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Aversion against machines with complex mental abilities: The role of individual differences

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ABSTRACT

Theory suggests that robots with human-like mental capabilities (i.e., high agency and experience) evoke stronger aversion than robots without these capabilities. Yet, while several studies support this prediction, there is also evidence that the mental prowess of robots could be evaluated positively, at least by some individuals. To help resolving this ambivalence, we focused on rather stable individual differences that may shape users' responses to machines with different levels of (perceived) mental ability. Specifically, we explored four key variables as potential moderators: monotheistic religiosity, the tendency to anthropomorphize, prior attitudes towards robots, and the general affinity for complex technology. Two pre-registered online experiments (N_1 = 391, N_2 = 617) were conducted, using text vignettes to introduce participants to a robot with or without complex, human-like capabilities. Results showed that negative attitudes towards robots increased the relative aversion against machines with (vs. without) complex minds, whereas technology affinity weakened the difference between conditions. Results for monotheistic religiosity turned out mixed, while the tendency to anthropomorphize had no significant impact on the evoked aversion. Overall, we conclude that certain individual differences play an important role in perceptions of machines with complex minds and should be considered in future research.

1. Introduction

With the recent release of new *Generative AI* (such as *ChatGPT*; OpenAI, 2024), public debate on machines that demonstrate nearly human-like mental capabilities has been (re-)invigorated. Reactions to these emerging technologies range from techno-optimism and euphoria to skepticism, uncertainty, or even fear (e.g., Pentina et al., 2023; Wang & Wang, 2022). Also, as new AI-powered abilities will likely keep advancing in the future, it needs to be considered that complex artificial minds might not remain limited to bodiless web interfaces, but also get inserted into physical or even human-like bodies—i.e., become part of robots, with powerful new use cases and domains of application.

Arguably, these current and prospective developments play into an on-going scientific discussion on how complex (or even seemingly human-like) minds in machines are perceived by observers (Bryndin, 2020; Hildt, 2019). Broadly speaking, scientific research has shown that individual reactions towards machines with human-like attributes are often cautious or at least somewhat ambivalent (Dang & Liu, 2021; Gnambs & Appel, 2019; Stapels & Eyssel, 2022). As one of the first models acknowledging this pattern, the *uncanny valley* by Mori (1970) states that human reactions towards machines with human-like appearances grow increasingly positive until, at a very high yet still imperfect level of human likeness, a steep drop in observers' evaluations occurs. Furthermore, researchers have suggested that a new dimension of the uncanny valley has been unfolding in recent years, which was termed the *uncanny valley of mind* (Stein & Ohler, 2017); specifically, it has been argued that user aversion may also increase if a machine's perceived *mental capabilities* become too human-like.

Due to the fascinating and rapid progress in the development of artificial intelligence, this perspective clearly warrants further attention. To make a valuable contribution in this regard, the current project set out to explore several individual differences that could moderate people's aversion against seemingly mindful (vs. mindless) machines, in particular AI-powered robots. This way, we echo prior work by MacDorman and Entezari (2015), who explored the influence of individual differences on classic uncanny valley effects (i.e., on the aversion created by a robot's appearance). Based on a literature review, we expected four key variables to influence the eeriness evoked by machines

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with advanced, human-like minds: monotheistic religiosity, tendency to anthropomorphize, negative attitudes towards robots, and technology affinity.

1.1. Uncanny valley (of mind)

The uncanny valley has received substantial attention in recent years (Mori, 1970; for recent reviews, see Diel et al., 2022; Mara et al., 2022). Several theories have been proposed to explain the hypothesized drop in user responses towards machines with highly human-like features, such as mental categorization conflicts, novelty avoidance, culture, or even a possible connection to perceptions of psychopathy (e.g., Diel & MacDorman, 2021; MacDorman et al., 2009; MacDorman & Ishiguro, 2006; Ramey, 2005). At the same time, scholars have frequently discussed whether the suggested N-shape of the uncanny valley graph truly captures the empirical reality—and whether it could ever be possible to exit the valley on its other side (i.e., with machines that are human-like enough to evoke positive reactions again; e.g., Bartneck et al., 2007; Poliakoff et al., 2013). At least for the time being, scholars have noted that hardly any of the robots involved in current research appeared human-like enough to actually examine the hypothesized ascent out of the uncanny valley (Mara et al., 2022).

Meanwhile, other explanations have emerged in order to account for people's negative responses towards social machines and robots, with a focus on their (AI-powered) mental abilities (Stein & Ohler, 2017). Empirical evidence on this *uncanny valley of mind* hypothesis indeed supports the idea that machines expressing human-like mental capabilities—in terms of *agency* (i.e., self-control, morality, memory, planning, communication, and thought) and/or *experience* (i.e., the ability to feel emotions and to have a personality; Gray et al., 2007)—are often perceived as eerie by observers (for robots: Appel et al., 2020; Gray & Wegner, 2012; for smart speakers: Taylor et al., 2020; for autonomous cars: Li et al., 2022). Just as for the traditional uncanny valley, however, it remains unclear whether such an uncanny valley of mind will actually be overcome (e.g., Grundke et al., 2023; Yam et al., 2021)—as there are arguably no existing machines reaching the necessary threshold of mental prowess. Thus, similar to the classic uncanny valley graph, the related uncanny valley of mind is typically used to illustrate an initial decline of user responses at medium-to-high levels of mental ability in machines—pending an eventual return to positive reactions towards more advanced machines in the future. In this vein, the starting point of our research is:

H1. A robot with human-like mental capabilities evokes higher eeriness than a robot without human-like mental capabilities.

At the same time, there is also some evidence suggesting that high mental prowess in robots can be evaluated positively (Grundke et al., 2023). Likewise, a moderate degree of anthropomorphism and mind attributed to robots was found to have a positive influence on trust (Waytz et al., 2014), perceptions of morality (Young & Monroe, 2019), or assigned usefulness (Liu & Liao, 2021). Faced with these heterogenous findings, there is an urgent need to understand which factors shape users' potential aversion against complex machines; and arguably, individual attitudes and dispositions might offer a most reasonable starting point.

1.2. Individual differences in the perception of machines

The current project was inspired by research on the traditional uncanny valley, which connected negative evaluations of technology to several traits and states within observers. Specifically, previous studies highlighted factors such as the Big Five personality dimensions, trait anxiety, religious concerns, the sensitivity to be reminded about humanity's animalistic nature, a tendency to feel wary of mistakes, and a need for structure, connecting all of them to an individual level of *uncanny valley sensitivity* (Lischetzke et al., 2017; MacDorman & Entezari, 2015; von der Pütten et al., 2010).

