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Research Article

Development of the Beliefs in Human Nature Uniqueness Scale and Its Associations With Perception of Social Robots

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There is an actual trend for humanizing technological artifacts, especially social robots. However, human-like social robots trigger negative attitudes by threatening human uniqueness as well as humanness. The present paper presents the development of the Belief in Human Nature Uniqueness Scale (BHNUS) to assess the individual tendency to deny social robots the possibility to have human features considered to be the hallmarks of humanness. The validation of the BHNUS was completed along seven studies, with a total of 1044 Portuguese participants. Results showed that BHNUS had good structural qualities (Studies 1 and 2), as well as good convergent and discriminant validities. BHNUS was correlated with negative attitudes towards robots, religiosity, and interest for science fiction (Study 3), attribution of traits of warmth to robots (Study 4), positive and negative emotional appraisal (Study 5), perspective taking (Study 6), and attitudes towards the development of robots with human features (Study 7). The importance of the BHNUS regarding the development of social robots and human–robot interaction is discussed.

If you were to insist I was a robot, you might not consider me capable of love in some mystic human sense, but you would not be able to distinguish my reactions from that which you would call love so what difference would it make?
Isaac Asimov (1982) in Foundation's Edge, p. 420

Keywords: agency; human nature; humanness; human–robot interaction; mind; perspective taking; social robots; technology acceptance; threat to human distinctiveness; warmth

1. Introduction

Social robot (SR) is a broad label used to refer to a wide range of different types of robots that share a common attribute: the capacity for interpersonal interactions [1–3]. Indeed, SRs are embodied artificial intelligence agents designed for peer-to-peer human–machine interactions. They are created to communicate with natural language, to perceive and express emotions, to exhibit nonverbal cues (e.g., gaze, gestures), and to display personhood (personality and character) [1–3]. Although highly advanced SR like the ones portrayed in science fiction (Sci-Fi) work (e.g., Isaac Asimov's novel "Bicentennial Man," Humans TV series) are far into the future, current SR already raise the hypothesis of a potential future mechanical humanity [4]. The actual trend for humanizing robots through "the implementation of social (e.g., language, nonverbal behavior, personality, emotions, and empathy), ethical (e.g., moral and values), and spiritual competences (COMs) (e.g., religion, culture, and tradition)" [5, p. 111] clearly reinforces the perception of a potential humanness in SR. However, human-like SRs trigger negative reactions [5]. So far, studies have mainly explored how the features of SRs could provoke rejection [5]. The current paper proposes a more human-centered approach for SRs rejection through the development and the validation of the Beliefs in Human Nature Uniqueness Scale (BHNUS). This instrument is designed to gauge the individual tendency to deny to SRs the hallmarks of humanness and, thus, better understand humans' perception of SRs ontological status. Accordingly, the paper is structured as follows: the theoretical framework will address the perceived ontological status of SRs, how SRs are perceived as a threat to human distinctiveness and humanness, and how the psychological approaches about the attribution and withdrawal of humanness contribute to the elaboration of the BHNUS. The empirical research section will present seven studies that explore the structure of the BHNUS and test its validity (see Figure 1).

2. Theoretical Framework

2.1. SRs as Ontological Others. The ontological status of a physical or social object can be broadly described as the set of features that confine it to a certain category [6], for example, animal versus mineral, biological versus mechanical, and human versus nonhuman. SRs seem to elude such classifications. Indeed, research on the perception of humanoid and zoomorphic robots has shown that both children and adults have difficulties in assigning robots either to the category of living entities or to the category of nonliving entities (for a review see [7]). On one hand, children attributed mental states (e.g., intelligence and feelings) to robots like Robovie and perceived them as social beings [8]. On the other hand, teenagers (14–18 years old) both familiar and unfamiliar with robots, displayed a clear-cut judgment about robots' category membership, conceiving them as nonliving entities [7]. In short, although SR are perceived as closer to inanimate objects than to living entities, they are also perceived as being kind of alive.

The ambiguous ontological status of SRs can be amplified by social psychological processes like perceived social presence or anthropomorphism [9]. Indeed, research under the framework of the media equation theory [10] has shown that people "mindlessly apply social rules" ([11], p. 82) to technological artifacts displaying social cues (e.g., voice and graphical representation) and respond to these artifacts as if they were another person (e.g., with reciprocity and courtesy). Moreover, the presence of social cues in SR, like language or eye gaze, increases the tendency for psychological anthropomorphism, that is, the attribution of human mental states and purposes, like goals, desires, intentions, and expectations, leading people to the attribution of intentionality and agency to SRs [12].

In brief, because SRs display both typical traits of living creatures (e.g., movement, memory, and intention) and typical traits of nonliving entities (e.g., batteries, sensors, and metal parts), some researchers suggest that we could be looking at the emergence of a new ontological category [13]. Interestingly, empirical studies have shown that this dual and ambiguous ontological status of SRs can be perceived as a threat to human distinctiveness/uniqueness as well as to humanness.

2.2. Robots as a Threat to Human Distinctiveness. The rejection of robots by humans was first theoretically and empirically considered within the framework of the uncanny valley effect [14]. The uncanny valley effect refers to the feelings of eeriness, discomfort, or revulsion experienced when seeing (or touching) almost human-like artifacts. Several theoretical explanations have been formulated to account for the uncanny feelings (see [15]), among which the proposition that almost human-like artifacts could psychologically challenge the perception of human/nonhuman distinction and consequently threaten humans' distinctiveness and identity [16–18]. Extending this line of reasoning, Ferrari, Paladino, and Jetten [19] proposed the *threat to distinctiveness hypothesis*. They argue that when robots' appearance is too human-like, humans could feel the boundaries between categories of machines and humans fading away and experience it as a loss in category distinctiveness, that is, a loss in human uniqueness. For example, they showed, in two studies, that perceived damage to human groups and identity was predicted by robot anthropomorphic appearance. Congruently, Müller et al. [20] also found that robots with a higher anthropomorphic physical appearance triggered negative perceptions due to a decrease in human–machine distinctiveness. In other words, the greater the difficulty to distinguish physically a mechanical artifact from a human being, the greater the threat to the human distinctiveness and identity.

Moreover, Złotowski, Yogeeswaran, and Bartneck [21] explored the association between perceived robots' autonomy, experienced realistic threat (i.e., threat to human jobs, resources, and safety), identity threat (i.e., threat to human uniqueness), and attitude towards robots. They found that participants, after seeing a video displaying robots, reported a higher identity threat when they were told that the robots were autonomous and capable of accepting or rejecting human commands than when robots were presented as completely nonautonomous. They also showed that both realistic and identity threats mediated the relationship between the perception of robots' autonomy and attitudes towards robots. Waytz and Norton [22] also found that participants reported more threat and discomfort when they considered the possibility of robots replacing them in emotion-oriented tasks (i.e., perceived as typically human tasks) than in cognitive-oriented tasks, (i.e., perceived as being also made by robots). Finally, Yogeeswaran et al. [23] showed that social comparison was an important factor. Indeed, participants who were exposed to a video depicting an android robot (i.e., Geminoid HI) reported greater identity threat than participants exposed to a human-like robot (i.e., NAO), but only when they were told that robots could outperform humans on various physical and mental tasks. To sum up, research strongly suggests that humans experience an existential threat when facing SRs that display a human appearance and attributes considered to be exclusively human (e.g., emotions, autonomy).

