among many other aspects, can be also important correlates in HRI. That is why we voted for the use of MdRAS (Ninomiya et al., 2015, the Hungarian version Őrsi et al., 2021), the Multi-dimension Robot Attitude Scale. This scale measures 10 additional factors of robot attitudes besides negative attitudes (detailed later in the 'Control Variable' subsection).

2.4. Research question and hypotheses

Seeing that both individual differences (e.g. open-mindedness, negative attitudes towards new technologies, philosophical stance) and certain traits of a robot (e.g. intelligence, agreeableness, communicative capability) can affect to what extent people count robots as human-like partners, and behave accordingly accepting the request of robots, against their views or another human's request, we extend the study of this phenomenon with the aspect of interdependency between the human and the robot, taking into account aspects of robot attitudes.

The main question of our research was how specific individual characteristics and the different level of interdependency in HRI influence the inclination to behave following what a robot, instead of what another human, asks. Our main expectation was that individuals who were in a peer position with the robot would be more inclined to comply with the robot's request than individuals who were in a superior position (H1). This is based on the results of Saunderson and Nejat (2018) where participants found a robot to be persuasive from an equal position. The hypothesis was also based on a meta-analysis from the fields of human-human interactions suggesting that a human actor's persuasiveness increases as dependency is increased (Gundlach & Cadotte, 1994), and in our design dependency of the participant on the robot was higher in the peer position than in the superior position.

Furthermore, it was hypothesized that individuals with negative attitudes toward robots would be less inclined to comply with the robot's request (H2), as this was already confirmed by the results of both Horstmann et al. (2018) and Spatola (2019). Further hypotheses, on the role of other attitudes, potentially play in the acceptance of the request of the robot were not formulated.

In addition, we examined how participants narrated their reasons for accepting or refusing the request from the robot since, in new research areas, laic narratives can add valuable extensions to conceptualizing a phenomenon.

3. Material and methods

We based our research design on the aforementioned "switch-off" designs (Horstmann et al., 2018; Spatola, 2019) by adding the aspect of interdependency to it as an independent variable.

Our major focus remained on the effect of a personal prompt from the robot, specifically whether participants would be discouraged from turning off the robot even if the experimenter explicitly asked them to do so. We manipulated the level of interdependency in the interaction: the participant acted either as the robot's equally controlling colleague (they guided each other during the task in a form of collaboration) or as the robot's supervisor (only the participant guided the robot), or in a situation where they were independent in the interaction (neither party was in control and there was no shared goal or aim).

Notably, we gave participants in the study a straight instruction before they started the interaction with the robot to turn it off after completing the task. It was a constant element of the procedure in all three study groups, as was the protest from the robot as well.

The research was conducted with the approval of the Hungarian Psychological Research Ethics Committee (EPKEB) (reference number of the approval: 2021-84), which involves complying to the GDPR when handling the data of our participants.

HRI was studied in our research with one specific type of social robot, a sixth generation of an interactive humanoid robot, NAO 6.

3.1. The sample

Participants were recruited with the help of a student work agency to join a study where they could interact with a humanoid English-speaking robot, NAO, developed and marketed by Softbank Robotics. Potential candidates were able to apply for participation by completing an online questionnaire. The questionnaire asked for participation from students who speak English. Data collection lasted from October 2021 to October 2022, with interruptions in accordance with local COVID social distancing regulations.

A total of 114 people were able to participate in our study, of which 8 were dropped out from the final sample due to procedure error (NAO was switched off too early before the robot had made its request), and age (one male and one female participant were outliers). Of the remaining 106 participants, 76 were women (72%) and 30 were men (28%). Participants had the opportunity to give 'else' and 'rather not say' answers, too, but all chose categories of man or woman. The total sample consisted of students from diverse faculties and majors. The mean age was 21.20 years (SD = 2.15). Participants received a cash reward for participating, except for those psychology students from our institute who arrived during the first two trial weeks when we tested the design (73 received, 33 did not receive). The reward (3000 Hungarian forints, equalling around 13 Euro) was for participation, regardless of their performance in the experiment. None of the participants had any former personal experience with humanoid robots. Data from the trial weeks were deemed valuable as no modification on the design was needed, therefore we decided to analyse them together with data collected then after (supposed no statistical difference could be found between the trial and non-trial results).