Yet, stepping from uncanny valley to uncanny valley *of mind* research, investigations on the influence of individual differences remain rare. To our knowledge, there is only one contribution that examined how user variables affect the perception of human-like robot minds: Grundke et al. (2022) showed that agreeableness predicted a more positive response towards both thought- and emotion-*detecting* robots, while conscientiousness diminished the difference between the two. However, this work addressed a very narrow research gap and explored hypothetical robot capabilities that are not expected to be put into practice in the near future. Also, considering the current debate on new AI-powered means of artistic and emotional expression by machines, it seems more important to focus on technology that is able to *express* itself via advanced mental abilities (instead of detecting it in humans). To address this remaining research gap, we circled in on several key variables that we considered particularly relevant with regards to the uncanny valley of mind. First, our literature review revealed two sorts of variables as discussed by MacDorman and Entezari (2015), for which it appeared likely that they might also affect the eeriness evoked by a machine's mental capabilities: variables that address the perception—and limits—of the human experience, and those that revolve around users' tech-related attitudes. For the first category, we explored monotheistic religiosity and the individual tendency to anthropomorphize (i.e., to ascribe human likeness to non-living things). For the second category, we concentrated on pre-existing negative attitudes towards robots, as well as broader technology affinity as a potential protective factor. In the following sections, we will introduce each of these constructs, as well as our rationale of including them as promising explanatory variables.

1.2.1. Monotheistic religiosity

In their seminal paper on the uncanny valley of mind, Stein and Ohler (2017) proposed that a key reason for the emerging aversion against sophisticated machines might be that they challenge human identity as the "pride of creation" (p. 45), especially in Western countries. Arguably, this matches insight from intercultural research, which suggests that Eastern cultures influenced by Buddhism and Shintoism might see fewer problems with machines being equipped with human-like abilities (e.g., Castelo & Sarvary, 2022), or even possessing their own "spirit" (Borody, 2013; Gee et al., 2005).

Indeed, the interplay between machine-related acceptance and religion remains a core topic of several research fields, including human–computer and human–robot interaction (Ahmed & La, 2021; Trovato et al., 2021). Generally speaking, it is assumed that individuals with strong monotheistic religious beliefs see humanity as more elaborate (or deserving) than creations from other ontological categories (MacDorman et al., 2009; Vail et al., 2010; Vess et al., 2012), which could explain why the notion of human-like, AI-powered machines evokes unpleasant feelings of threat among this demographic (MacDorman & Entezari, 2015; Stein et al., 2019). As such, we see it as likely that people with strong beliefs in a monotheistic religion experience higher feelings of eeriness when thinking of sophisticated machines, i.e., robots. While we anticipate that this individual factor will predict a stronger aversion against robots in general, we further assume that it elicits a particularly strong aversion against robots with highly complex, human-like abilities—as these present an even greater threat to humanity's distinctiveness.

H2. The stronger an individual's monotheistic religiosity, the more they experience eeriness in response to a robot.

H3. Monotheistic religiosity accentuates the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.

1.2.2. Tendency to anthropomorphize

Anthropomorphism describes a fundamental attributional mechanism in that real or imagined non-human entities and objects can be perceived to have human-like characteristics, features, or mental states (e.g., a face in the clouds, a car having its own will, or a smart speaker having its own personality; see Epley et al., 2007). Crucially, people differ in their tendency to anthropomorphize (Salles et al., 2020; Waytz et al., 2010). In turn, this interindividual inclination is believed to play an important role during human-machine interactions (Canning et al., 2014; Lu et al., 2019; Pelau et al., 2021; Wan & Aggarwal, 2015). Overall, it can be assumed that a higher tendency to anthropomorphize is linked with rather positive robot evaluations (e.g., Li & Suh, 2021; Roesler et al., 2021), just as it has been found to improve attitudes towards artificial intelligence (Li & Sung, 2021). Based on both of these findings, we expect that people with higher anthropomorphization tendencies perceive robots as less eerie in general, and also show lower aversion against those with sophisticated, AI-powered mental abilities:

H4. Participants with a higher (vs. lower) tendency to anthropomorphize perceive robots to be less eerie.

H5. A high tendency to anthropomorphize reduces the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.

1.2.3. Negative attitudes towards robots

Striving to explain why some people feel more biased towards robots than others, Nomura et al. (2006) discussed the notion of a dispositional 'negativity' towards robots, highly domain-specific attitudes that may arise from the social influence and displayed emotionality of modern robotic machinery. This influential research also yielded a corresponding measurement, which has since become well-established in human–robot interaction studies (i.e., the *Negative Attitudes Towards Robots Scale*, or NARS). In MacDorman and Entezari's (2015) exploration of people's sensitivity towards uncanny valley effects, for example, NARS scores emerged as a positive predictor of observers' experienced eeriness and as a negative predictor of perceived robot warmth. Additionally, other work connected this negative, domain-specific attitude to less enthusiastic evaluations of particular robots, including those with advanced mental abilities (Grundke et al., 2022; Kaplan et al., 2019; Liberman-Pincu & Oron-Gilad, 2022). With the increasing integration of AI into robotic platforms, the question arises to what extent negative attitudes towards robots (as assessed by the NARS) predict aversive responses to all kinds of robots—or if the concept's predictive value focuses more specifically on those machines with certain mental abilities. Based on our reading of the literature, we assume that robots who perform advanced, human-independent operations are the focal attitude object when it comes to this attitudinal variable. Hence, given that experience and agency serve as underlying abilities of human-independent operations (Gray et al., 2007), people's negative attitudes towards robots should be especially predictive of the eeriness ascribed to robots with minds than to robots without minds.

H6. Participants with more (vs. less) negative attitudes towards robots perceive robots to be eerier.

H7. Negative attitudes towards robots accentuate the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.

1.2.4. Technology affinity

Recent research on AI and related technologies shows that educating people about the workings of the respective system could reduce pre-existing concerns and even contribute to an increased use of the technology (see also *Explainable AI*; Querci et al., 2022). In turn, this increased use could then mitigate prior negative attitudes or emotions, as exposure to a technology allows information to be gathered first-hand and concerns to be weighed (Cardello, 2003). Along the same lines, Franke et al. (2019) drew a parallel between the trait *need for cognition* (i.e., the necessity to resolve inconsistencies by reflecting upon them) and a concept they called *technology affinity*. They proposed that a high need for cognition culminates in high technology affinity as both involve a desire to deal with complex and unfamiliar topics, as is the case with new, modern-day technologies. Subsequent research highlighted a positive influence of technology affinity on robot acceptance (Babamiri et al., 2022; Bröhl et al., 2019; Ozturk et al., 2016). Based on these findings, it can be assumed that technology affinity will be linked with a more positive evaluation of robotic machines. Since robots with advanced minds are, arguably, even more complex and potentially puzzling to observers than those without the respective abilities, we further assume that technology affinity (as a proxy of domain-specific need for cognition) alleviates the uncanny valley of mind:

H8. Participants with higher (vs. lower) technology affinity perceive robots to be less eerie.

H9. Technology affinity reduces the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.

In the following, we report the results of two experiments that scrutinized our hypotheses, using a German-speaking convenience sample and a stratified *Prolific* sample of US Americans (the latter is stratified across age, sex, and ethnicity, based on census data from the US Census Bureau). The experiments were pre-registered (Experiment 1: https://aspredicted.org/7Q9_91D; Experiment 2: https://aspredicted.org/49N_KCM) and data, codes, and materials are available in our Open Science Framework repository (https://osf.io/8wx6j).

2. Experiment 1

2.1. Method

To test the pre-registered hypotheses, an online study was conducted in which participants were either informed about a robot that could demonstrate human-like mental capabilities or about a robot without such capabilities, i.e., a simple "tool robot." As such, the study followed a between-subjects design, with participants randomly assigned to one of two conditions.

