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Culture and anthropomorphism towards robots in middle school students: Evidence from Human-Robot Interaction

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Abstract

Individual differences play a fundamental role in shaping people's attitudes towards robots. Among them, culture is one of the most deeply ingrained in individuals throughout their growth. Thus, given the crucial role of culture in shaping individuals' development, the present study investigated whether, and to what extent, individuals' cultural profile modulates their tendency to anthropomorphise robots, i.e., the likelihood of attributing human-like traits to them. Specifically, we focused on middle school students as one of the main targets of technological artefacts, including robots, in the near future. To this aim, we asked our sample (*N* = 85) to fill out a set of questionnaires about their cultural profiles beyond their nationality. Then, we adapted two well-established paradigms in experimental and social psychology to capture two dimensions of their anthropomorphism towards robots: (1) the Implicit Association Test (IAT), which allowed us to measure the strength of the association between the concept of "robot" and the attribute "anthropomorphic"; and (2) the Cyberball ball-tossing game, which measures participants' tendency to socially include robots. Results showed that individuals' cultural profile, operationalised as participants' scores at the cultural questionnaires, modulated their tendency to anthropomorphise robots, yet differently based on the kind of task (IAT vs. Cyberball). Interestingly, only some cultural values significantly affected participants' anthropomorphism towards robots, thus indicating that culture is a multi-faceted concept that deserves attention in future studies in the field of human-robot interaction.

Keywords: Culture, Anthropomorphism, Robot, IAT, Cyberball.

1. Introduction

Anthropomorphism has been defined as the attribution of human-like characteristics to non-human entities (Epley, Waytz & Cacioppo, 2007). This definition presents anthropomorphism as a psychological phenomenon, which Fischer (2021) termed *psychological anthropomorphism* and as conceptually distinct from the level of morphological similarity between non-human entities and human beings, called by Fisher *anthropomorphic design*.

As psychological anthropomorphism is a *psychological* phenomenon, there are good reasons to believe that it may affect people's interactions with non-human entities such as technological artefacts. This means that, in certain contexts, people may react to and interact with them differently depending on whether they anthropomorphise them or not. This makes the study of anthropomorphism in relation to robots – a particular class of technological systems that are becoming increasingly prevalent in various fields, including healthcare, personal assistance and education – of particular interest to the community working in the field of human-robot interaction (HRI). Roesler, Manzey and Onnasch (2021) presented a meta-analysis of 78 studies investigating the effect of anthropomorphism on human-robot interaction (HRI): they concluded that many aspects of this relationship need to be further investigated, which is not surprising given the novelty of the field and the rapid advancement of technologies.

Focusing on how *children* anthropomorphise robots may shed light on their relationship with this technology. The study presented here builds on existing literature (reviewed below) by examining how children's cultural profiles influence their tendency to anthropomorphise robots, with a particular focus on the pre-adolescent period (roughly from ages 11 to 14). Why focus on culture and pre-adolescence specifically? Let us start with the latter question. The existing scientific literature supports the general hypothesis that age is negatively correlated with the tendency to anthropomorphise robots. Goldman and colleagues (2023), for example, recently examined the role of robot morphology in preschoolers' likelihood of anthropomorphising robots. A sample of both 3- and 5-year-old children responded to a set of questions about whether, in their opinion, non-human entities such as animals, artefacts, and robots have mechanical or biological internal parts. Results showed that 3-year-old children often confused the internal parts of robots, sometimes assigning them with biological "insides" (e.g., a heart). However, at age 5, children were better at identifying robots as mechanical entities, although they still tended to attribute feelings and thoughts to a humanoid robot like NAO (Goldman et al., 2023). Similarly, Manzi and colleagues (2020) explored the attribution of mental states to two humanoid robots, i.e., NAO and Robovie (which differed in the degree of anthropomorphic appearance), in three groups of children of various ages: 5-, 7-, and 9-year-olds. The results showed that the attribution of mental states to robots is a function of the children's age: indeed, 5-year-old children were more likely to anthropomorphise robots than older children, regardless of the type of robot. On the contrary, both 7- and 9-year-old children tend to differentiate between robots, in such a way that they overall attributed greater mental states to NAO (the more anthropomorphic robot) as compared to Robovie. This might suggest that the older the children, the more the robots should be endowed with physical characteristics resembling a human-like shape to increase their perception of human-likeness. This hypothesis seems to be supported by additional evidence that directly tested whether children's age significantly influences their perception of a robot as a "person-like" vs. a mechanical artefact. For example, by comparing 6- and 7-year-old children, Cameron and colleagues (2015) observed that 6-year-old children tended to rate a humanoid robot as being like a person significantly more than older children (7-year-olds).