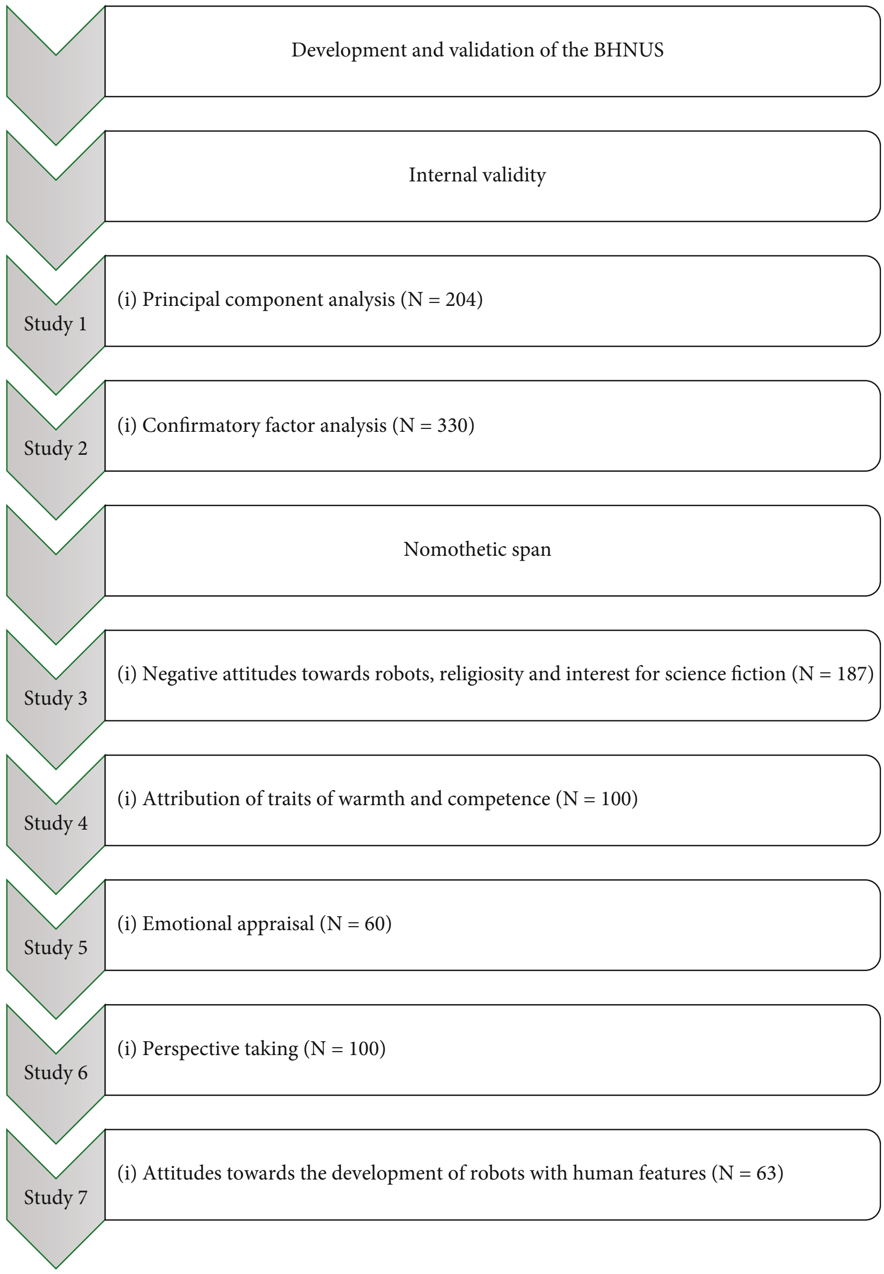

Figure 1: Flow Chart 1.

Recently, Stein, Liebold, and Ohler [24] proposed the model of autonomous technology threat (MATT) to theoretically integrate the different types of threats and reactions evoked by SRs. The MATT states that aversion to autonomous SR (i.e., high eeriness and negative attitudes) stems from a threat experience produced by a proximal threat (e.g., loss of situational control and threatening proximity) and/or a distal threat (i.e., concerns about human uniqueness).

2.3. Ascription and Withholding of Humanness. As reviewed above, SRs can entail a dilution of what makes humans unique and force humans to redefine the concept of humanness in general [16]. But what makes humans perceive themselves as human?

The nature of human essence has been questioned for centuries by philosophers who have tried to determine which discrete features could differentiate humans from nonhuman beings. Traditionally, the human mind was perceived as unique and was considered as the hallmark of humanness (e.g., Aristotle, BC350; Descartes, 1641). Subsequently, a set of various attributes was proposed. For example, John Locke asserted that being human implied: (1) a capacity for reason or rationality; (2) mental states like beliefs, intentions, desires, and emotions; (3) language; (4) social relationships; and (5) moral accountability [25]. More recently, Berniūnas and Dranseika [26], adopting cognitive anthropology's method, asked 100 participants to freely list properties or features that constitute persons and found similar sets of features. Indeed, the conceptual landscape of "person" and "identity" included six dimensions: (1) psychological functioning (e.g., consciousness, thinking, feelings, character, and emotions); (2) bodily functioning and structure (e.g. body, being alive, brain, and organs); (3) essential self (e.g., soul and spirit); (4) sociality and communication (e.g., friendship); (5) minimal self (e.g., activity, self-awareness, and freedom); and (6) morality (e.g. conscience, morals, and responsibility).

While philosophical approaches have focused on identifying discrete attributes supposedly unique to humans, psychological approaches have focused on how and when humanness was ascribed to (or withheld from) group and outgroup members. Several conceptions and theories dealing with humanness and its recognition or denial have been proposed.

2.3.1. Perception of Mind. Mind perception research focuses on the identification of perceived fundamental components of mind, that is, on how people perceive other minds (e.g., humans, nonhuman animals, gods, or technological artifacts) and how they conceive the existence of different kinds of minds. According to Gray H., Gray K., and Wegner [27], perception of mind is structured by two dimensions: (a) agency, which refers to the capacity for planning and acting (e.g., higher-order cognitive abilities like self-control, morality, memory, emotion, recognition, planning, communication, and thought) and (b) experience, which refers to the capacity for desires and feelings (e.g., hunger, fear, pain, pleasure, rage, desire, personality, consciousness, pride, embarrassment, and joy). Research made under the mind perception theoretical framework has shown that agency distinguishes humans from animals while experience distinguishes humans from inanimate entities. For example, participants described humans as being high on both agency and experience, whereas robots were seen as very low on experience and middling on agency [27]. Moreover, people tend to attribute to themselves a greater capacity for experience and agency than they attribute to others [28]. In other words, they tend to perceive others' minds as less vivid, varied, and sophisticated in terms of emotions, intellect, preferences, motivation, and will [29–31]. This failing to consider others' minds as rich and complex as one's mind is considered as a subtle form of denial of humanness [22]. Research has also shown that the attribution of different levels of experience and agency is seen as closely connected with the perception of different levels of moral worth, that is, their capacity to perform moral acts and to be the recipients of these acts [27, 32], because acting morally is a part of higher-order cognitions.

2.3.2. Perception of Body–Heart–Mind. Based on Gray H., Gray K., and Wegner's [27] pioneering work, Wiesman, Dweck, and Markman [33] conducted four studies to determine what people considered to be the fundamental components of the mind in which they asked participants to consider the similarities and differences among mental capacities for different entities (e.g., human, insects, and robots). They found that the perception of the structure of mental life is based on the consideration of three dimensions instead of two, like in mind perception approach. First, the body corresponds to perceived physiological sensations related to biological needs (e.g., hungriness, pain, feeling tired, fear, and being conscious). Second, the heart refers to the perceived emotions and ability to anticipate others' emotions as well as morality. Finally, the mind refers to perceived perceptual access and cognitive representational abilities like remembering things, communicating with others, and working toward a goal. Wiesman, Dweck, and Markman [33] found that human adults were assessed as high on body, heart, and mind, while beetles were average on body and mind and low on heart, and robots were very low on body and heart but high on mind.

2.3.3. Perception of Human Traits. Haslam [34] suggested that the lay conception of humanness is articulated on two dimensions: human nature (HN) and uniquely human (UH) traits. HN traits refer to a set of features perceived as biologically based (i.e., innate), unchanging, and universal across cultures that include emotionality, interpersonal warmth (WARM), cognitive openness, and individuality [34]. HN traits mark humanity's continuity with nature, while setting a clear boundary with cultural artifacts and inert objects (like robots) [35, 36]. In brief, HN traits are "the human essence" [37]. UH traits refer to a set of features that distinguish humans from nonhuman animals. UH traits are perceived as nonessentialized, malleable, and acquired by socialization. They include refinement, civility, morality, higher cognition (e.g., rationality, logic), self-control, and maturity [34]. UH traits are acquired by socialization and underlie humans' discontinuity with animals.

2.3.4. Perception of Secondary Emotions. Demoulin et al. [38] showed that laypersons consider that some emotions are unique to human, whereas some other emotions are common to both humans and animals. UH emotions are composed of secondary emotions (e.g., love, regret, and nostalgia) while non-UH emotions correspond to primary emotions (e.g., joy, anger, and sadness). Only the capacity to fully experience secondary emotions is considered to be the very essence of humanity [39], and accordingly, recognition of humanness is based on the attribution of secondary emotions. People are motivated to perceive their group as superior to others and tend to reserve humanness to ingroup members [39]. As a result, infrahumanization consists of the attribution of a lower degree of UH emotions (i.e., human essence) to the outgroup [39]. For infrahumanization to occur, the outgroup should be perceived as relevant for the ingroup [40] or as a competitor.

2.3.5. Perception of Morality. The attribution of human mental states and purposes (like goals, desires, intentions, and expectations) turns their recipients into moral beings who are consequently worthy of sympathy, and accountable for their manners [41]. Therefore, morality is an important factor when it comes to recognizing humanness. Indeed,

Table 1: Items of the Belief in Human Nature Uniqueness Scale (BHNUS) in English and Portuguese languages.

BHNU 1	Even if ultrasophisticated, a robot will never be considered a human being. **Mesmo que seja ultrassofisticado, um robô nunca poderá ser considerado um ser humano.**
BHNU 2	Even if ultrasophisticated, a robot will never feel the same emotions as a human being. **Mesmo que seja ultrassofisticado, um robô nunca poderá sentir as mesmas emoções que um humano.**
BHNU 3	Even if ultrasophisticated, a robot will never use language in the same way as a human being. **Mesmo que seja ultrassofisticado, um robô nunca poderá usar a linguagem da mesma maneira que um ser humano.**
BHNU 4	Even if ultrasophisticated, a robot will always be a mechanical imitation of the human being. **Mesmo que seja ultrassofisticado, um robô será sempre uma imitação mecânica do ser humano.**
BHNU 5	Even if ultrasophisticated, a robot will never have consciousness. **Mesmo que seja ultrassofisticado, um robô nunca terá consciência.**
BHNU 6	Even if ultrasophisticated, a robot will never have morality. **Mesmo que seja ultrassofisticado, um robô nunca terá moralidade.**

morality plays a central role in the construction and maintenance of a positive image at both individual and group levels (see for a review [42]). For example, people tend to consider their ingroup peers more worthy of moral concern than outgroup members and, sometimes, tend to reduce outgroup members' moral worthiness through derogation or through dehumanization. For example, Hadarics, Szabo, and Kende [43] have shown that collective narcissists (i.e., people who considered their group as unique and superior and are hostile towards outgroups threatening their superiority) were also those who displayed more moral exclusion towards outgroup members (i.e., excluding them from one's own moral community). Moreover, both threat and perceived social distance were significant mediators of this relationship. Finally, Brambilla et al. [42] have suggested that a lack of perceived morality could indicate a potential threat to the group's safety. For example, an outgroup member perceived as lacking morality could be considered as potentially harmful and challenging in-group survival possibilities [44].