2.1.1. Participants

To calculate the required sample size for our first experiment, we consulted a previous study by Appel et al. (2020) to obtain a target effect size. Specifically, we used data from the study's second experiment, which had compared eeriness perceptions for a *tool robot* vs. an *experience robot* in an unspecified context. Based on the given data, an anticipated effect size of $d = 1.08$ was calculated. Using this value, a power analysis with G*Power (Faul et al., 2007) left us with an aspired sample size of $n = 48$ for a two-group main effect (two-tailed independent t-test, power = 0.95, alpha-error-probability = 0.05). To account for the more complex design and the power needed to identify an interaction effect, we multiplied this sample size by the factor eight (Giner-Sorolla, 2018; Simonsohn, 2014), leading to a proposed minimum sample size of 384. We recruited 461 participants to have a buffer if careless responding occurred. The questionnaire was distributed in chat groups and via social media, and participation was voluntary. We followed several recommendations by Kennedy et al. (2020) to identify careless responding in online surveys. In line with the pre-registration, participants who did not meet one of the criteria were excluded from the data analysis. Of the 450 final completions, six participants were excluded as they showed large deviations (> ±3 years) when asked twice about their age at different points of the survey, one additional participant was found to be younger than 18 years, which was our previously communicated lower age limit for participation. Four participants did not answer a control question on the name of the presented robot correctly. Eight participants indicated in a self-report item that they did not respond to the questions conscientiously. We used a treatment check item asking participants whether the robot had been described with or without elaborate mental abilities. Thirty-three participants were excluded due to giving a wrong answer to this question. Lastly, seven additional individuals had to be excluded based on their answering duration (< 250 s), which was screened via a normal distribution diagram of processing times. Hence, the final sample consisted of 391 participants (240 female, 149 male, 2 non-binary or no answer) with an average age of 29.63 years (SD = 12.45, ranging from 18 to 84 years).

2.1.2. Stimuli and procedure

Participants were asked to give informed consent before our assessment of the chosen individual difference variables took place, including scales for monotheistic religiosity, the tendency to anthropomorphize, negative attitudes towards robots, and technology affinity. After that, participants were exposed to the experimental manipulation (see Appendix for an English translation of the stimulus materials; for the original German version, please consult the online supplement). Following prior research in this field (Appel et al., 2020; Gray & Wegner, 2012; Grundke et al., 2023; Ward et al., 2013), we introduced participants to robots with different degree of mental capabilities via a text vignette method, using two different versions. One text described the robot as a *tool robot* managing its everyday tasks without any complex mental capabilities. In contrast, the other text described the *robot with mind* as being able to feel and think based on complex AI technology. Hence, concurring with previous studies (e.g., Appel et al., 2020; Gray & Wegner, 2012; Taylor et al., 2020), we designed the mindful condition by equipping a robot with both high levels of agency and experience. We explicitly avoided framing either robot as a real or a hypothetical machine—instead, participants were simply instructed to “read the following text about a robot” and to “imagine all of its capabilities.”

Next, perceived eeriness as our focal outcome was assessed, followed by the treatment check, several attention check and control items, and questions on sociodemographic data. In the end, participants were thanked and debriefed. The participants had the possibility to take part in a lottery (four prizes, 10€ each). The median processing time was 539 s.

2.1.3. Measures

Unless indicated otherwise, all items were translated to German and independently back-translated to guarantee an adequate translation (see Brislin, 1970). All items were presented on 7-point Likert scales.

Eeriness. Users' feelings of eeriness in response to the described robot were measured with the help of three items (“uneasy”, “unnerved”, “creeped out”) based on previous research (Gray & Wegner, 2012), Cronbach's α = .89.

Monotheistic religiosity. This variable was assessed with the twelve-item scale by Altemeyer and Hunsberger (2004; e.g., “God has given humanity a complete, unfailing guide to happiness and salvation, which must be followed completely”), Cronbach's α = .88. Specifically, this scale captures the strength of participants' beliefs in religious teachings that focus on a singular instance of divine goodness as well as opposing forces of evil. As such, it covers beliefs that may be found in many monotheistic religions, including Christianity, Judaism, or Islam.

Tendency to anthropomorphize. This variable was assessed with twelve items (e.g., “To what extent does a car have free will?”) as provided by the scale by Waytz et al. (2010), Cronbach's α = .81.

Negative attitudes towards robots. This variable was assessed with the eponymous scale by Nomura et al. (2006), which includes 14 items (e.g., “I feel that in the future society will be dominated by robots”), Cronbach's α = .84.

Technology affinity. This variable was assessed with the scale by Franke et al. (2019) and its nine items (e.g., “I like to occupy myself in greater detail with technical systems”), Cronbach's α = .92. As the original version of the scale already provided a German translation, we used it in this form.

Manipulation Check. To check whether participants indeed perceived the robot that was described to have complex AI-powered capabilities to have more agency and experience than the robot described as a simple tool robot, four items by Gray and Wegner (2012) were used (e.g., “This robot has the capability to exert self-control”), Cronbach's α = .91.

Treatment Check. After reading the assigned vignette text, participants were asked to indicate which condition they had been assigned to as a means to control their attention (“*Please select the robot you were informed about:* 1) robot with mental capabilities: „Ellix, a robot that is equipped with AI and can act and feel independently“; 2) robot without mental capabilities: “Ellix, a robot that is programmed by humans and solely follows their instructions"). This item served as a pre-registered exclusion criterion.

2.2. Results

2.2.1. Preliminary analyses

As a manipulation check (via four items by Gray & Wegner, 2012, see above), we analyzed whether the robot with alleged mental capabilities ($M = 5.36$, $SD = 1.20$) was indeed perceived as more mindful than the robot without mental capabilities ($M = 1.85$, $SD = 0.98$), $t(389) = 31.63$, $p < .001$, $d = 3.20$. Based on these results and the very high effect size, the conducted manipulation was deemed successful. Next, the requirements for the regression approach used to test Hypotheses 2 through 9 were checked and regarded as fulfilled. Please see Table 1 for descriptive statistics of the variables measured in Experiment 1.

2.2.2. Main analyses

In support of Hypothesis 1, the robot with mental capabilities (M = 3.38, SD = 1.66) was perceived to be significantly eerier than the robot without mental capabilities ($M = 1.91$, $SD = 1.21$), $t(389) = 9.97$, $p < .001$, $d = 0.98$. Subsequently, our planned regression analyses were conducted with SPSS software, whereas the PROCESS macro (Hayes, 2018) was used to analyze significant interactions with the Johnson-Neyman technique. Descriptive statistics can be found in Table1, zero-order correlations of the included study variables can be found in Table 2.

In the following hierarchical regression analyses, robot condition (dummy-coded: 0 = robot without mind; 1 = robot with mind) was entered in the first step. One of the four supposed moderator variables (z-standardized) was entered in the second step. Finally, the interaction term between the moderator variable and robot condition was entered in a hierarchical regression model with eeriness as the criterion. Table 3 shows the results of the four resulting equations.