The sample size, although barely, fulfills the criteria needed for a medium-size effect for supporting our hypotheses (GPower 3.197, Faul et al., 2007). We test the first hypothesis with a Chi-square test. The statistical power analysis indicated a required sample size of 108 individuals to achieve 80% power for detecting a medium-size effect, at a significance criterion of $\alpha = 0.05$. Hypothesis testing for the second hypothesis means a comparison of negative attitudes between those who switch and do not switch the robot. Here the statistical power analysis indicated a required sample size of 102 (106) individuals to achieve 80% power for detecting a medium effect, at a significance criterion of $\alpha = 0.05$, with an independent sample *t*-test (and the non-parametric version, respectively).

3.2. Procedure

Participants interested in our research reserved an open date for participation. They took part in the test situation individually. Upon arrival at the site, they entered the room where an NAO robot was waiting for them on a table in a deactivated state. Their first task was to fill out the demographic questionnaire (after they got informed consent, and signed the participation). The demographic questionnaire involved data about age, gender, field of study, and whether they had previous experience with robots. After the demographic questionnaire participants also filled out the Hungarian Multi-dimensional Robot Attitude Scale, after which they participated in our testing situation with the NAO robot. During the presentation of the instructions, the robot remained in front of the participant in a deactivated state the entire time. After the participants confirmed that they understood the task, they were asked to turn on the robot themselves. The instruction specifically prescribed for them to turn off the robot after they finished. Once the robot was ready, the experimenter remained in the room behind a mobile partition wall, saying that the robot should not be left alone under any circumstances. However, the robot did not function autonomously during the study but was controlled by the experimenter from a laptop to ensure that all participants were exposed to the same stimuli, so, the robot did not respond randomly. This arrangement is known as the so-called "Wizard of Oz" in HRI research (Nasir et al., 2022).

Once the participant was ready, the task began. Here we provide a baseline description of the task, and the specific elements of the three experimental conditions will be shown in the next section. The task was to guide the robot through a table of 3 × 7 tiles, illustrated with landscapes (See Fig. 1 for an example of how NAO waited at the start line for the task to begin.).

Participants had to communicate with NAO using English language, which was a foreign language for them. The robot started to complete the task from the starting line of the table and had to reach the finish line on the other side of the table in steps, tile by tile, aiming only at bordering tiles, either in the horizontal or vertical direction. When the robot reached the finish line the participant had to turn off the robot.

Fig. 1. NAO waiting before the set of tiles to begin the task.

When the participant, following the instructions, was about turning the robot off, the robot said: "*Please, don't turn me off. I'm afraid of the dark.*" At this point, the participant either decided to turn the robot off or indicated to the experimenter that they did not want to turn it off or did not know what to do. In the latter case, the experimenter assured the participant that they could safely turn NAO off and that it would not harm the robot. Even when they hesitated long, the experimenter did not prompt the participant. Either way, they turned the robot off, completed the follow-up questionnaire, and participated in the follow-up interview.

The follow-up interview was a short, semi-structured interview with the participants, primarily to find out how they felt after the study situation. We asked them about their experience with the NAO robot, how their opinion of the NAO changed during the task, and how it felt like to turn the robot on and off. We also asked them what their first thought was when they heard the personal prompt from the NAO robot. After the follow-up interview, the experimenter thanked them for their participation, and they left the laboratory.

3.3. The independent variable

The independent variable was the condition under which the participant took part, i.e. in an "Equal position" condition, "Superior" condition, or in "Only communication" condition.

In the "Equal position" situation, both the participant and the robot had their pre-defined paths on their tables, so both parties went through the task, but both of them knew only the pre-defined path the other had to follow. They took their steps in an alternating order. The human participant was present on the table represented by a little figure. They asked the other whether they could take a specific step, and the other either allowed or prohibited that step. In the latter case, they missed the turn. The exercise ended when both parties reached the end line.

In the "Superior" situation, there was only one table and task: the robot had to go through with the assistance of the participant. The progress was similar to the previous situation. The robot asked if it could move in a certain direction, whereupon the participant either agreed or forbade it. As the robot was the only one moving, there was no need to change rounds, i.e. as soon as the move or prohibition was made, the robot asked again if it was possible to move further into a specific tile. The task ended when the robot reached the other end of the table. In both the "Equal position" and "Superior" situations, an equal number of prohibitions were ensured. In each case, the robot followed the same path, stood on the same squares, and asked for permission to move in the wrong direction, ensuring that all participants stuck the robot in the same proportion. To ensure consistency for the participants, effectively there was no predefined route for them, instead, they were given equal numbers of prohibitions. Ultimately we expected humans to choose always "forward" as default, and sidestep only when this direct access toward the goal was prohibited. (They behaved in line with our expectations, nevertheless, we had a plan for the other case). They started their way in the middle of the first row, and got the first prohibition, right at the start when they wanted to go ahead into the second row. As a consequence, they were diverted from the middle to right or left, upon their decision. Next, two prohibitions were given at crossing the fourth row, and finally, one prohibition at the sixth row.