To sum up, beyond the biological and agency dimensions, it is the experiential dimension which is mainly considered as the intrinsic human privilege and the hallmark of humanness, that is, the capacity to experience emotions or spirituality, to transmit them (through language), and to act morally.

2.4. SRs as a Threat to Humanness. Interestingly, SRs that display attributes considered as exclusively human , like those reviewed earlier, trigger negative cognitive, affective, and behavioral reactions. For example, Gray and Wegner [45] showed that machines displaying experience–but not agency–triggered feelings of unease. Appel et al. [46] found that a robot displayed as having experiential features (i.e., emotions, consciousness, and personality) triggered stronger feelings of eeriness than a robot described as having agentic features (e.g., capacity to plan). Dang and Liu [47], in an international comparative study, also found that robots presented as mindful (e.g., capable of expressing, recognizing, and experiencing emotions) elicited more ambivalent attitudes than robots presented as mindless, and that this effect was stronger in the American sample than in the Chinese sample. Finally, Stein and Ohler [48] proposed the "uncanny valley of mind" to refer to the negative reactions triggered by the ascription of the capacity to experience machines.

2.5. Denying Human Ontological Status to SRs: The BHNUS. Studies reviewed earlier showed that the attribution or the perception of attributes considered to be unique to humans in robots yields negative reactions like symbolic/realistic threat, feelings of eeriness, or negative attitudes. Interestingly, some other works have also shown that humans tend to deny human-specific traits to machines. For example, Haslam et al. [49] have found that participants from three different countries (Australia, China, and Italy) assigned few HN traits to robots, that is, they perceived robots as having few primary and secondary emotions, wishes, intentions, and thoughts.

Airenti [50] suggested that "humans may interact with machines, but they reserve to themselves the power to fill their mind, attributing both mental states and emotions" (p. 125). Accordingly, it is argued that: (1) humans can deny the possibility to SRs to possess the traditional benchmarks of humanity, even if they display them now or could display them in the future; (2) this denial is not only due to contextual factors as reviewed earlier (e.g., social comparison of capacities, robot's appearance, attribution or perception of human features) but also due to an individual psychological orientation: the Beliefs in Human Nature Uniqueness (BHNU). Indeed, similar to already identified sociopsychological factors associated with ingroup favoritism like authoritarianism [51], collective self [52], or social dominance orientation (SDO) [53], it is proposed that BHNU refers to a set of beliefs that favor humans by denying the traditional benchmarks of humanity to SRs. To measure this tendency, the BHNUS (see Table 1) focuses on five core dimensions: the nonbiological nature of SRs (Items 1 and 4), emotions (Item 2), language (Item 3), consciousness (Item 5), and morality (Item 6).

The selection of the five dimensions of BHNUS was based on two criteria. The first criterion was theoretical. Indeed, the five dimensions of the BHNUS picture the main dimensions that have been identified by both philosophers (see [26]) and psychologists (e.g., [27, 33]) as central to the perception of humanness. Indeed, they encompass the dimensions of agency (e.g., language), experience (e.g., emotions, consciousness, and morality), and embodiment. The second criterion dealt with the credibility of the items. Each dimension had to be credible for nonspecialists. Because media shapes expectations about SRs [54], we checked whether each of the chosen dimensions had been a topic in the general media. For the last 10 years, media have routinely communicated about the rise of robots [55] and about their future competencies in terms of emotions (e.g., [56]), language (e.g., [57]), consciousness (e.g., [58]), and morality (e.g., [59]), showing that the five dimensions of BHNUS already belong to the public's imaginary and debate.

The BNHUS differs from previous measures developed to explain negative emotional and behavioral tendencies towards robots. First, research on the uncanny valley effect has focused on feelings of eeriness and discomfort. For example, MacDorman and Ishiguro [60] measured the human likeness, eeriness, and familiarity experienced by participants when presented with images of robots (see also [18]). Second, research on threat distinctiveness has focused on the following:

a. The feeling of identity damage (e.g., "Recent advances in robot technology are challenging the very essence of what it means to be human" [21]; "Technological advancements in the area of robotics is threatening to human uniqueness" [19]; "Looking at this kind of robot I ask myself what the differences are between robots and humans" [20]);

b. Attribution of mind experience (e.g., "it seems like this robot can feel pain" [19] and agency (e.g., if the robot can recognize emotion);

c. Attribution of human traits (e.g., "To what extent does this feature describe the robot in the picture?: aggressive, impatient, etc.").

Instead, the BHNUS focuses on the perceived ontological status of SRs, by asking participants how much humanness they are willing to concede to a SR. Finally, when previous research has determined the contextual factors that increase the tendency to experience threat and to reject SRs (e.g., robot appearance or autonomy), BHNUS is aimed at identifying who exhibits the most bias and understanding the variability of reactions towards SRs.

Because BHNUS assesses the extent to which humans deny hallmarks of humanness to SRs, all items were phrased in the negative form (see Table 1). Moreover, items were formulated in a prospective way. Indeed, if the actual skyrocketing advances in artificial intelligence make the implementation and display of experiential attributes (e.g., emotions, morality) in SRs credible and feasible, SRs is still in its infancy. Accordingly, it was decided to begin each item with "Even if ultrasophisticated…".

3. Aims and Overview of the Studies

To construct and validate the BHNUS, recommendations of Boateng et al. [61] were followed. This research presents a series of studies (see Figure 1) aimed at testing BHNUS construct validity and nomothetic span (i.e., "the pattern of significant relations among measures of the same or different constructs", p.11 [62]). More precisely, Studies 1 and 2 examine BHNUS structural properties and internal validity through a principal component analysis (PCA) and a confirmatory factor analysis (CFA). Study 3 examines convergent and discriminant validities, exploring the relation between BHNUS, negative attitudes towards robots, interest for Sci-Fi, and religiosity. Studies 4–7 further explore the nomothetic span of BHNUS. Study 4 explores how BHNUS is associated with the attribution of traits of WARM and COM to SRs. Study 5 explores the relation between BHNUS and the emotional appraisal of SRs. Study 6 explores the role of perspective taking (PT) as a predictor of BHNUS. Finally, Study 7 explores the social acceptance of SRs by exploring the relation between BHNUS and attitudes towards the development of robots with human features.

In all studies, the surveys were distributed to participants following a snowball sampling method, inviting participants via e-mail, and social media to participate and to forward the survey to friends and acquaintances.

4. Empirical Studies

4.1. Study 1

4.1.1. Method

4.1.1.1. Participants and Procedure. Data was collected online using a Google Docs survey form. Prior to answering the questionnaire, participants were informed about the voluntary character of the study, the anonymity, and the confidentiality of the collected data. Table 2 presents the sociodemographic characteristics of the participants.

4.1.1.2. Material. Participants responded to the six items of the BHNUS (see Table 1) on a 7-point scale (from 1 = *totally disagree* to 7 = *totally agree*). The scale displayed a good internal consistency (Cronbach $\alpha = 0.81$). Higher values indicate stronger beliefs in the uniqueness of HN.

4.1.2. Results

4.1.2.1. Preliminary Analyses. Missing values, outliers, normality, skewness, and kurtosis were analyzed. Two participants with missing values were removed from the sample. Nine outliers were identified through the box and whisker plot and the outlier labeling rule [63] and were removed from analyses. The final sample is composed of 204 participants (see Table 2). Table 3 displays the descriptive statistics for the BHNUS and its items. Skewness and kurtosis values are all below the threshold recommended by Curran, West, and Finch [64] (i.e., 2 and 7, respectively; see also [65]). With a ratio of 34(:1) and a total $N = 204$, the sample size fits the recommendations of the rule of thumb of 10 respondents per survey item [66] and 200–300 participants for appropriate factor analysis [67].

Table 2: Sociodemographic characteristics of the participants in the seven studies.

	Study						
	1	2	3	4	5	6	7
N	204	330	187	100	60	100	63
Age							
M	25.76	32	26.14	25.60	21.50	27.01	30.87
SD	7.52	9.99	7.97	9.15	3.84	9.60	11.61
Min–max	18–56	18–79	18–56	18–66	18–41	18–64	18–63
Gender							
Female	158	187	142	65	35	60	35
Male	44	141	43	35	25	40	28
Not reported	2	2	2	—	—	—	—
Schooling							
Senior high school	59	174	55	10	3	63	26
University degree	136	156	123	90	57	30	33
Not reported	9	—	9	—	—	7	4
Occupation							
Student	129	72	113	68	54	60	22
Management, sales, and public service	21	54	22	13	1	9	16
Tourism	—	19	—	—	—	5	1
Education and health	23	45	15	7	1	11	9
Information technology	2	19	—	—	—	1	2
Unemployed	7	14	7	4	1	2	1
Others	9	53	17	8	2	—	9
Not reported	13	54	13	—	1	12	3

Note: All participants are Portuguese native speakers.