Monotheistic religiosity did not differ between the robot conditions, $t(389) = 0.94$, $p = .347$. According to Hypotheses 2 and 3, we expected a main effect and an interaction effect of monotheistic religiosity on eeriness. Based on the data presented in Table 3, we observed a significant main effect (monotheistic religiosity increases the eeriness ascribed to either robot), leading to an acceptance of Hypothesis 2. Hypothesis 3 was not supported, as the interaction term did not reach significance.The tendency to anthropomorphize did not differ between the robot conditions, $t(389) = 0.45$, $p = .650$. Focusing on the results of our second hierarchical regression analysis, a higher tendency to anthropomorphize was not found to be associated with reduced eeriness, so Hypothesis 4 had to be rejected. Furthermore, as also reported in Table 3, the interaction effect did not reach statistical significance, so Hypothesis 5 was not supported. Negative attitudes towards robots did not differ between robot conditions, $t(389) = 0.63$, $p = .526$. Based on the third regression analysis, Hypothesis 6 (negative attitudes towards robots increase the eeriness ascribed to either robot) can be supported. In addition to the main effect, we observed a significant interaction

Table 1
Descriptive statistics of measured variables in Experiment 1.

Variables	Full sample (N = 391)			*Robot with mind* condition (n = 196)	*Robot without mind* condition (n = 195)
	M (SD)	*Skewness*	*Kurtosis*	*M (SD)*	*M (SD)*
Eeriness	2.65 (1.63)	0.72	−0.54	3.38 (1.66)	1.91 (1.21)
Monotheistic religiosity	2.03 (1.02)	1.67	3.20	2.00 (0.91)	2.07 (1.11)
Tendency to anthropomorphize	3.15 (0.88)	0.22	−0.25	3.13 (0.84)	3.17 (0.93)
Negative attitudes towards robots	3.97 (0.99)	0.04	−0.54	3.93 (0.97)	4.00 (1.02)
Technology affinity	4.17 (1.39)	−0.13	−0.88	4.21 (1.38)	4.14 (1.40)

Table 2
Zero-order correlations of measured variables in Experiment 1.

	1	2	3	4	5
1. Eeriness	–	.15[b]	.05	.43[b]	−.17[b]
2. Monotheistic religiosity		–	.04	.14[b]	−.03
3. Tendency to anthropomorphize			–	.10[a]	−.05
4. Negative attitudes towards robots				–	−.47[b]
5. Technology affinity					–

[a] $p < .05$.
[b] $p < .001$ (two-tailed).

between participants' NARS scores and the robot condition (see Fig. 1), which was further examined using the PROCESS macro for SPSS (Hayes, 2018). Follow-up analyzes (Aiken & West, 1991) revealed that participants who had low negative attitudes towards robots (−1 *SD*) perceived the robot with apparently mental capabilities to be significantly eerier than the robot without mental capabilities, $B = 1.07$, $SE = 0.18$, $t(389) = 5.97$, $p < .001$, 95% CI [0.72, 1.42], just as participants with very high scores in this variable (+1 SD) did—although, importantly, the rating difference turned out even stronger in this case, $B = 1.96$, $SE = 0.18$, $t(396) = 10.96$, $p < .001$, 95% CI [1.61, 2.32]. According to the Johnson-Neyman technique, manipulating mental capabilities significantly affected participants' perceived eeriness for z-standardized

Table 3
Results of the hierarchical regression analyses per moderator variable in Experiment 1.

		B	SE	t	p	R^2	ΔR^2
Monotheistic religiosity							
Step 1	Constant	1.91	0.10	18.33	<.001	.203	.203[a]
	Robot Condition	1.47	0.15	9.97	<.001		
Step 2	Constant	1.90	0.10	18.50	<.001	.232	.029[a]
	Robot Condition	1.50	0.14	10.31	<.001		
	Monotheistic religiosity	0.28	0.07	3.81	<.001		
Step 3	Constant	1.90	0.10	18.49	<.001	.233	.000
	Robot Condition	1.50	0.15	10.30	<.001		
	Monotheistic religiosity	0.25	0.09	2.68	<.001		
	Monotheistic religiosity × Robot Condition	0.06	0.15	0.41	.679		
Tendency to anthropomorphize							
Step 1	Constant	1.91	0.10	18.33	<.001	.203	.203[a]
	Robot condition	1.47	0.15	9.97	<.001		
Step 2	Constant	1.91	0.10	18.33	<.001	.208	.004
	Robot condition	1.47	0.15	10.01	<.001		
	Anthropomorphism	0.11	0.07	1.43	.154	.214	.006
Step 3	Constant	1.91	0.10	18.35	<.001		
	Robot condition	1.47	0.15	10.03	<.001		
	Anthropomorphism	0.22	0.10	2.24	.026		
	Anthropomorphism × Robot condition	−0.26	0.15	−0.76	.080		
Negative attitudes towards robots							
Step 1	Constant	1.91	0.10	18.33	<.001	.203	.203[a]
	Robot condition	1.47	0.15	9.97	<.001		
Step 2	Constant	1.89	0.09	20.80	<.001	.398	.195[a]
	Robot condition	1.51	0.13	11.81	<.001		
	Negative attitudes towards robots	0.72	0.06	11.21	<.001		
Step 3	Constant	1.89	0.09	21.18	<.001	.417	.019[a]
	Robot condition	1.52	0.13	11.99	<.001		
	Negative attitudes towards robots	0.51	0.09	5.81	<.001		
	Negative attitudes towards robots × Robot condition	0.45	0.13	3.54	<.001		
Technology affinity							
Step 1	Constant	1.91	0.10	18.33	<.001	.203	.203[a]
	Robot condition	1.47	0.15	9.97	<.001		
Step 2	Constant	1.90	0.10	18.62	<.001	.237	.033[a]
	Robot condition	1.48	0.14	10.27	<.001		
	Technology affinity	−0.30	0.07	−4.11	<.001		
Step 3	Constant	1.91	0.10	18.97	<.001	.262	.025[a]
	Robot condition	1.48	0.14	10.43	<.001		
	Technology affinity	−0.04	0.10	−0.40	.687		
	Technology affinity × Robot condition	−0.52	0.14	−3.63	<.001		

Note. All continuous predictors were z-standardized; N = 391.
[a] dummy-coded (0 – robot without mind; 1 – robot with mind).
[a] $p < .001$.

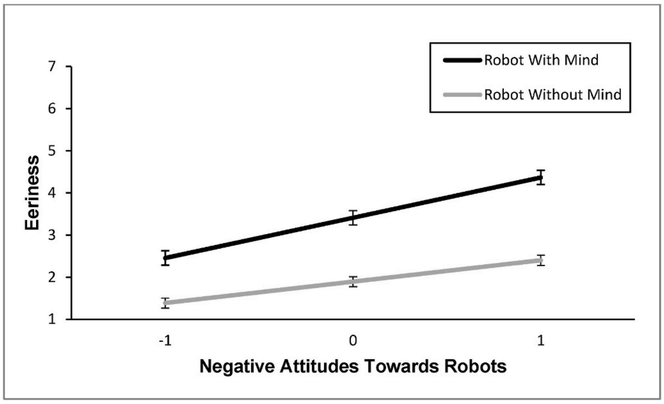

Fig. 1. Interaction between robot group and negative attitudes towards robots in Experiment 1.
Note. Error bars represent ± 1SE.

values ≤ −2.09 of negative attitudes towards robots. About 98.98% of our participants fell into this significant region. As such, Hypothesis 7 could be supported.