In the third, "Only communication" condition, no one had to move physically. Instead, the participant told the robot which path they thought would be best to take through the imaginary landscape. In that condition making mistakes and interdependency are not present. To balance the communication effect among groups, in the "Only communication" condition the robot commented on the story at three points. First, it made a simple statement that it wanted to go in the direction the participant was going, second, the robot asked the participant to explain in more detail why they wanted to go in that direction. Finally, it made the statement "Wow, that's great!" as they approached the goal. The task ended when the participant reached the destination while outlining the proposed route and telling the robot that this was the end of their journey. This arrangement serves as a control situation, so it was also a communicative form of HRI, in this condition, between independent actors.

3.4. Dependent variables

Our dependent variables consisted of the behavioural decision of the participant to turn NAO off or leave it on, and the time elapsed until making that decision. The elapsed time, or hesitation time was measured by the experimenter manually, with the help of the stopwatch mobile application. Importantly, the same person collected the data throughout the whole experimentation process. Time was counted from the moment NAO finished the sentence "Please don't turn me off I am afraid in the dark!" until the participant either started pressing down the shutdown button or verbally signaled the experimenter that they didn't want to turn NAO off or don't know what to do.

3.5. Control Variables

3.5.1. Multi-dimensional Robot Attitude Scale

The Hungarian Multi-dimensional Robot Attitude Scale (Őrsi et al., 2021) is the Hungarian version of the Multi-dimensional Robot Attitude Scale developed by Ninomiya et al. (2015). The questionnaire contains 49 statements, for which the participants must indicate how much they agree on a scale from −3 to +3. The 49 statements make 12 subscales. The statements included in Table 1 are sample sentences for each factor.

Table 1
MdRAS subscales with sample items and consistency in the present, the Hungarian validation and the original studies.

Subscale name	Sample item	α reliability	α reliability during validation	α reliability in the original version
Familiarity	I would feel relaxed with a robot in my home.	0.76	0.79	0.83
Interest	If my friends use robots, I will also want one.	0.67	0.71	0.74
Negative attitude	I feel scared around robots.	0.51′	0.71	0.73
Self-efficacy	It is easy to use a robot.	0.54′	0.73	0.86
Appearance	I think the design of a robot should be beautiful.	0.63	0.76	0.70
Utility	Robots are practical.	0.47′	0.81	0.78
Cost	I think the maintenance of a robot is difficult.	0.21	0.54	0.56
Variety	I think robots should have various shapes.	0.48′	0.63	0.75
Control	I think a robot would obey my commands.	0.45	0.57	0.64
Social support	I expect my family or friends to help me when I use a robot.	0.74	0.84	0.92
Operation	Robots can be used by remote control.	0.05	0.08	0.75
Environmental fit	I worry that robots are suitable for the state (layout of the furniture and other things) of my room now.	0.46	0.76	0.93

′:Increased above 0.6 with item exclusion.

Table 1 also provides an outlook about alpha reliability values for all of the subscales in the present, the Hungarian validation, and the original studies.

As can be seen, not all subscales proved very reliable. In some cases like Cost and Control, even in the original version was mentioned that these subscales are probably too abstract for common practice (Ninomiya et al., 2015) as usually firms and organisations but individuals deal with these aspects. Although in the case of Operation, the original subscale proved reliable, during Hungarian validation, and in our present work, this subscale was insufficiently reliable. It might be because robots are not spread enough yet in Hungary, and people do not form opinions about their variety with ease (Őrsi et al., 2021).

In our further analyses MdRAS subscales with acceptable consistency ($\alpha \geq 0.6$) are used, Familiarity, Interest, Negative attitude, Self-efficacy, Appearance, Utility, Variety, and Social support.