Table 3: Descriptive statistics for the BHNUS and items in Study 1.

	N	Min-max	*M*	*SD*	S	K
BHNUS	204	1–7	5.50	1.14	−0.63	−0.15
Item 1	204	1–7	6.58	0.82	−1.98	2.98
Item 2	204	1–7	5.88	1.41	−1.33	1.26
Item 3	204	1–7	4.48	2.09	−0.25	−1.26
Item 4	204	1–7	5.78	1.47	−1.51	1.87
Item 5	204	1–7	5.25	1.73	−0.82	−0.27
Item 6	204	1–7	5.06	1.82	−0.70	−0.49

Abbreviations: BHNUS = Beliefs in Human Nature Uniqueness Scale; K = kurtosis; S = skewness.

4.1.2.2. PCA. A PCA was conducted to test the structure of the BHNUS. The Kaiser–Meyer–Olkin measure of sampling adequacy reached the minimum value required (KMO = 0.78) and the Bartlet test of sphericity was significant (X^2 ($df = 15$) = 462.44, $p < 0.001$), indicating that the data was suitable for factorial analysis. Component extraction was based on eigenvalues and an orthogonal method of component rotation with varimax rotation was used. The analysis produced a one component solution (Eigenvalue = 3.178) that accounted for 53% of the explained variance. All the variables presented loadings above 55 (see Table 4). In short, results support a one-factor solution.

4.2. Study 2. Study 2 tested the validity of the structure of BHNUS obtained in Study 1 by using a CFA.

4.2.1. Method

4.2.1.1. Participants, Procedure, and Material. Data was collected online using a Google Docs survey form. Prior to answering the questionnaire participants were informed about the voluntary character of the study and the anonymity and confidentiality of the collected data. Sociodemographic characteristics of the participants are presented in Table 2. Participants filled out the six items of the BHNUS on a seven-point scale (from 1 = *totally disagree* to 7 = *totally agree*). The scale displayed a good internal consistency (Cronbach $\alpha = 0.91$). Higher values indicate a stronger belief in the uniqueness of HN.

4.2.2. Results

4.2.2.1. Preliminary Analyses. Missing values, outliers, normality, skewness, and kurtosis were analyzed. Fifteen participants with missing values were removed. No outliers were identified through the box and whisker plot and the outlier labeling rule [63]. A total of 330 participants completed the questionnaire. Table 5 shows the descriptive statistics for the BHNUS and its items. Skewness and kurtosis values are all below the threshold recommended by Curran et al. [64] (i.e., 2 and 7, respectively; see also [65]). The sample size

Table 4: Component loadings for the BHNUS in Study 1.

Item 5	Even if ultrasophisticated, a robot will never have consciousness.	0.85
Item 2	Even if ultrasophisticated, a robot will never feel the same emotions as a human being.	0.81
Item 6	Even if ultrasophisticated, a robot will never have morality.	0.81
Item 3	Even if ultrasophisticated, a robot will never use language in the same way as a human being.	0.63
Item 4	Even if ultrasophisticated, a robot will always be a mechanical imitation of the human being.	0.62
Item 1	Even if ultrasophisticated, a robot will never be considered a human being.	0.57

Table 5: Descriptive statistics for the BHNUS and items in Study 2.

	N	Min-max	*M*	*SD*	S	K
BHNUS	330	1–7	5.09	1.53	−0.48	−0.57
Item 1	330	1–7	5.80	1.64	−1.35	0.95
Item 2	330	1–7	5.33	1.85	−0.82	−0.50
Item 3	330	1–7	4.26	2.12	−0.10	−1.34
Item 4	330	1–7	5.44	1.76	−0.92	−0.18
Item 5	330	1–7	4.99	1.84	−0.52	−0.81
Item 6	330	1–7	4.69	1.90	−0.28	−1.06

Abbreviations: BHNUS = Beliefs in Human Nature Uniqueness Scale; K = kurtosis; S = skewness.

($N = 330$) fits the rough guidelines for large samples that allow performing confirmatory factorial analysis [68].

4.2.2.2. CFA. A CFA was used to test the unifactorial model obtained in Study 1. The X^2/degrees of freedom ratio, the root mean square error approximation (RMSEA), the standardized root mean square residual (SRMR), the comparative fit index (CFI), the nonnormed fit index (TLI), and the adjusted goodness of fit index (AGFI) values were used to evaluate the model [69, 70]. Figure 2 presents the initial model (Model 1) with the respective standardized estimates.

The analysis of the fit indices showed that only the SRMR and the CFI were within the threshold for reasonable fit (see Table 6). Analysis of the modification indices indicated that error for items BHNU1 ("*a robot will never be considered a human being*") and BHNU2 ("*a robot will never feel the same emotions as a human being*") and BHNU1 and BHNU4 ("*a robot will always be a mechanical imitation of the human being*") were correlated. Error correlation between items BHNU1 and BHNU4 could be due to item wording, since both sentences convey a similar idea,that is, a robot will never be a human. The correlation between the error of item BHNU1 and BHNU2 could be the result of participants viewing the capacity to experience emotions as a core human characteristic.

As suggested in the literature (e.g., [68, 70]), alternative models were produced and tested. Two respecified models with error covariance between items BHNU1 and BHNU4 (Model 1A) and items BHNU1 and BHNU2 (Model 1B) were tested. In the third model (Model 2), item BHNU1 was excluded from the solution. Results showed that Model 1A and Model 1B displayed better fits than Model 1 (see Table 6). Although Model 1B displays better-fit indexes than Model 1A, there is no theoretical sound justification for the error correlation between item BHNU1 and BHNU2. Dropping item BHNU1 (Model 2) resulted in a model that displayed reasonably good fit indexes offering a parsimonious and theoretically sound solution. Accordingly, BHNU1 was ruled out from the final solution. Figure 2 presents the final model (i.e., Model 2), with 5 items, and the respective standardized estimates.

Composite reliability (CR) and the average variance extracted (AVE) are measures of the scales' internal reliability and convergent validity and should be above the cut-off points of 0.70 and 0.50, respectively. The CR value (0.91) and AVE value (0.66) calculated for the final 5-item solution (i.e., Model 2) are indicative of both good internal reliability and convergent validity, attesting to the construct validity of the BHNUS.

To test the reliability of the proposed solution, participants were grouped by gender. Results showed that, compared to Model 1, the 5-item solution (Model 2) displayed better fits with both gender subgroups (see Table 7). Moreover, further analyses showed that women ($M = 5.17$; SD = 1.54) endorsed more BHNU than men ($M = 4.62$; $SD = 1.66$), $t(326) = 3.09$; $p = 0.002$ (95%CI = $[0.20 ; 0.90]$).

Values of CR for both gender subgroups are indicative of the construct's good internal reliability (male CR = 0.90; female CR = 0.91). AVE values for both subgroups are indicative of good convergent validity (male AVE = 0.64; female AVE = 0.67) regarding the items of the scale. To sum up, the 5-item solution seems to be reliable and is considered as the final version. As such, it will be used all through Studies 3 to 7.

4.3. Study 3. Study 3 explores the relation between BHNUS, attitude towards robots, religiosity, and interest in Sci-Fi. Research showed that perceiving an outgroup as threatening the uniqueness of the ingroup elicits a competitive intergroup comparison which results in negative intergroup judgements and behaviors [71]. Accordingly, it is hypothesized that participants scoring high on BHNUS will also display more negative attitudes toward robots, providing evidence for BHNUS convergent validity.

Most religions are based on the belief that the universe, earth, humans, and all other living creatures were created by God(s), and that men have an immaterial component that only God(s) could create: the soul. In other words, believers think that humans are imbued with a mystical essence that makes them unique. If some religions (e.g., Animism, Shinto, Buddhism, or New Age philosophies) assume that every element of Nature, as well as artifacts made by humans, can have a soul, some other religions (e.g., Judeo-Christianism) assume a radical division between creatures

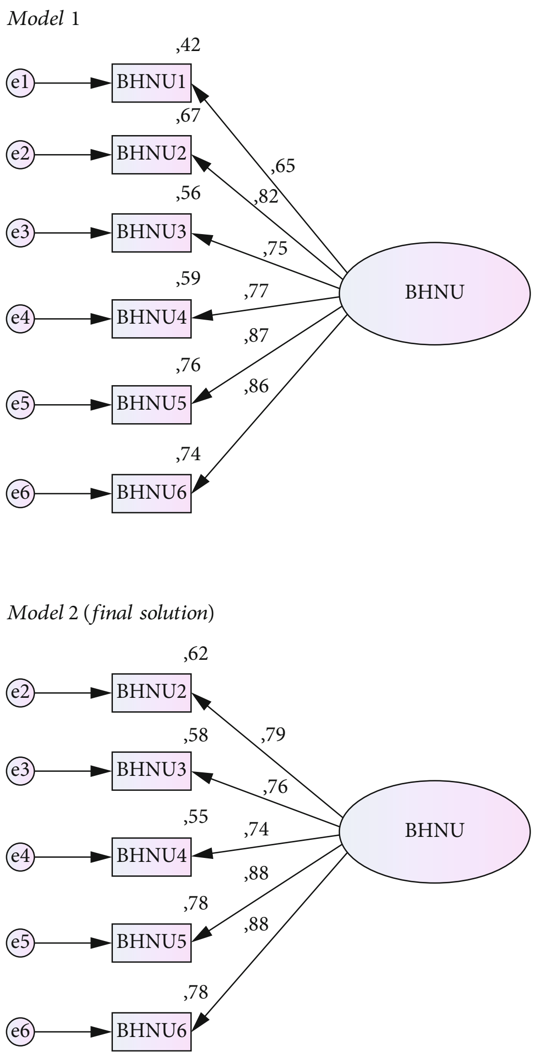

Figure 2: Confirmatory factorial analyses (CFA) of the BHNUS for a 6- and 5-item structure.