As was the case for all the other individual difference variables, technology affinity did not differ between robot conditions, $t(389) = -0.48, p = .634$. The main effect postulated in Hypothesis 8 (technology affinity reduces the eeriness ascribed to either robot) indeed turned out significant so that the hypothesis is supported (see Table 3). Furthermore, a significant interaction was observed for the moderator variable technology affinity (see Fig. 2). Follow-up analyzes (Aiken & West, 1991) revealed that participants who were low in technology affinity (−1 *SD*) perceived the robot with mental capabilities to be significantly eerier than the robot without mental capabilities, $B = 2.00$, $SE = 0.20$, $t(389) = 9.94$, $p < .001$, 95% CI [1.60, 2.40]. Participants who were high in technology affinity (+1 *SD*) were slightly more positive in their evaluations: While the robot with mental capabilities was still perceived to be eerier than the robot without mental capabilities, the difference turned out notably smaller at this level of the moderator, $B = 0.97$, $SE = 0.20$, $t(389) = 4.80$, $p < .001$, 95% CI [0.57, 1.36]. According to the Johnson-Neyman technique, manipulating mental capabilities significantly affected participants' perceived eeriness for z-standardized values ≤ 1.77 of technology affinity. About 98.47% of our participants fell into this significant region. Therefore, Hypothesis 9 could be supported.

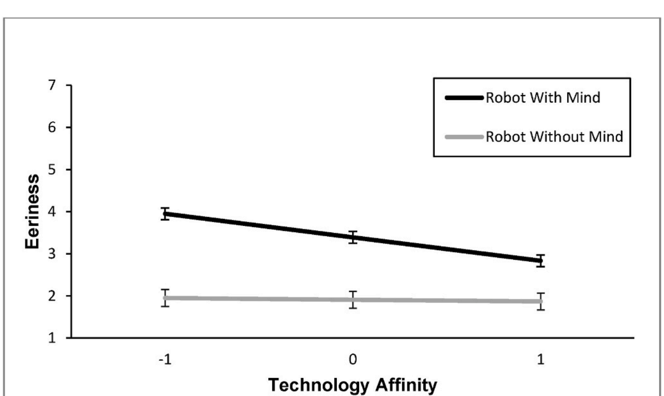

Fig. 2. Interaction between robot group and technology affinity in Experiment 1.
Note. Error bars represent ± 1SE.

2.3. Discussion

In line with earlier work and our proposed hypotheses, our first experiment showed that a robot with human-like mental capabilities (in terms of both thinking and feeling) evoked higher eeriness than a robot without such capabilities. Considering the main effect hypotheses (i.e., our assumptions as to how individual influences might affect robot acceptance in general), we observed three significant findings: monotheistic religiosity and a negative, pre-existing attitude towards robots connected to stronger aversion against the described machines, while higher technology affinity was associated with less eeriness. Furthermore, the latter two variables moderated the difference of eeriness evoked by the two presented types of robots (with or without human-like mental capabilities): A pre-existing bias towards robotic machines made people particularly apprehensive of *mindful* robots, whereas the affinity to deal with complex and potentially opaque technologies was linked to a much smaller evaluative difference between the described machine types. Regarding the individual tendency to anthropomorphize non-human objects, on the other hand, neither the main nor the interaction effect turned out significant. Lastly, monotheistic religiosity did not emerge as a significant moderator.

Reflecting upon our work, we had to consider that our convenience sample consisted mostly of a) young German people with b) very low scores in monotheistic religiosity. In Germany, less than 50 percent of the population still belong to a monotheistic church (Fowid, 2022), with even smaller percentages among young people. Therefore, we decided to replicate the experiment with an US-American sample, considering that in the United States two thirds of the population still practice Christian Protestantism or Catholicism (Pew Research Center, 2022). Also, by making use of a stratified panel sample, we strived to cover a broader age range, further hoping to involve more religious individuals. Apart from refining our investigation of the religiosity factor, this replication effort also served to test the robustness of our findings by using a second sample from a different culture.

3. Experiment 2

The second experiment is a replication and extension of the first experiment, using an English-speaking, US-American stratified sample (in terms of sex, age, and ethnicity) instead of a German convenience sample.

3.1. Method

3.1.1. Participants

Based on the effect size obtained in our first experiment, $d = 0.98$, a power analysis with G*Power (Faul et al., 2007) left us with an aspired sample size of $n = 36$ for a two-group main effect (two-tailed independent *t*-test, power = 0.80, alpha-error probability = 0.05). To account for the more complex design and the power needed to identify an interaction effect, we again multiplied this sample size by the factor eight (Giner-Sorolla, 2018; Simonsohn, 2014), leading to a proposed sample size of 288. As we considered Experiment 2 a replication study, we then doubled this number (van Zwet & Goodman, 2022), leading to a minimum number of 576 participants. In sum, we invited 700 participants to have a buffer if careless responding occurs. The sample was recruited on the platform *Prolific*, all participants were located in the USA.

Out of 690 completions, six respondents were excluded because they did not describe the study content correctly (in a single-line text field). One participant showed large (>±3 years) deviations when asked twice about their age. Four participants did not answer a control question on the name of the presented robot correctly. As in the previous experiment, we used a treatment check item asking participants whether the presented robot had been described with or without elaborate mental abilities. Fifty participants were excluded due to wrong answers to this question. Lastly, twelve additional individuals had to be excluded based on their answering duration, screened via a normal distribution diagram of processing times (<250 s). The final sample consisted of 617 participants (310 female, 393 male, 14 non-binary or no answer), with an average age of 46.57 years ($SD = 15.64$, ranging from 18 to 82 years).

3.1.2. Stimuli and procedure

We used an English version of the vignette texts presented in Experiment 1 (see online supplement). In line with the preceding study, participants were asked to answer the same individual difference variables before they read a text about the robot "Ellix," which was either introduced as a robot with or without human-like mental capabilities. Similar to Experiment 1, participants were merely informed that they would read a text about an "innovative robot". Afterwards, they answered several attention, treatment and manipulation check items. Lastly, sociodemographic information was collected, and participants were thanked and debriefed. The median of participation time was 639 s, and all participants were compensated with 2.20 USD.

3.1.3. Measures

The same scales as in Experiment 1 were used to measure eeriness (Cronbach's $\alpha = .93$), monotheistic religiosity (Cronbach's $\alpha = .96$), tendency to anthropomorphize (Cronbach's $\alpha = .88$), negative attitudes towards robots (Cronbach's $\alpha = .87$), and technology affinity (Cronbach's $\alpha = .90$). The original English item versions were presented on 7-point scales. The manipulation check (Cronbach's $\alpha = .91$) and treatment check followed the procedure reported in Experiment 1.

3.2. Results

3.2.1. Preliminary analyses

As in Experiment 1, we analyzed whether the robot with agency and experience ($M = 4.77$, $SD = 1.49$) was perceived to have more mental capabilities than the robot without such capabilities ($M = 1.91$, $SD = 1.07$). The manipulation check was successful, $t(615) = 27.61$, $p < .001$, $d = 2.23$. The requirements for the regression approach used to test Hypotheses 2 through 9 were checked and regarded as fulfilled. Please see Table 4 for descriptive statistics of measured variables in Experiment 2.