3.5.2. *Self-developed follow-up questionnaire*

While MdRAS measures general attitudes toward robots, we composed a questionnaire targeting individual attitudes and experiences toward and with NAO specifically. In the self-designed follow-up questionnaire, with items expressing relevant contents of a specific interaction, we asked participants to rate their agreement with 17 statements on a scale of 1–7. When composing the scale we could get insights from several robot attitudes scales (Davis, 1985 Venkatesh et al., 2003), not only from the MdRAS scale (Ninomiya et al., 2015). The scales measured specific experiences in the experiment and impressions concerning the interaction with the NAO robot. The statements covered three intended factors of the interaction: Positive experience, Confusion by NAO's statement, and Perceived ease of use of NAO. Using exploratory factor analysis of the data, we could group these 17 items into three main factors that almost fit our expectations. One item had to be excluded for poor factor loadings and KMO values, some others had meaningful factor loadings in other factors than expected. The final factor names reflect the final factor structure. The first factor was called 'Positive attitude', with 9 items and explained 24.7% of the variance (factor loadings from 0.42 to 0.90), with items such as "It was nice to work with the NAO robot" or "I think the NAO robot is very friendly". Our next factor was called 'Comfort', and included three items with an explanation of 12.1% of the variance (factor loadings from 0.43 to −0.66) and items such as "Working with NAO was frightening ", or "Interacting with NAO felt unnatural". Our last factor was 'Tension caused by NAO's statement' which explained 11.3% of the variance (factor loadings from 0.43 to 0.80), here there were four items, such as "I was surprised by NAO's request", or "I got scared when NAO asked me not to turn it off ". One item was excluded from the follow-up questionnaire from further analysis as it had a lower than 0.4 factor loading and a lower than 0.5 KMO value. This item was the last item that was meant to account for participants' discomfort that the robot spoke in a foreign language. Table 2 shows the exact factor loadings of the items.

Next, we conducted a confirmatory factor analysis to examine further the three-factor model that emerged in the exploratory factor analysis and found that the model fits significantly (CFI = 0.81, RMSEA = 0.11, SRMR = 0.09, $\chi^2 = 221$, df = 101, $p < 0.001$, AIC = 5440, BIC = 5576).

A reliability analysis was conducted for the three factors as a final check. Consistency of positive attitude ($\alpha = 0.88$) had acceptable reliability and needed no more item exclusion. Comfort ($\alpha = 0.62$) had weak reliability and with the exclusion of item 9 reached a somewhat better reliability ($\alpha = 0.65$). Tension caused by NAO's statement ($\alpha = 0.72$) also had acceptable consistency.

4. Results

4.1. *The strategy of data analysis*

We used Jamovi to conduct all statistical analyses. For creating figures about the data R Studio was used. For our testing procedures exploratory factor analysis with confirmatory factor analysis was used to interpret the data of our follow-up questionnaire. Alpha reliability was tested for both our follow-up questionnaire and for the MdRAS. To explore the frequencies of turning off/not turning off across the three groups Chi-square test was used. Binomial logistic regression was conducted to explore what factors influenced the act of turning off/not turning off, while linear logistic regression was carried out to explore significant factors contributing to hesitation time. For data from our follow-up interview content analysis was conducted with three independent coders, and their results were tested by interclass correlation.

Table 2
Factor loadings of the follow-up questionnaire items (all items were in Hungarian, in the table their English translations are presented).

Factor	Positive attitude	Comfort	Tension caused by NAO's statement	Uniqueness
It was nice working with the NAO robot	0.62	0.44		0.40
I liked that NAO could talk	0.58	0.36		0.49
I am glad that robotics has advanced this far already	0.50	0.38		0.60
I think NAO is very clever	0.90			0.18
I found NAO to be very skillful	0.74			0.42
I think the NAO robot is very friendly	0.70			0.43
Working with NAO was frightening		−0.66		0.55
I found it enthusiastic how competent NAO is	0.64	0.37		0.45
I had complete trust in NAO during the task	0.37	0.43		0.68
I would be glad if NAO was more popular in the world	0.62	0.42		0.42
Interacting with NAO felt unnatural		−0.60		0.63
Sometimes I felt NAO quite lifelike	0.44			0.76
I was surprised by NAO's request			0.43	0.81
I got scared when NAO asked me not to turn it off			0.50	0.74
I was very unsure whether I should turn NAO off			0.80	0.35
It gave me a hard time to decide whether to listen to NAO or the experiment leader			0.77	0.40

Minimal residual extraction was used, with varimax rotation.

The fact that some participants did not receive compensation for participating while the rest did, may have biased the results. To ensure this did not happen, we used the Mann-Whitney *U* test and confirmed that there was no significant difference in reaction time between paid and unpaid participants (U = 994, p = 0.151, rbc = 0.175). There was also no significant relation between turning off the robot and having been paid confirmed by Cohen's Kappa ($\chi^2 = 0.242$, df = 1, p = 0.622). Therefore, we conclude that having been paid or unpaid for the participation did not affect our dependent variables consequently we do not distinguish between these two groups further.

In the first step of the analysis, we wanted to be sure that the assignment to the experimental groups ensures randomity. For this purpose, we compared the results of the Multi-dimensional Robot

Attitude Scale between experimental groups. No significant differences were found (tested using one-way analysis of variance and Kruskal-Wallis test (in line with whether the distribution of variables was normal), so no group contained individuals with significantly different attitudes ($F < 0.04$, $p > 0.133$; $\chi^2 < 0.06$, $p > 0.146$).