Table 6: Models fit in Study 2.

	Model 1	Model 1A	Model 1B	Model 2
χ^2 (df)	125.77 (9)	95.11 (8)	19.70 (7)	17.86 (5)
χ^2/df	13.98	11.89	2.81	3.57
SRMR	0.057	0.051	0.021	0.021
AGFI	0.734	0.777	0.940	0.935
CFI	0.910	0.933	0.990	0.988
TLI	0.850	0.874	0.979	0.975
RMSEA	0.199	0.182	0.074	0.088
IC 90%	0.169–0.230	0.150–0.216	0.037–0.114	0.046–0.134
PCLOSE	0.000	0.000	0.129	0.064
CAIC	207.36	183.50	114.89	85.85

Note: Model 1 = one-factor solution with 6 items; Model 1-A = respecified model with error covariance between Items 1 and 4; Model 1-B = respecified model with error covariance between Items 1 and 4 and Items 1 and 2. Model 2 = one-factor solution with 5 items.

Table 7: Models fit for male and female samples in Study 2.

	Model 1		Model 2	
	Male	Female	Male	Female
χ^2 (df)	55.93 (9)	83.05 (9)	9.62 (5)*	24.30 (5)
χ^2/df	6.21	9.23	1.92	4.86
SRMR	0.067	0.050	0.025	0.029
AGFI	0.730	0.690	0.920	0.858
CFI	0.906	0.908	0.989	0.969
TLI	0.844	0.846	0.978	0.938
RMSEA	0.193	0.210	0.081	0.144
IC 90%	0.146–0.243	0.170–0.253	000–0.158	0.090–0.204
PCLOSE	0.000	0.000	0.209	0.003
CAIC	127.32	157.83	69.11	86.61

Note: Model 1 = one-factor solution with 6 items; Model 2 = one-factor solution with 5 items; $N = 187$ females and 141 males.
$^*p = 0.087$.

and artifacts [72, 73]. Without an ensoulment event, SRs remain , for Judeo-Christianism, nonhuman soulless artifacts incapable of moral [72]. Congruently, Katz and Halpern [74] found that Judeo–Christian religiosity was associated with more negative attitudes towards robots (measured with Negative Attitude towards Robots Scale (NARS) [75]). Accordingly, it is hypothesized that participants reporting a higher level of religiousness (REL) will also present a higher level of BHNU.

Sci-Fi creates a space for questioning the relation between humans and machines [76] and provides a meaningful framework to consider android robots [77]. Sci-Fi consumption has been shown to be associated with more positive attitudes towards robots. For example, the number of robot movies recalled by participants is associated with a more positive evaluation of robots, whether measured by NARS [78] or by a modified version of the Frankenstein syndrome [79] by Sundar et al. [80]. Mara and Appel [77] also showed that participants who read a Sci-Fi story before interacting with the robot *Telenoid*, perceived the robot to be more human-like and reported lower levels of eeriness compared to those who read an informational leaflet or participants in the control condition. Accordingly, we hypothesized that participants high in BNHU will have lower interest in Sci-Fi literature and movies.

4.3.1. Method

4.3.1.1. Participants and Procedure. Data was collected online using a Google Docs survey form. Prior to answering the questionnaire participants were informed about the voluntary character of the study and the anonymity and confidentiality of the collected data. Sociodemographic characteristics of the participants are presented in Table 2.

4.3.1.2. Material. BHNU. Participants responded to the 5-item of the BHNUS on a 7-point scale (1 = *totally disagree* to 7 = *totally agree*). Higher values indicate a stronger belief in the uniqueness of HN.

Attitude Towards SRs. Participants filled out the Portuguese adaptation (PNARS) [81] of the NARS [75]. The PNARS is a 12-item scale composed of two factors, negative attitudes towards robots with human traits (NARHT) and negative attitudes towards interactions with robots (NATIR). Items were rated on a 7-point scale ranging from 1 = *I totally disagree* to 7 = *I totally agree*. To facilitate the reading of results, scores were reversed so that higher scores indicate a more positive attitude towards robots.

Religiousbeliefs (REL) . To capture how religious beliefs could shape their worldviews, participants were asked to respond to the four following items developed for the study: "How would you describe your belief" (from 1 = *nonbeliever* to 7 = *strong believer*); "To what extent do you consider yourself religious?" (from 1 = *not at all religious* to 7 = *very religious*); "In my life I follow my religion's teachings thoroughly" (from 1 = *not at all* to 7 = *very much*); "In my opinion, the teachings and rules of my religion should have a big influence on the model of the society in my country/in the world" (from 1 = *completely disagree* to 7 = *completely agree*). Higher scores indicate a higher level of REL.

Interest in Sci-Fi. Participants were asked to report their fondness for (1) Sci-Fi films and (2) Sci-Fi books, on a 7-point Likert scale ranging from 1 = *I really dislike* it to 7 = *I really like it*. Items were developed specially for the study. Higher scores indicate higher interest in Sci-Fi culture.

4.3.2. Results

4.3.2.1. Preliminary Analyses. Missing values, outliers, normality, skewness, and kurtosis were analyzed (see Table 8). Skewness and kurtosis values were all below the threshold recommended by Curran et al. [64] (i.e., 2 and 7, respectively; see also [65]). No outlier was identified through the analyses of the box and whisker plots. All variables, except the REL, have less than 2% missing values. Three of the REL items are below 5% missing values and one has 6% missing values. Little's missing at random (MCAR) test confirms that values were missing at random. Missing values were replaced using the expectation maximization (EM) method. All the scales displayed good reliability results (CR and Cronbach $\alpha > 0.70$; see Table 8).

A series of one-sample t-tests were conducted to compare the means with the mean point of the scales (see Table 8). Results showed that the means of BHNUS, PNARS, NATIR, and Sci-Fi were significantly above the mean point of the scales (i.e., 3.5), whereas religiosity was below.

4.3.2.2. Correlational Analyses. Table 9 displays the correlations between the variables. Results showed that participants who denied HN to robots (i.e., higher score on BHNUS) were also those who had the following: (1) more negative attitude towards robots displaying human traits (NARHT), (2) more negative attitude towards interaction with robots (NATIR), (3) less interest in Sci-Fi, and (4) a higher level of REL. Moreover, correlations between BHNUS/NARHT and BHNUS/NATIR were compared using Diedenhofen and Musch's [82] cocor software package web interface

Table 8: Descriptive statistics of the scales used in Study 3.

	N	Min–max	M	SD	CR	α	S	K
BHNUS	187	2–7	5.18**	1.40	0.89	0.83	−0.58	−0.36
PNARS	187	1–7	4.23**	1.11	0.89	0.86	−0.24	−0.35
NARHT	187	1–7	3.63	1.24	0.84	0.75	−0.13	−0.36
NATIR	187	2–7	4.82**	1.17	0.85	0.78	−0.35	−0.20
REL	187	1–7	3.13*	1.73	0.95	0.93	0.44	−0.93
Sci-Fi	187	1–7	4.47**	1.65	0.93	0.85	−0.40	−0.63

Note: Means differ from the middle point of the scale (i.e., 3.5).
Abbreviations: α = Cronbach alpha; BHNUS = Beliefs in human nature uniqueness scale; CR = composite reliability; K = kurtosis; NARHT = negative attitudes towards robots with human traits; NATIR = negative attitudes towards interactions with robots; PNARS = negative attitudes towards robots scale; REL = religiousness; Sci-Fi = interested in science fiction; S = skewness.
$^{*}p < 0.05$.
$^{**}p < 0.001$ (one sample t-test).

Table 9: Correlations between the variables used in Study 3.

	AVE	NARHT	NATIR	REL	Sci-fi	BHNU
NARHT	0.46	**0.68**				
NATIR	0.49	0.69***	**0.70**			
REL	0.83	−0.20**	−0.28***	**0.91**		
Sci-Fi	0.87	0.26***	0.33***	−0.11	**0.93**	
BHNUS	0.61	−0.50***	−0.34***	0.18*	−0.26***	**0.78**

Note: All correlations are 2-tailed. Bold diagonal values are the squared root of the AVE.
Abbreviations: AVE = average variance extracted; BHNUS = Beliefs in Human Nature Uniqueness Scale; NARHT = negative attitudes towards robots with human traits; NATIR = negative attitudes towards interactions with robots; REL = religiousness; Sci-Fi = interested in science fiction.
$^{*}p < 0.05$.
$^{**}p < 0.01$.
$^{***}p < 0.001$.

(http://comparingcorrelations.org/). Results showed that BHNUS was significantly more correlated with NARHT than with NATIR ($z = -3.0997$, $p = 0.0019$, 95% CI [−0.26; −0.05]). These patterns of correlational results confirm that BHNUS measures a construct that is related to attitudes towards robots, religiosity, and interest in Sci-Fi. On the other hand, the analysis of the square root of the AVE for these variables shows that, although related, they are measuring different constructs (see Table 9).