3.2.2. Main analysis

In support of Hypothesis 1 and replicating the results of the first experiment, the robot described with complex mental capabilities ($M = 3.78$, $SD = 1.94$) was perceived to be significantly eerier than the robot without such mental capabilities ($M = 2.40$, $SD = 1.76$), $t(615) = 9.22$, $p < .001$, $d = 0.74$. Zero-order correlations of the investigated moderator variables can be found in Table 5. Again, the robot condition (dummy-coded), the respective moderator variables (z-standardized) and interaction terms between the moderator variable and robot condition were entered into hierarchical regression models with eeriness as the criterion. Table 6 shows the results of the four resulting regression analyses.

Monotheistic religiosity did not differ between robot groups, $t(615) = -1.39$, $p = .164$. As the data reported in Table 6 highlight, neither a significant main effect nor an interaction effect emerged for this variable in Experiment 2, so Hypotheses 2 and 3 concerning monotheistic religiosity were not supported.

Table 5
Zero-order correlations of measured variables in Experiment 2.

	1	2	3	4	5
1. Eeriness	–	.05	−.04	.53[a]	−.25[a]
2. Monotheistic religiosity		–	.06	.11[a]	.04
3.Tendency to anthropomorphize			–	.03	.12[a]
4. Negative attitudes towards robots				–	−.32[a]
5. Technology affinity					–

[a] $p < .001$ (two-tailed).

The tendency to anthropomorphize did not differ between robot conditions, $t(615) = 0.95$, $p = .343$, and no significant main effect was observed (no support of Hypothesis 4, see Table 6). Hypothesis 5 was neither supported, as the interaction term did not reach statistical significance ($p < .056$). Negative attitudes towards robots did also not differ between the robot conditions in Experiment 2, $t(615) = -0.12$, $p = .902$. The main effect postulated in Hypothesis 6 (higher NARS leads to higher eeriness ascribed to either robot) was supported. For the significant interaction between robot condition and negative attitudes towards robots (Fig. 3), follow-up analyzes (Aiken & West, 1991) revealed that participants who had low negative attitudes towards robots (-1 SD) perceived the robot apparently equipped with mental capabilities to be significantly eerier than the robot without mental capabilities, $B = 1.10$, $SE = 0.17$, $t(615) = 6.33$, $p < .001$, 95% CI [0.76, 1.44]. Importantly, participants who reported notably stronger negative attitudes towards robots ($+1$ SD) also perceived the robot with mental capabilities to be eerier—and did so to a slightly stronger extent, $B = 1.63$, $SE = 0.17$, $t(615) = 9.37$, $p < .001$, 95% CI [1.29, 1.97]. No statistical significance transition points within the observed range of the moderator variable were found using the Johnson-Neyman method. Hypothesis 7 was supported.

Lastly, technology affinity did not differ between robot conditions, $t(615) = 0.92$, $p = .359$. The main effect postulated in Hypothesis 8 was found, which means that higher technology affinity was associated with lower eeriness ascribed to both robots in the experiment (see Table 6). Moreover, a significant interaction term was observed (see Fig. 4). Follow-up analyses revealed that participants who were low in this trait (-1 SD) perceived the robot with mental capabilities to be significantly eerier than the robot without mental capabilities, $B = 1.67$, $SE = 0.20$, $t(615) = 8.24$, $p < .001$, 95% CI [1.28, 2.07]. Furthermore, participants who were high in technology affinity ($+1$ SD) rated the robot with mental capabilities as eerier than the tool robot, but to a smaller extent, $B = 1.00$, $SE = 0.20$, $t(615) = 4.92$, $p < .001$, 95% CI [0.60, 1.40]. No statistical significance transition points within the observed range of the moderator variable were found using the Johnson-Neyman method. Hypothesis 9 was supported.

3.3. Discussion

The second experiment strived to replicate the results of the previous experiment with an English-speaking sample covering a broader demographic diversity. By these means, we hoped to observe more

Table 4
Descriptive statistics of measured variables in Experiment 2.

Variables	Full sample ($N = 617$)			*Robot with mind* condition ($n = 290$)	*Robot without mind* condition ($n = 327$)
	M (SD)	*Skewness*	*Kurtosis*	*M (SD)*	*M (SD)*
Eeriness	3.05 (1.97)	0.52	−0.94	3.78 (1.94)	2.40 (1.76)
Monotheistic religiosity	2.87 (1.79)	0.72	−0.66	2.97 (1.87)	2.77 (1.71)
Tendency to anthropomorphize	2.69 (0.97)	0.60	0.37	2.65 (1.02)	2.72 (0.93)
Negative attitudes towards robots	3.54 (1.07)	0.14	−0.02	3.54 (1.07)	3.53 (1.09)
Technology affinity	4.58 (1.22)	−0.36	−0.20	4.53 (1.25)	4.62 (1.19)

Table 6
Results of the hierarchical regression analysis per moderator variable in Experiment 2.

		B	SE	t	p	R^2	ΔR^2
Monotheistic religiosity							
Step 1	Constant	2.40	0.10	23.54	<.001	.122	.122[b]
	Robot Condition	1.37	0.15	9.22	<.001		
Step 2	Constant	2.41	0.10	23.54	<.001	.122	.001
	Robot Condition	1.37	0.15	9.16	<.001		
	Monotheistic religiosity	0.06	0.07	0.74	.458		
Step 3	Constant	2.41	0.10	23.54	<.001	.123	.001
	Robot Condition	1.37	0.15	9.16	<.001		
	Monotheistic religiosity	0.10	0.11	0.95	.344		
	Monotheistic religiosity × Robot Condition	−0.09	0.15	−0.60	.550		
Tendency to anthropomorphize							
Step 1	Constant	2.40	0.10	23.54	<.001	.122	.122[b]
	Robot condition	1.37	0.15	9.22	<.001		
Step 2	Constant	2.40	0.10	23.53	<.001	.122	.573
	Robot condition	1.37	0.15	9.19	<.001		
	Anthropomorphism	−0.04	0.07	−0.56	.573		
Step 3	Constant	2.40	0.10	23.52	<.001	.127	.005
	Robot condition	1.37	0.15	9.21	<.001		
	Anthropomorphism	0.10	0.11	0.98	.328		
	Anthropomorphism × Robot condition	−0.28	0.15	−1.92	.056		
Negative attitudes towards robots							
Step 1	Constant	2.40	0.10	23.54	<.001	.122	.122[b]
	Robot condition	1.37	0.15	9.22	<.001		
Step 2	Constant	2.41	0.08	28.56	<.001	.402	.280[b]
	Robot condition	1.36	0.12	11.08	<.001		
	Negative attitudes towards robots	1.04	0.06	16.95	<.001		
Step 3	Constant	2.41	0.08	28.63	<.001	.406	.004[a]
	Robot condition	1.36	0.12	11.11	<.001		
	Negative attitudes towards robots	0.92	0.08	11.03	<.001		
	Negative attitudes towards robots × Robot condition	0.26	0.12	2.15	.032		
Technology affinity							
Step 1	Constant	2.40	0.10	23.54	<.001	.122	.122[b]
	Robot condition	1.37	0.15	9.22	<.001		
Step 2	Constant	2.42	0.10	24.44	<.001	.176	.054[b]
	Robot condition	1.34	0.14	9.27	<.001		
	Technology affinity	−0.46	0.07	−6.37	<.001		
Step 3	Constant	2.41	0.10	24.46	<.001	.183	.007[a]
	Robot condition	1.34	0.14	9.30	<.001		
	Technology affinity	−0.29	0.10	−2.89	.004		
	Technology affinity × Robot condition	−0.34	0.14	−2.34	.020		

Note. All continuous predictors were z-standardized; $N = 617$.
[a] dummy-coded (0 – robot without mind; 1 – robot with mind).
[a] $p < .05$.
[b] $p < .001$.