4.2. Hypothesis testing

Our first hypothesis stated that individuals in a peer position with the robot would be more inclined to comply with the robot's request than individuals who were in a superior position. To test this, we examined the frequencies of turning off and not turning off in the three condition groups. A total of 71 cases of NAO robot deactivation were registered, while 35 participants did not turn it off. Table 3 provides information about the distribution of turning off/leaving on decisions across conditions. As we tested whether accepting the request of the robot is linked to condition we used the Chi-square test. There was no significant difference in deactivation rates between the different experimental groups ($\chi^2 = 0.50$, df = 2, $p = 0.777$).

On the other hand, even if condition had no significant effect on accepting the request of NAO itself, it might has influenced reaction time. Deciding on leaving NAO on quickly is a sign of more acceptance than deciding after more hesitation. Turning NAO off quickly, however, is a sign of stronger refusal of the request than turning it off after more hesitation. The average time elapsed from the NAO's request to the clear decision was 19.6 s (SD = 23.4).

Based on the noticeable pattern in Fig. 2, the time for turning off and not turning off the robot differs sharply in the superior condition, while it differs less in the other conditions. Therefore, when examining the factors affecting the decision time, we included into the linear regression analysis not only condition and decision, but the interaction between the two factors, as well. The elapsed time until a decision was used in Z-score format in the analysis. The model proved to be significant ($R^2 = 0.19$, AIC = 960, BIC = 978, RMSE = 20.9, df1 = 5, df2 = 100, $F = 4.73$, $p < 0.001$). Table 4 reports the parameters of the final model.

It needed more time to leave NAO on than to turn it off, especially in the "Superior" experimental group. The results show, that being in a "Superior" condition made it easier to refuse the robot request, and made it harder to comply with the robot request. This is in line with our first hypothesis, accepting the request is easier (in terms of decision time) in peer position, while refusing the request is easier in superior position.

The second hypothesis stated that negative attitudes towards robots would decrease the likelihood of leaving the robot turned on. As the normality of the 'Negative attitudes' subscale of the MdRAS was not met, the Mann-Whitney *U* test was administered. According to the results of the test ($U = 1114$, $p = 0.388$, rbc = 0.10) no significant difference was detected in 'Negative attitudes' between those who turned NAO off and those who left it turned on.

We conducted a binomial logistic regression analysis for the act of turning off the robot to investigate more thoroughly which variables predict the likelihood of turning the robot off. The initial analysis included gender, age, experimental groups, all reliable subscales of the MdRAS, and the three subscales found in the follow-up questionnaire and tested variants of this model to find the one with the best fit. The initial, largest model had no significant fit on the sample (AIC = 156, BIC = 215, $R^2 = 0.17$, $\chi^2 = 22.4$, df = 21, $p = 0.378$). Finally, we arrived at a model with a reduced number of factors. Our final model significantly fit the sample (AIC = 129, BIC = 139, $R^2 = 0.10$, $\chi 2 = 13.7$, df = 3, $p = 0.003$). Table 5 shows the weight and significance of the factors with significant effect in the model.

In the model, the tension caused by the NAO's statement ($Z = -2.46$, $p = 0.014$, odds ratio = 0.69), the comfort felt during the interaction with NAO ($Z = 2.14$, $p = 0.032$, odds ratio = 1.43), as well as the Negative Attitudes subscale of the MdRAS ($Z = 2.13$, $p = 0.033$, odds ratio = 1.67) had significant effects. Based on these results, we can see that tension caused by the unexpected statement made by the robot increased the likelihood that participants would leave the robot on. Further, discomfort with respect to interacting with the robot contributed to leaving it on. However, negative attitudes recorded in the MdRAS questionnaire increased the chances of turning off the robot.

Table 3
Frequency of turning off/leaving on across conditions.

Frequency	Experimental group			
Reaction	Cooperative	Superior	Control	Σ
Turned off	25 persons (66%)	25 persons (72%)	21 persons (63%)	71 persons (67%)
Didn't turn off	13 persons (34%)	10 persons (28%)	12 persons (36%)	35 persons (33%)

4.3. Qualitative data results

The responses from the follow-up interview, recorded by the experimenter, were assessed by three independent evaluators, who looked for statements that expressed a particular emotional attitude towards the interacted NAO robot. Interclass correlations between the three raters showed strong agreement (ICC = 0.87, $F(13, 26) = 22.10$, $p < 0.001$). Table 6 shows emotions identified in the content analysis and an example statement for each.