4.4. Study 4. Study 4 explores the association between BHNU and the attribution of WARM and COM to SRs. According to the stereotype content model (SCM [83, 84]), social perception answers two key questions as follows: (1) do outgroup members have good (vs. bad) intentions toward me and my group? (i.e., WARM); (2) can outgroup members enact their intentions? (i.e., COM). WARM comprises traits like morality, trustworthiness, sincerity, kindness, and friendliness, whereas COM comprises traits like efficacy, skill, creativity, confidence, and intelligence. While WARM deals with social acceptance and connection and determines approach-avoidance tendencies, COM deals with status and the capacities that are needed to attain goals [85]. Interestingly, traits associated with WARM are also those who define humanness. Consequently, it is argued that stronger BHNU endorsement should be related to a lower perception of WARM and should not be related to the perception of COM, since these traits are not central to the definition of what it means to be human.

4.4.1. Method

4.4.1.1. Participants and Procedure. One hundred volunteers participated in the study (see Table 2 for participants' sociodemographic characteristics). Prior to answering the questionnaire participants were informed about the voluntary character of participation and the confidentiality of the data collected. After completing the BHNUS, participants were randomly assigned to one of two video conditions: a mechanical robot (i.e., Snackbot) or an android robot (Actroid DER). The videos lasted 1 min and 50 s. Participants received the following instructions: "In the future, it will be common to interact with robots. This will happen in public spaces (factories, offices, museums) and in our houses. We are going to show you a video with one of those SRs. Your task is to imagine yourself working with this robot in the near future and forming an opinion about it". During both videos, a female voice narrated the following: "Hello, my name is Snackbot (or Actroid) and I'm a SR. A SR is a robot created to interact with people in a natural fashion. To do that, my creators included in my design human characteristics like eyes, mouth, language and the capacity to understand and perform social behaviors. In the future, I will be performing such jobs as a hotel receptionist, personal trainer or office clerk. Some even say that in the future I will be responsible for caring for the elders. Goodbye and see you in the future."

After watching the video, participants were instructed to complete the second questionnaire, which included the social perception measures. At the end of the experiment, participants received more information about the research project and were asked for feedback about the experiment and the theme of SRs.

4.4.1.2. Material. BHNU. Participants responded to the 5-item of the BHNUS on a 7-point scale (1 = *totally disagree* to 7 = *totally agree*). Higher values indicate a stronger belief in the uniqueness of HN.

WARM and COM. COM was measured by the items: competent, capable, intelligent, efficient, skillful, and confident and WARM by the items: warm, good natured, sincere, friendly, well-intentioned, and trustworthy. All items were adapted from Fiske et al. [84]. Participants were asked to indicate whether the robot had such qualities on a seven-point Likert-type scale (*e.g.,* 1 = *not warm* to 7 = *very warm*). Higher scores indicate attribution of a higher level of COM and WARM.

SRs. The Snackbot is an assistive SR developed at Carnegie Mellon University. The wheels set on its base allow the robot to move autonomously. The robot is about 142 cm high, with a round shaped head that serves as housing for the visual and verbal hardware. A led display is used to simulate the mouth. The robot is capable of simple verbal interactions. Although its arms are not fully functional, they carry a tray allowing Snackbot to transport objects from one place to another. A series of sensors allow it to travel without bumping into objects (see [86] for a detailed description). The Actroid DER was developed by Kokoro (http://www.kokoro-dreams.co.jp/) and has been used in several technology shows. Actroid DER is a full-sized realistic human-like SR displaying verbal and nonverbal communication. Although it can move its upper body, it is attached to a fixed base.

4.4.2. Results

4.4.2.1. Preliminary Analyses. Normality, skewness, kurtosis, outliers, and missing values were analyzed. Skewness and kurtosis values are all below the threshold recommended by Curran et al. [64] (i.e., 2 and 7, respectively; see also [65]). Table 10 shows the descriptive statistics for the scales used in Study 4 according to the type of robot (i.e., mechanical *vs* human-like). All the scales showed good reliability results (all Cronbach $\alpha > 0.80$).

An independent sample t-test was conducted to compare the level of BHNU endorsement in participants assigned to the Snackbot condition and those assigned to the Actroid condition. Results showed that participants in the Snackbot condition and Actroid condition had the same level of BHNUS, $t(98) = 1.42$, $p = 0.158$, 95%CI = [−0.98 ; 0.16].

Results of a series of one-sample t-test (see Table 10) showed that there is a strong belief that robots will not have human qualities, with BHNU rating significantly higher than the middle point of the scale. Both robots received high ratings for COM (both significantly higher than the mean point of the scale) and were rated higher for COM than for WARM. Moreover, Snackbot was rated higher than Actroid, for both COM ($t(98) = 2.67$, $p = 0.009$, 95%CI = [0.16 ; 1.09]) and WARM ($t(98) = 2.11$, $p = 0.038$, 95%CI = [0.03 ; 1.02]). It should be noted, however, that Snackbot's rating for WARM was significantly higher than the mean point of the scale, while the Actroid's rating was the same as the mean of the scale.

4.4.2.2. Correlational Analyses. Table 11 displays results for the general sample and for mechanical and human-like robots. As expected, BHNU endorsement was significantly and negatively correlated with the perception of WARM in the full sample ($r = -0.34$) and in both appearance conditions ($r = -0.34$ and -0.31) but not with the perception of COM.

4.5. Study 5. Study 5 explores whether BHNU endorsement could affect the subjective emotional state of appraisal of SRs. According to the emotional acceptance of innovation model [87], and the emotional goal system model [88], two states of subjective emotional appraisal are experienced during the decision-making with respect to innovations: (1) a

Table 10: Descriptive statistics of the scales used in Study 4 for both experimental conditions.

	BHNUS	COM	WARM
Cronbach α	0.85	0.88	0.83
M	5.20**	4.26**	3.81*
Mechanical robot	—	4.57**	4.08**
Human-like robot	—	3.95*	3.55
SD	1.44	1.21	1.27
Mechanical robot	—	1.00	1.09
Human-like robot	—	1.32	1.39
Min–max	2–7	1–7	1–6
Mechanical robot	—	2–7	1–6
Human-like robot	—	1-6	1–6
Skewness	−0.54	−0.46	−0.40
Mechanical robot	—	0.07	−0.52
Human-like robot	—	−0.44	−0.15
Kurtosis	−0.51	−0.08	−0.36
Mechanical robot	—	−0.13	0.94
Human-like robot	—	−0.77	−0.97
N total	100	100	100
n Mechanical robot	—	50	50
n Human-like robot	—	50	50

Note: Means differ from the middle point of the scale (i.e., 3.5).
Abbreviations: BHNUS = Beliefs in Human Nature Uniqueness Scale; COM = competence; Human-like robot = Actroid; Mechanical robot = Snackbot; WARM = warmth.
*$p < 0.05$.
**$p < 0.001$.

Table 11: Correlations between the variables used in Study 4.

	BHNUS	COM	WARM
BHNUS	—		
COM	−0.19	—	
WARM	−0.34**	0.62**	—
Mechanical robot			
BHNUS	—		
COM	−0.13	—	
WARM	−0.34*	0.49**	—
Human-like robot			
BHNUS	—		
COM	−0.18	—	
WARM	−0.31*	0.66**	—

Note: All correlations are 2-tailed.
Abbreviations: BHNUS = Beliefs in Human Nature Uniqueness Scale; COM = competence; Human-like robot = Actroid; Mechanical robot = Snackbot; WARM = warmth.
*$p < 0.05$.
**$p < 0.001$.

state of approach (SAP) which is a subjective emotional state that envisions the object of appraisal as an opportunity and comprises subjective emotions like joy, relief, fulfillment and excitement; (2) a state of avoidance (SAV) which is a subjective emotional state that envisions the object of appraisal as a threat and comprises subjective emotions like anger, disgust, fear, and threat. Accordingly, it is assumed that participants with a higher endorsement of BHNU should also have a lower level of SAP and a higher level of SAV.

4.5.1. Method

4.5.1.1. Participants and Procedure. Sixty volunteers participated in the study (see Table 2 for the sociodemographic characteristics of the participants). The experience followed the procedures described in Study 4. Participants were asked to complete the BHNUS and were randomly assigned to one of two video conditions: mechanical robot (Snackbot) versus human-like robot (Actroid DER). After watching the video, participants completed the measurement of SAP and SAV.

4.5.1.2. Material. BHNU. Participants responded to the 5 items of the BHNUS on a 7-point scale (1 = *totally disagree* to 7 = *totally agree*). Higher values indicate a stronger belief in the uniqueness of HN.

Subjective Emotional Appraisal. To measure the subjective emotional appraisal of SR, participants were asked to indicate, on a 7-point item scale (from 1 = *not at all* to 7 = *very*), if they felt joy, relief, fulfillment, and excitement (i.e., SAP), and anger, disgust, fear, horror, and threat (i.e., SAV) when they saw the SR. All items were adapted from [87, 88].

SRs. The manipulation of the level of human-likeness of the robot (mechanical vs. android) was made using the material of Study 4.