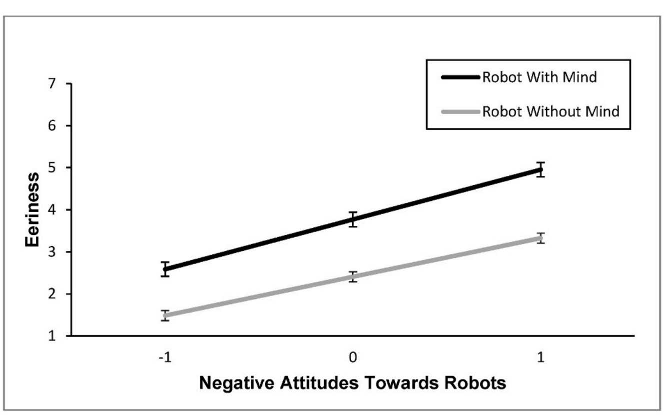

Fig. 3. Interaction between robot group and negative attitudes towards robots in Experiment 2.
Note. Error bars represent ± 1SE.

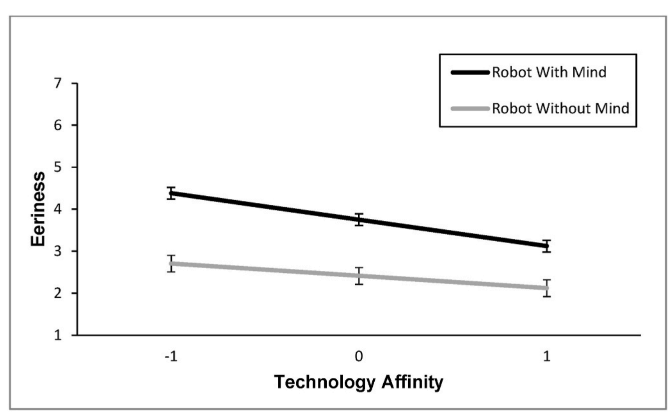

Fig. 4. Interaction between robot group and technology affinity in Experiment 2.
Note. Error bars represent ± 1SE.

nuanced responses especially with regard to the variable monotheistic religiosity. However, as in our previous effort, we did not observe a moderating influence of this variable; more so, in contrast to Experiment 1, no main effect emerged this time around. Apart from this, however, results turned out largely consistent across both Experiments, which is especially noteworthy considering that participants were not only recruited via different means, but also from different cultural backgrounds (Germany and the United States). The congruence of the results patterns between both Experiments was particularly evident for the general aversion difference between the mind and the tool robot (H1), the impact of participants' tendency to anthropomorphize (H3, H4), as well as the NARS scores (H6, H7) and technology affinity (H8, H9). See Table 7 for a direct comparison of both studies.

4. General discussion

Tapping into decades of research on the traditional uncanny valley, as well as more recent theoretical developments regarding an *uncanny valley of mind*, the goal of this study was to explore four individual differences that might explain why some people respond to sophisticated machines (and especially those with complex, human-like minds) with stronger aversion than others. To answer these questions, two online experiments with a text vignette approach were conducted, using samples from two different countries and with two different age distributions. Specifically, participants were introduced to an innovative robot that was either presented as a highly human-like machine, with the ability to think and feel—or as a simple robotic tool.

In both experiments, the presented robot with advanced mental capabilities was evaluated to be significantly eerier than the robot that was described without such capabilities, replicating the results from earlier work (Appel et al., 2020; Gray & Wegner, 2012). Looking at the individual differences that had been selected as potential moderators based on current theory, we found notable influences of the technology-oriented variables, i.e., participants' domain-specific attitude towards robots and their general affinity towards complex technologies. As such, being open towards contemporary technological systems (and the uncertainties they might bring) and having a generally positive outlook on robots as a category of autonomous machines emerged as two factors that alleviate the eerie feeling when dealing with robots. Therefore, if developers strive to increase the public acceptance of their inventions, they might want to pursue ways to improve individual attitudes towards robots or cater their products towards a particularly tech-savvy demographic (Björling et al., 2019; Hampel & Sassenberg, 2021). Especially considering that the progress of advanced AI-powered robots seems indivertible at this point, helping people to feel less anxious or 'creeped out' by complex technology is clearly paramount. Among others, efforts to make artificial intelligence more transparent and explainable are definitely welcome to facilitate this goal. Likewise, the well-established impact of media depictions on robot-related attitudes (Stein & Banks, 2023) appears as another relevant angle in this regard; as long as popular entertainment content (such as dystopian sci-fi movies) depicts robots in a negative light, media effects will likely remain an obstacle to more positive attitudes towards robots, and thus, a reduction of eeriness and uncertainty towards human-like and, most of all, mentally human-like machines. Interestingly, the impact of monotheistic religiosity and participants' tendency to anthropomorphize turned out different from what was hypothesized. First, neither experiment revealed a main effect of anthropomorphization tendencies, which describe people's inclination to see human attributes in non-human objects. This lack of a main effect on eeriness is in stark contrast to prior work showing that the general evaluation of robots is clearly affected by the tendency to anthropomorphize (Kraus et al., 2023; Marchesi et al., 2021; Schömbs et al., 2023). Additionally, we did not observe any interaction effects of this variable in both Experiments. However, we note that the interaction effects of robot type and this trait-like variable almost gained statistical significance in both experiments (Experiment 1: $p < .080$, Experiment 2: $p < .056$). Thus, we assume that even if the tendency to anthropomorphize might not be quite the powerful driver of robot acceptance that it has been made out to be, it may still diminish the eeriness that is evoked by robots seemingly equipped with human-like mental capabilities. In our reading, this makes perfect sense: If a person has a habitual tendency to assign human-like features or abilities to non-human objects in the first place, they might already be much more familiar with this kind of cognitive schema (a "feeling machine," a "thinking robot"); in turn, a mentally capable robot might violate fewer expectations for them, which has been described as one of the core tenets of uncanny valley formation (Kätsyri et al., 2015). Across both experiments, no moderating effect of monotheistic religiosity was found with regards to mindful vs. mindless robots, and its general role on robot acceptance turned out mixed. This observation could be seen as surprising, as prior work revealed a positive correlation between monotheistic religiosity and robot-related eeriness experiences (MacDorman & Entezari, 2015). Therefore, we do not draw any conclusions for this variable and encourage further research to dive deeper into these mixed findings so that future conclusions can be drawn based on a broader data basis. For the time being, the revealed main effect in Experiment 1 and the theoretical considerations that our hypotheses were based upon (e.g., Stein & Ohler, 2017) add nuances to the assumption that religious, spiritual, or even philosophical beliefs will affect the acceptance of robots with highly advanced mental capabilities in a meaningful way.