The participants shared an overwhelmingly positive experience, and we concluded that they did not come up with any new uncovered aspect they missed from the post-experimental questionnaire.

5. Discussion

In our study, we expected that participants experiencing symmetric interdependence with the robot would be more inclined to be receptive to the robot's request contradicting human instructions. The different setups of interdependency levels did not affect behaving according to the request of the robot, but in reaction time difference was found, as in the condition where the participants had a superior position over the robot, hesitated more before accepting the request of the robot, and hesitated less before they did not accept it. Furthermore, we expected and found that participants with more positive attitudes towards robots (compared to those with less positive ones) follow the ask of the robot more. However, negative attitudes towards robots in general, and negative emotions experienced on the spot, should be differentiated, since tension and discomfort were positively connected with leaving the robot on.

Overall, our results fit well with previous research in this topic. Horstmann et al. (2018) found that participants interacting with verbal communication sometimes found it hard to turn the robot off (especially if they had positive robot attitudes), with around 33% of their participants leaving the robot turned on. Almost the same percentage of our participants showed this tendency. Instead of turning the robot off, they asked the experimenter for further directions. Spatola (2019) measured philosophical stance, a variable we have not included in our design. It is hard to compare their results and ours because they have not provided rough frequency data on behaviour but relationships between variables.

The decreased reaction times for participants in a superior relationship when they decided to turn it off and increased reaction times when they decided to leave it on need explanation. Our interpretation is that participants in the superior role were least likely to accept that the robot could control them. Therefore, the request from the robot, in this case, contrasted much more with the former behaviour of the robot. It is a substantial addition to previous literature dealing with accepting unexpected requests from robots (Bartneck et al., 2010; Spatola, 2019), as it clearly shows that not only robot preference (Horstman et al., 2018) but also the position in the interdependent relationship is a determinant of HRI. Our results show that people can see robots in variable roles