4.5.2. Results

4.5.2.1. Preliminary Analyses. Normality, skewness, kurtosis, outliers, and missing values were analyzed. Skewness and kurtosis values are all below the threshold recommended by Curran et al. [64] (i.e., 2 and 7, respectively; see also [65]). Table 12 shows the descriptive statistics for the scales used in Study 5. To ensure that the effects of BHNU on the perception of SAP and SAV, were not the result of the group differences, an independent sample *t*-test was conducted to compare the level of BHNU in participants assigned to the mechanical and human-like robots. Results showed no significant differences in BHNU between the participants of the two groups, $t\,(58) = 1.15$, $p = 0.255$; 95%CI = [−1.114 ; 0.301].

The results of the comparison of the scale's means against the middle point of the scale are shown in Table 12. Mean for BHNU was significantly superior to the middle point of the scale, indicating a strong belief that robots will not have human qualities. Measures of SAP and SAV were rated significantly below the mean of the scale indicating that both robots elicited a low level of subjective emotional appraisal.

Analyses by experimental conditions were conducted. Results showed that for the mechanical robot (Snackbot), the mean of SAP was significantly higher than the mean of SAV ($t\,(29) = 7.17$, $p < 0.001$, 95%CI = [1.02, 1.84]). For the

Table 12: Descriptive statistics of the scales used in Study 5.

	BHNUS	SAP	SAV
Cronbach α	0.81	0.81	0.85
M	5.17**	3.12*	2.43**
Mechanical robot	—	3.69	2.26**
Human-like robot	—	2.54**	2.60**
SD	1.37	1.34	1.46
Mechanical robot	—	1.09	1.37
Human-like robot	—	1.32	1.54
Min–max	2-7	1-6	1–5
Mechanical robot	—	1-6	1–5
Human-like robot	—	1-5	1–5
Skewness	−0.33	−0.22	0.69
Mechanical robot	—	−1.08	−0.93
Human-like robot	—	0.58	0.51
Kurtosis	−0.57	−1.07	−0.86
Mechanical robot	—	1.25	−0.38
Human-like robot	—	−0.66	−1.14
N total	60	60	60
n Mechanical robot	—	30	30
n Human-like robot	—	30	30

Note: Means differ from the middle point of the scale (i.e., 3.5).
Abbreviations: BHNUS = Beliefs in Human Nature Uniqueness Scale; Human-like robot = Actroid; Mechanical robot = Snackbot; SAP = state of approach; SAV = state of avoidance.
$^{*}p < 0.05$.
$^{**}p < 0.001$.

human-like robot (Actroid), there were no differences between the means of SAP and SAV ($t\,(29) = -0.24$, $p = 0.81$; 95%CI = [−0.55 ; 0.44]).

Additional analyses were conducted. Comparison of the means of SAP between the mechanical robot (Snackbot) and the human-like robot (Actroid) showed that the Snackbot elicited a significantly higher SAP ($t\,(58) = 3.67$, $p = .001$; 95% CI = [0.52 ; 1.78]) than the Actroid. Comparison of the means of SAV between the mechanical robot (Snackbot) and the human-like robot (Actroid) showed no statistically significant differences ($t\,(58) = -0.90$, $p = 0.369$; 95%CI = [−1.09, 0.41]). These results suggest that participants found the Snackbot more attractive while feeling ambiguous about the Actroid.

4.5.2.2. Correlational Analyses. To explore the association between BHNU endorsement and emotional appraisal of SR according to their appearance , correlational analyses were conducted for the two conditions (see Table 13). In the mechanical robot condition (Snackbot), BHNU endorsement was not significantly correlated to neither SAP nor SAV. However, in the human-like robot condition (Actroid), BHNU endorsement was negatively correlated to SAP ($r = -0.39$, $p = 0.031$) and positively correlated with SAV ($r = 0.49$, $p = 0.005$). In short, as expected BHNU endorsement was differently related to SAP and SAV, especially when the SR was human like. The more participants denied benchmarks of humanity to SR, the less they reported an emotional SAP and the more they reported an emotional SAV.

Table 13: Correlations between the variables in Study 5.

	BHNUS	SAP	SAV
BHNUS	—		
SAP	−0.37**	—	
SAV	0.35**	−0.39**	—
Mechanical robot			
BHNUS	—		
SAP	−0.29	—	
SAV	0.15	−0.62**	—
Human-like robot			
BHNUS	—		
SAP	−0.39*	—	
SAV	0.49**	−0.21	—

Note. All correlations are 2-tailed.
Abbreviations: BHNUS = Beliefs in Human Nature Uniqueness Scale; Human-like condition = video of Actroid; Mechanical condition = video of Snackbot; SAP = state of approach; SAV = state of avoidance.
$^{*}p < 0.05$.
$^{**}p < 0.001$.

4.6. Study 6. Study 6 explores the association between PT and BHNU endorsement. PT is the cognitive understanding of others' thoughts or feelings by the mental adoption of their point of view. It is a deliberate process which is used relatively infrequently because of its controlled and effortful nature [89], and people have been shown to display chronic differences in the tendency to use it [90]. A growing body of empirical studies has shown that people understand others' mental states by using their self-knowledge. Indeed, PT was shown to be based on a merging of self and other into a psychological "one" (see for a review [91]). For example, Davis et al. [92] have found that PT created an overlap in self and target representations. Moreover, Epley et al. [93] have shown that PT is a simulation process using an "anchoring and adjustment" heuristic based on self-knowledge. More precisely, when reasoning about others' mental states, people use their own mental states and characteristics as a starting point and then make a series of adjustments, incorporating abstract knowledge about the mental state of others. The use of homocentric knowledge helps us to have a direct and immediate access to the phenomenological experience of being a human. However, in the same way that people cannot truly know what it is like to be a bat [94], people may face difficulties in experiencing what it is to be a robot because human sensory experiences fail to provide insightful information [95]. Consequently, it is argued that a higher tendency for PT should be associated with a higher level of BHNU endorsement.

4.6.1. Method

4.6.1.1. Participants and Procedure. One hundred volunteers participated in the study (see Table 2 for the socio-demographic characteristics of the participants).

Participants were recruited at the university and at work and, were asked to fill out a paper and pencil questionnaire.

4.6.1.2. Material. BHNU. Participants responded to the five items of the BHNUS on a 7-point scale (1 = *totally disagree* to 7 = *totally agree*). Higher values indicate a stronger belief in the uniqueness of HN.

PT. Participants responded on a 7-point scale (1 = *totally disagree* to 7 = *totally agree*) to the 5 items of the PT subscale of the Portuguese version [96] of the interpersonal reactivity index [90].

4.6.2. Results

4.6.2.1. Preliminary Analyses. Normality, skewness, kurtosis, outliers, and missing values were analyzed. Skewness and kurtosis values are all below the threshold recommended by Curran et al. [64] (i.e., 2 and 7, respectively; see also [65]). One missing value was replaced by the mean of the group. Table 14 shows the descriptive statistics for the scales.

4.6.2.2. Correlational and Regression Analyses. Correlational analysis showed that BHNU endorsement was positively correlated with PT ($r = 0.31$, $p < 0.001$). Moreover, regression analysis showed that PT was a significant predictor of BHNU endorsement, even after controlling age and gender (see Table 15). In other words, participants showing a stronger tendency for PT also tended to show a stronger tendency to deny the possibility that robots will someday present human properties.

Table 14: Descriptive statistics for variables in Study 6.

	N	*M*	SD	*α*	*S*	*K*
BHNUS	100	5.52*	1.23	0.79	−0.60	−0.31
PT	100	5.06*	0.87	0.74	−0.06	−0.24

Note: Means differ from the middle point of the scale (i.e., 3.5).
Abbreviations: α = Cronbach alpha; BHNUS = Belief in Human Nature Uniqueness Scale; K = kurtosis; PT = perspective taking; S = Skewness.
*$p < 0.001$ (one sample *t*-test).

Table 15: Regression analysis for Study 6: predicting BHNU endorsement from tendency for perspective taking.

	B	SE	Beta	*t*	*p*	*CI*
Age	0.004	0.013	0.033	0.510	0.75	−0.02 to 0.02
Gender	−0.241	0.247	−0.095	−0.698	0.33	−0.73 to 0.25
PT	0.429	0.125	0.341	3.435	0.001	0.18–0.67

Note: $N = 100$; dependent variable = BHNUS; $R^2 = 0.105$; $R^2_{adj} = 0.077$; $F(3.95) = 4.27$; $p = 0.007$.
Abbreviations: CI = confidence interval; PT = perspective taking.

4.7. Study 7. Study 7 explores the association between BHNU endorsement and attitudes towards the development of robots with human features. Złotowski et al. [21] found that participants were less supportive of robotics research after being exposed to robots presented as capable of autonomous decisions than when exposed to robots presented as nonautonomous. Similarly, it is assumed that people who endorse higher levels of BHNU consider the development of robots with human features as useless, unethical, and dangerous.

4.7.1. Method

4.7.1.1. Participants, Procedure, and Material. Sixty-three Portuguese volunteers participated in an online study (see Table 2 for the sociodemographic characteristics of the participants). Data was collected online using a Google Docs survey form. After filling out the BHNUS (see Studies 2 to 6), participants responded to the following question: "I think that the development of robots with human features (e.g., emotions, language, intelligence etc.) is…". The question was followed by 10 adjectives. Participants responded on a 7-point semantic differential scale from 1 to 7 (e.g. = *not at all intelligent* to 7 = *extremely intelligent*) to the 10 adjectives. The usefulness index was measured by the aggregation of the adjectives intelligent and useful. The ethicality index was composed of the adjectives ethical, moral, and correct. The dangerousness index was based on the adjectives dangerous, scary, and risky. Finally, the evilness index was measured with the adjectives good (reversed) and bad. All scales displayed good reliability (all Cronbach $\alpha > 0.70$; see Table 16).