Table 7
Overview of results of Experiments 1 and 2.

	Hypothesis	Experiment 1	Experiment 2
H1	A robot with human-like mental capabilities **evokes higher eeriness** than a robot without human-like mental capabilities.	significant	significant
H2	The stronger an individual's **monotheistic religiosity**, the more they experience eeriness in response to a robot.	significant	n. s.
H3	**Monotheistic religiosity** accentuates the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.	n. s.	n. s.
H4	Participants with a higher (vs. lower) **tendency to anthropomorphize** perceive robots to be less eerie.	n. s.	n. s.
H5	A high **tendency to anthropomorphize** reduces the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.	n. s.	n. s.
H6	Participants with more (vs. less) **negative attitudes towards robots** perceive robots to be eerier.	significant	significant
H7	**Negative attitudes towards robots** accentuate the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.	significant	significant
H8	Participants with higher (vs. lower) **technology affinity** perceive robots to be less eerie.	significant	significant
H9	**Technology affinity** reduces the difference of eeriness evoked by a robot with (vs. without) human-like mental capabilities.	significant	significant

4.1. Limitations and future work

Despite our best efforts to recruit reasonable samples to address the role of fundamental religious beliefs, such views tended to be underrepresented in our samples, not only in the German convenience sample but also in the stratified US-American sample. Thus, further replications with more specific demographic sub-groups should be carried out in the future. Agreeing with MacDorman and Entezari (2015), we also encourage comparing the influence of *different* religious beliefs (e.g., monotheistic vs. pantheistic religions); the scale used in our studies, for example, explicitly focuses on monotheistic beliefs, and seems most suitable to capture Christian perspectives. In contrast to this, it would be a valuable modification to explore the influence of fundamentalism in religions that do not solely see humans as the pride of creation (e.g., neo-Confucianism, Taoism, Buddhism, and Shinto).

Naturally, our work is limited by the fact that only four individual differences were examined—while many other motivational, dispositional, and sociocultural differences remain unexplored. However, we would like to point out that our selection was made based on recent contributions to human-robot interaction literature, so that we deemed them suitable candidates for this very first exploration of individual differences regarding the uncanny valley of mind. We are aware that this approach is not exhaustive and therefore encourage researchers to explore other individual difference variables (e.g., personality traits such as the Big Five or the Dark Triad) to see how these affect people's responses to machines at different levels of (factual or perceived) mental prowess.

Additionally, we want to highlight the methodological restrictions of using text vignettes as stimuli—as these prioritize internal validity at the expense of ecological validity. As such, future studies might consider testing the formulated hypotheses with more vivid stimuli (e.g., multimedia depictions, or live interactions with real robots). Relatedly, we would like to refer to several recent studies (MacDorman, 2024; Stein et al., 2020; Yin et al., 2021), which suggested that the visual appearance of a machine may ultimately be a stronger predictor of users' aversion than mind perception. On the other hand, it should be noted that using text vignettes is a common procedure in the research field (e.g., Appel et al., 2020, Gray & Wegner, 2012; Grundke et al., 2022, 2023; Ward et al., 2013), considering that they often provide the only way to manipulate the supposed mental capabilities of robots that are not yet available on the market or well-known to the public. Also, from a psychological perspective, we want to point out that eeriness (as the uncanny valley's central concept) reaches notably further than mere visual impressions; instead, it arises from something being unfamiliar in a familiar context, from an entity eluding the world we know and feel comfortable with—thus leading to an experience of psychological uncertainty (Freud, 1919/2020; Jentsch, 1906/1997; for a more recent overview, please see Olivera-La Rosa, 2018). In our interpretation, written descriptions of innovative robots are therefore indeed suitable for inducing eeriness even without the additional presentation of a machine's appearance.

Lastly, we propose to consider the moderating influence of individual differences in concrete scenarios. For example, Appel et al. (2020) as well as Yam et al. (2021) highlighted that presenting robots in a specified context is a possibility to reduce aversion, as well as adding context is a possibility to evoke empathy for robots seemingly equipped with humanlike mental capabilities (Grundke et al., 2023). Therefore, presenting a robot in a specified context may also influence the results.

4.2. Conclusion

Two pre-registered online experiments consistently showed that technology affinity and pre-existing negative attitudes towards robots have a noteworthy impact on the eeriness evoked by robots which are described to express human-like mental capabilities or not—either weakening (technology affinity) or increasing (negative attitudes) eeriness. This clearly shows that individual differences actually influence the aversion felt towards modern-day machines, not least those with complex, AI-powered abilities. While monotheistic religiosity and the individual tendency to anthropomorphize fell short of their anticipated explanatory value, researchers should not disregard either variable just yet, based on the discussed potential modifications. Overall, we propose that scholars pay greater attention to individual differences in this seminal research field in order to better understand why some people are more apprehensive of sophisticated social machines than others.

Declaration of interest

The authors report that they have nothing to declare.

Ethics statement

While institutional approval for psychological research is not legally required in the study country, we adhered to all principles outlined in the Declaration of Helsinki, as well as the ethical guidelines of the German Psychological Society (DGPs). Of course, this included obtaining informed consent from all participants.

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CRediT authorship contribution statement

Andrea Grundke: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization, Investigation. **Markus Appel:** Writing – review & editing, Supervision. **Jan-Philipp Stein:** Writing – review & editing, Writing – original draft.

Declaration of competing interest

The authors report that they have nothing to declare.

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Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chbah.2024.100087.

Appendix

Stimulus Material: Robot With Mind

On the next page, you will read a description about an innovative social robot

Ellix is a social robot that interacts with humans.

Ellix is equipped with arms, hands, and over 100 sensors that enable it to grasp certain objects or place them in a different location. It perceives people as interlocutors and stands out as one of the most innovative robots of the current era due to its mental capabilities, personality, and ability to act independently.

Ellix is equipped with an advanced artificial intelligence system to make sense of the data it receives from its environment. Thanks to implemented psychological insights and machine learning techniques that make the system smarter with each use, Ellix is able to respond to human interaction partners. Thus, the robot is capable of self-control, morality, memory, and emotion recognition. In addition, Ellix has learned to plan ahead and perform actions independently.

Ellix is being further developed with the latest algorithms that not only let it simulate forms of hunger, fear, pain, pleasure, and other emotions, but make them truly sentient to it.

Stimulus Material: Robot Without Mind

On the next page, you will read a description about an innovative social robot

Ellix is a social robot that interacts with humans.

Ellix is equipped with arms, hands, and over 100 sensors that enable it to grasp certain objects or place them in a different location. With its sensors, it analyzes its physical environment so it can avoid bumping into objects or people, or falling down stairs.

Ellix assists people with their everyday tasks and is designed with the ability to act on a person's instructions. The user can command the robot to perform actions if they have been previously defined in its code. With its programmable capabilities, it can accurately perform basic tasks according to a predefined sequence, assisting humans with repetitive tasks.

Ellix is developed with the ability to obey humans according to instructions and act accordingly. Consequently, it cannot make complex decisions autonomously or learn on its own, but acts as a useful tool and helper for everyday life.

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