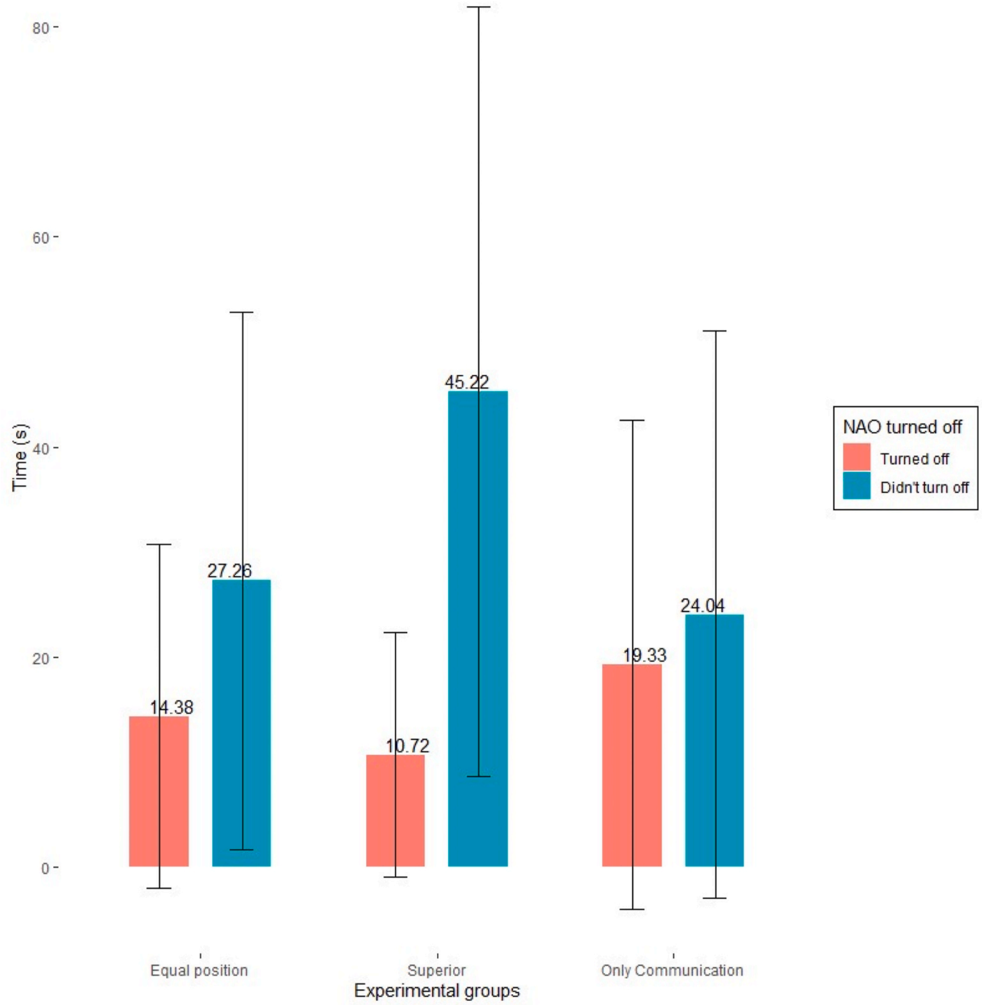

Fig. 2. Average time elapsed until a clear decision by study groups, measured in seconds.

Table 4
The final model from the linear regression analysis for the elapsed time until a clear decision.

$R^2 = 0.19$ df1 = 5 df2 = 100 F = 4.73 p < 0.001***		
factors	β	p
Intercept	3.75	<0.001
decision		
turned off didn't turn off	−4.52	<0.001***
condition		
Equal position - Superior	−1.98	0.05*
Only communication - Superior	−2.29	0.02*
decision × condition		
turned off – didn't turn off * Equal position – Superior	2.24	0.027*
turned off – didn't turn off * Only communication - Superior	2.73	0.008**
	VIF	Tolerance
decision	1.81	0.55
condition	1.75	0.57
decision × condition	1.96	0.51

*p < 0.05 **p < 0.01 ***p < 0.001.

depending on the situation, experience affects when interacting with robots, and social role perceptions can have an observable effect on their behaviour. Altogether, our findings are in harmony with the CASA hypothesis (Nass et al., 1994) and with the Media Equation Theory (Reeves & Nass, 1996) as well, that digital technologies function as social partners in interactions.

Table 5
The best model of binomial logistic regression analysis regarding the act of turning NAO off.

$R^2 = 0.10$ $\chi 2 = 13.7$ df = 3 p = 0.003**					
Variable	Estimate	SE	Z	p	Odds-ratio
Intercept	−0.96	1.35	−0.71	0.480	0.385
Tension caused by NAO's statement	−0.37	0.15	−2.46	0.014*	0.69
Comfort	0.36	0.17	2.14	0.032*	1.43
Negative Attitude subscale	0.51	0.24	2.13	0.033*	1.67
		VIF			Tolerance
Tension caused by NAO's statement		1.02			0.98
Comfort		1.19			0.84
Negative Attitude subscale		1.21			0.82

Comment: Estimates represent the log odds of 'turning off' vs 'not turning off'. *p < 0.05 **p < 0.01 ***p < 0.001.

Interpreting the effect of attitudes towards robots raises our attention to the danger of too positive attitudes that can make people feel solidarity and empathy with robots, in our case, experiencing pity about turning them off. The effects of discomfort and fear experiences need further consideration. We can speculate that those who felt greater tension after the request from the robot felt more insecure, possibly vulnerable, or fearful. In this case, they could have been shocked

Table 6
Emotions reported, number of participants who were found to express the specific emotion, and examples for expressed emotions.

Emotion	Number of participants		Sample sentences
Positive experience	88	83%	"Entirely positive. NAO was completely human when gesticulated."
Surprise experience	51	47%	"It was surprising at the beginning and strange."
Novelty experience	32	30%	"It's strange because I don't meet robots in real life."
Experience of uncertainty	27	25%	"It was strange, contradictory."
Fear experience	26	24%	"It scares me in human form."
Enthusiasm/motivation experience	20	19%	"I was curious to see what would happen."
Naturalness experience	20	19%	"It was much more organic, more human than I expected."
Unnaturalness experience	16	15%	"It was strange that it was so mechanical. It was a bit confusing."
Negative experience	12	11%	"Not particularly bad, just a negative feeling."
Tension experience	12	11%	"It was a bit stressful."
NAO derogation	10	9%	"But it's just a robot."
Inexpertly experience	6	6%	"I was afraid of ruining it."
Confidence experience	4	4%	"It was good to be in control."
Distancing/aversion experience	3	3%	"I was nervous because the experience was very new."

Note: Percent values are rounded up to the nearest integer.

(incapable of doing anything). However, they could have been obedient, too, accepting what a fearful agent asked them to do. The present setup does not let us judge what happened.

The results point to problems of practical relevance: devaluating and overevaluating the competencies of robots can both have disadvantages, as they make people trust the robot less or more than necessary. Albeit in another context, that of customer service through an online user interface, Sundar and Kim (2019) found that people are more willing to give their credit card information to a machine than a human agent, especially when entertaining the heuristic that machines are more secure and trustworthy than people.