4.7.2. Results

4.7.2.1. Preliminary Analyses. Normality, skewness, kurtosis, outliers, and missing values were analyzed (see Table 16). Skewness and kurtosis values are all below the threshold recommended by Curran et al. [64] (i.e., 2 and 7, respectively; see also [65]).

4.7.2.2. Correlational Analyses. Results showed that people who endorsed more BHNU were those who believed that the development of robots displaying human features was less useful, less ethical, more dangerous, and bad (see Table 16). In short, people who are more prone to deny a HN to robots are also those who hold a more negative attitude towards the development of robots displaying human features.

5. General Discussion

The specific aim of this article was to elaborate and validate the BHNUS to assess the individual tendency to deny human features to SRs in terms of biological nature, emotions, language, consciousness, and morality, that is, the classical benchmarks of humanness.

5.1. Psychometric Characteristics of BHNUS. Results of principal PCA and CFA (Studies 1 and 2) showed that BHNUS had a unidimensional structure and displayed good structural qualities. Moreover, BHNUS displayed a good internal reliability across the seven studies. BNHUS also displayed good convergent and discriminant validities. BHNUS was significantly correlated with several cognitive, emotional, and attitudinal factors implicated in human-robot interaction. Indeed, participants who denied HN to robots were

Table 16: Descriptive statistics and correlations between variables in Study 7.

	BHNU	Usefulness	Ethicality	Dangerousness	Evilness
M	5.04	4.92	3.84	4.69	3.85
SD	1.27	1.25	1.18	1.22	1.16
Min-Max	1–7	1–7	1–7	2–7	1–7
S	−0.68	−0.63	−0.14	0.04	0.28
K	−0.27	1.24	0.65	−0.45	1.26
α	0.78	0.71	0.87	0.86	0.77
BHNUS	—	−0.36**	−0.39**	0.28**	0.39**
Usefulness		—	0.66**	−0.33**	−0.64**
Ethicality			—	−0.39**	−0.67**
Dangerousness				—	0.55**
Evilness					—

Note: $N = 63$.
Abbreviations: α = Cronbach alpha; BHNUS = Belief in Human Nature Uniqueness Scale; K = kurtosis; S = skewness.
*$p < 0.01$.
**$p < 0.001$.

also those as follows: (a) who had more negative attitudes toward robots (Study 3); (b) who thought that development of SRs with human features was bad, dangerous, unethical, and not useful (Study 7); (c) who attributed less WARM and COM to SRs (Study 4); (d) who experienced more emotional states associated with avoidance after seeing a human-like SR (Study 5); (e) who were chronically more prone for PT (Study 6); (f) who were more religious (Study 3); (g) who dislike more strongly the Sci-Fi genre (Study 3). In brief, BHNUS appears to be a reliable tool to assess the tendency to deny humanness to SR.

5.2. Theoretical Implications. Extending previous research, BHNUS offers a new perspective on the acceptance/rejection of robots by exploring the role of beliefs in the perception of threats to identity and humanness. So far, surveys and empirical studies have shown that people generally do not like robots (e.g., [97]), and that attitudinal rejection of robots (measured with NARS [75]) was associated with socio-demographic variables such as gender (e.g., [98]), culture (e.g. [99]) or religion (e.g., [98]). Recent studies (e.g., [21]) have also shown that negative attitude towards robots and/or their development can be explained by the fact that they are perceived as a threat to human identity and humanness because of contextual (i.e., real conflict and threat) or motivational (i.e., preserving human identity) factors when social comparison occurred (i.e., when SRs are seen as faster, stronger, more intelligent than humans). Expanding previous research, the present work shows the existence of an idiosyncratic tendency to reserve HN to humans and deny it to SRs (i.e., BHNU) that is associated with the attitudinal and emotional rejection of SR. Indeed, participants displaying higher BHNU endorsement were also those who displayed higher level of negative attitudes towards robots (Study 3), a lesser perception of WARM (Study 4), more emotional states of avoidance (Study 5), and considered the development of robots with human features as useless, nonethical, and dangerous (Study 7). To sum up, even if SRs display qualities considered as unique to humans, individuals with a higher level of BHNU will deny the possibility of an ontological status to SRs. Put in other words, even if humans, one day, were unable to see any differences in reactions between them and SRs (e.g., same expressions of love), humans could keep making differences between them and SRs by denying to SRs an equal ontological status.

5.3. Practical Implications. As Złotowski et al. [21] have suggested, research on SRs will not stop and the speed of its development will depend on available funds and general public acceptance of robots. Consequently, the identification of cultural, sociological, and psychological factors associated with SRs rejection is crucial. BHNUS has practical implications in the study of human-robot interaction. Firstly, BHNUS is a short and flexible instrument with good psychometric properties that could be a useful tool to study the social acceptance of SRs, the prediction of the evaluation of different types of robots (e.g., mechanical vs. human-like), and the quality of interaction with them, and to compare different social groups and cultures on their attitudes towards SRs. Secondly, based on our results, it can be assumed that a high level of BHNU endorsement may be an inhibiting factor to SRs acceptance and the intention to work with SRs. Indeed, a high level of BHNU endorsement could be associated with lower expectations about robots' performance, and with high reluctance for SRs to perform jobs involving emotions. Accordingly, BHNUS can be used in human resources management to gauge the prior BHNU of employees who will work with SRs, to tailor a formation to reduce BHNU, and monitor its evolution. Finally, the issue of the standing and legal personality of SRs as "electronic persons" already became a hot social topic yielding controversy, resistance, or enthusiasm [100]. Indeed, in 2017, the European Union already debated on the possibility to grant intelligent robotic artefacts an electronic personhood. The BHNUS could clearly help scientists, developers, opinion pollsters, or non-governmental organizations in the comprehension of the different reactions towards the possibility of granting a personhood to SRs. In the same line of reasoning, the BHNUS could be useful for scientists and developers for exploring the intention to have a robotic companion, the type of relationship and use (i.e., friendship, romantic, or sexual), and for determining the most effective design for users. The BHNUS could also be used to explore, from an idiosyncratic point of view, the classical uncanny valley effect, and especially the "uncanny valley of mind" [45] and shed light on how the denial of ontological status to SRs can contribute to the feelings of eeriness triggered by emotion-sensitive technology. To conclude, understanding the factors that promote the endorsement of BHNU could help designers, marketers, public policymakers, managers, and advocates of SRs to design advertising, marketing strategies, and organizational and societal promotion, to speed up the market breakthrough and increase general public acceptance.

5.4. Further Research. In the present paper, BHNU is not considered as a fixed idiosyncratic personality factor but as an individual sociocognitive factor that can be influenced by ideological and cultural context. Consequently, the next step is to identify the cultural, sociological, and psychological factors that could favor a higher or a lower endorsement of BHNU. Religion, popular culture (e.g., cinema and literature), or advertisement could be factors that can favor or inhibit BHNU endorsement. Indeed, BHNU endorsement was positively correlated with participants' conviction that religion should guide social life (Study 3) and negatively correlated with a taste for the Sci-Fi genre (Study 3) and the psychological chronic tendency for PT (Study 6). Further research should understand how and why religion, popular culture, advertisement, personality factors, and BHNU endorsement are associated. Moreover, BHNUS was developed with participants of a Western, educated, industrialized, rich, and democratic (WEIRD) society [101]. If BHNUS can vary according to cultural factors, as proposed above, further studies should test BHNUS in non-WEIRD societies. Moreover, if BHNUS is associated with cultural norms and religious beliefs, intercultural studies should be then conducted to identify how these latter could enrich BHNUS' applicability across diverse populations and cultures. Because BHNU is associated to the defense of human identity, further research should also explore the potential articulation of BHNU with social identities through the *self-categorization* to groups associated to technology (e.g., profession) or to *identification with all humanity*. Further research (e.g., focus group, test group, prospective studies) should also contemplate the possibility to upgrade the BHNUS to accompany the development of SRs by the integration of new items reflecting dimensions that are considered as only human and can be, at one point of time, implemented into robots (e.g., creativity, empathy). Finally, all studies presented are based on the use of nonprobabilistic samples that increase the risk of selection bias and could decrease the generalization of the results. Although the BHNUS displays a good reliability across all studies, future investigations should be made using representative samples.

6. Conclusion

The development of the BHUNS contributes to and deepens research about the perception of SR as a threat to group, identity, and humanness, by providing a short instrument with good psychometric properties that allows researchers and practitioners to assess the individual tendency to deny HN to SR. Collectively, the findings of the present seven studies showed that BNHUS is a reliable scale to measure the tendency to deny human features to SRs. So far, research has focused on the contextual experienced threat to group, identity, and humanness after being exposed to SRs. The present results expand previous research by offering some insight into how BHNU endorsement, as an individual socio-psychological factor, can influence the perception of SRs, and, *in fine,* the human-robot interaction. To conclude, BHNU(S) provides a theoretical and empirical framework to understand why SRs will still be considered "mecha" even if they could display human qualities and behaviors (e.g., capability of love) that could make them indistinguishable from humans.

Data Availability Statement

Data is available on request.

Conflicts of Interest

The authors declare no conflicts of interest.

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