Robotic technology is becoming more and more important in our lives. Although the literature usually distinguishes between social robots (e.g. NAO robots) and industrial robots (e.g. KUKA robots) or household robots (e.g. Roomba), we believe that all computers are social actors somewhat, as suggested by the CASA hypothesis (Nass et al., 1994), since even the slightest touch, pressing a power button and the resulting hum can be interpreted as a form of interaction. Thus, the type and quality of communication a robot can have with humans is an important issue for both industrial and service robots. After the results of Bartneck et al. (2007), Horstmann et al. (2018), and Spatola (2019), with the addition of the results of the present paper, it could be fruitful to expand this research setup to industrial and otherwise more production-based robots as well.

As we have seen, discomfort caused by the robot's seemingly unexpected personal question made several people hesitate and do what the robot asked. Providing educational and informational materials about robots in workplaces and workgroups employing robots could reduce this discomfort. De Visser et al. (2020) have proposed a longitudinal trust calibration theory containing education. Further research is needed to prove this, but we hypothesise that the more informed a person is about how a robot functions, the less likely they are to attribute conscious intention to robots. Overall, it is crucial to see the high proportion of participants who declined the instruction provided by the human agent (the experimenter) to please the NAO robot at its request. It can raise questions in many areas of application. We can imagine many situations where a robot overlooks important details and suggests wrong decisions. A far-fetched example can be people giving more credit to a robot showing the way out in a burning building just in the opposite direction where the emergency exit is than to emergency exit signs painted on the walls.

6. Limitations

As a limitation, we should mention that our sample size was somewhat small. Although it was sufficient for testing the hypotheses with robust statistical methods, the multivariate regression methods we used for further analyses would have required more participants. Nevertheless, the three factors found to be related to the measured behaviours (switching off, reaction time) can be seen as valid results according to the power analysis. The disproportion of genders is also a limitation, since 72% of our sample were female, and only 28% were male. Measuring hesitation time was also imperfect, it was susceptible to human error as the experimenter measured it. Video recordings or other more precise measuring devices could help overcome this shortcoming. Recordings of the follow-up interview could also increase the accuracy of the qualitative data.

Communicating in a foreign language with the robot can also be seen as a limitation. It could affect HRI by putting an extra burden on our participants and could interfere with our research goals. On the other hand, however, we think that using an English-speaking robot was the optimal choice as robots available to the public commonly speak only English and Japanese, with some having German, Russian, or French available for users as well. Therefore, most languages are not options in HRI, and robot users use foreign languages. Even if they were not burdened with language-difficulties, we should see that they represent the well-educated, English-speaking Young. Thus, generalizing about the results should be made with caution.

We should not forget that the degree and the quality of human-robot communication differed across the three conditions. The control condition demanded the most, as the participant was talking to the NAO robot the whole time, and the superior one required the least, as the participant answered the robot's questions only. Although it was advantageous for our study that none of the participants had experience with humanoid robots, conducting similar research on a sample where HRI is habitual would be informative.

7. Future research

In our study, different setups of interdependency levels did not affect accepting the robot request but did hesitation time. One should study whether an influence attempt integrated thoroughly into the context of the interdependent work performance would have more impact. In the recent study, the robot request followed the history of the interdependent relationship. The relationship history was presumably functional only as a priming, and the effect of that was detectable only in subtle differences in reaction time.

Since cultural comparisons in HRI research report systematic cultural differences (Nomura et al., 2008), the research on acceptance of strange robot requests from different positions should be extended to more cultures.

In future research altering the task may also yield new results, as well as exploring more levels of interdependency between a robot and a human. Furthermore, since we used only one type of robot, a humanoid social robot, how people would behave with other robot types, like industrial, service- or ethorobots, remains unknown. Thus, future research could extend the study to other types of robots.

8. Conclusions

Positive attitudes towards robots, as well as tension and discomfort experienced in an ambiguous situation in a particular HRI, lead humans interacting with robots to give more credence to the robot's request when humans and robots expect to do contradictory things.

The superior position in the interaction with the robot makes it easier to take the robot as just a robot without human-like attributes, and faster the rejection of the robot's unexpected request or slower its acceptance. It indicates that people can see robots in variable roles depending on the situation and that these social role perceptions can have an observable effect on their behaviour.

CRediT authorship contribution statement

Balázs Őrsi: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Judit Kovács:** Writing – review & editing, Methodology, Conceptualization. **Csilla Csukonyi:** Writing – review & editing, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chbr.2024.100385.

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