Interestingly, this negative trend (i.e., the older the children, the less likely to anthropomorphise robots) seems to stabilise in late childhood and pre-adolescence. For example, Barco and colleagues (2020) studied children aged from 7 to 14-years-old to see whether robot morphology (anthropomorphic, zoomorphic, or caricatured) modulated their perception of animacy, anthropomorphism, and social presence. Interestingly, they found that, while "strong" anthropomorphism (i.e., believing that a robot is literally human) fades as a function of age, “weak” anthropomorphism (i.e., higher social presence and similarity to self) tends to remain, and to a greater extent for humanoid than for zoomorphic and caricatured robots. Specifically, *weak anthropomorphism* consists of a functional projection, as the user knows that the robot is a machine but uses human characteristics to describe its behaviour; on the contrary, *strong anthropomorphism* refers to a more psychological projection, so that the user attributes real intentions, feelings, and moral standing to the robot (Duffy, 2003).

According to Piaget’s theory on stages of development (1976), pre-adolescents move into the Formal Operational Stage. It means that, during this cognitive transition, they become increasingly capable of understanding that a robot is a preprogrammed machine made of wires and code. Yet, they still retain a lingering “animism” – i.e., they tend to believe that inanimate objects have lifelike qualities – which is typical of early childhood stages of development and tends to fade over time. For example, Taniguchi and Okanda (2024) investigated animistic beliefs towards a humanoid robot and other types of objects in children aged 3 and 5 years. The results showed that, across age, children’s attitudes towards robots were different, with children aged 3 years being more prone to consider the robot as lifelike and children aged 5 years being more able to distinguish robots from other objects with faces. The authors argued that older children, while they might say that a robot is not alive in a biological sense, still attribute psychological characteristics (e.g., feelings, intentions) and treat them more gently than with traditional toys (Taniguchi and Okanda, 2024).

Around pre-adolescence, the strong anthropomorphism (in Piagetian terms) is replaced by a weaker and more sophisticated anthropomorphism, i.e., the perception of the robot as a specialised social tool without any belief that it is a person. Support for this comes from evidence (Beran et al., 2011), which directly observed the fading of Piagetian animism in pre-adolescents categorising robots. While examining perceived animism in children aged 5 to 16, they found that while older children (pre-adolescents and adolescents) were far less likely to attribute biological life to a robot arm, they still attributed affective and cognitive traits to it.

This result is compatible with the hypothesis that, while younger children are more likely to anthropomorphise robots “by default” (perhaps, due to early cognitive stages), additional factors – possibly connected to the individual cultural profiles, or to the characteristics of the robot – intervene during pre-adolescence. Peculiar phenomena are observed at this age, some of which are connected to the emergence of puzzling attributions similar to those discussed by Clark and Fischer (2023) and Fussell et al. (2008). For example, Kahn et al. (2012) found that while children aged 9, 12 and 15 (unlike toddlers) knew that robots are machines, they still attributed anthropomorphic traits to them, such as intelligence, feelings and moral standing. These children appear to have to reconcile two seemingly conflicting ideas: that the robot is a machine and that it can be a social being that deserves fair treatment. It is also worth mentioning that the Uncanny Valley effect, i.e. the sense of unease arising from entities that appear almost, but not quite, human, appears to emerge around the age of nine, in relation to children's changing perceptions about the robot's mind (Brink et al., 2019). Furthermore, younger children (e.g. preschoolers) tend to be more sensitive to the novelty of a robot's movements or speech than pre-adolescents, who are generally more tech-literate and sceptical. In other words, the excitement that younger children experience when encountering a robot as a new, reactive object may mask their actual psychological perception. Conversely, if a 12-year-old continues to treat a robot as a social agent (e.g., by attributing it a mind) even after the novelty effect has worn off, this could suggest that anthropomorphism is driven by the characteristics of the robot rather than simply by the child's lack of experience.

In summary, although there is still much to learn about how children of all ages anthropomorphise robots, the existing literature suggests that something interesting and peculiar begins to happen during the pre-adolescent period. This, combined with the relative lack of studies on this age group, suggests a need to focus on anthropomorphism towards robots in pre-adolescence.

Indeed, shedding light on factors modulating children's and pre-adolescents' tendency to anthropomorphise robots may also help to understand when it is beneficial for them to ascribe human-like features to robots and when it is not. Although Roesler and colleagues (2021) recently argued that, overall, anthropomorphism in HRI (and specifically, anthropomorphic design features) has a beneficial effect on human-related outcomes, it is equally true that the positive effects of anthropomorphism depend heavily on various moderators and application domains. For example, in a child-robot interaction scenario, anthropomorphism seems to enhance children's learning and engagement in a way that, when children attribute more human-like features to robots and perceive them as social peers rather than machines, they are more likely to stay engaged in educational contexts (Leyzberg et al., 2012; Maj et al., 2025). However, as mentioned above, anthropomorphic attributions tend to decline with age, and thus, from an application perspective, these age-based trends suggest that robot design should be tailored to the child's age. If younger children's engagement may be boosted by robots exhibiting expressive behaviours and emotional cues, for older children and pre-adolescents, there may be the risk of over-anthropomorphising, which could lead to confusion regarding the robot's limitations and agency (Turkle et al., 2006). Another potential concern may be deception, i.e., whether children may be tricked into forming an emotional bond with a robot, which, however, cannot reciprocate. In her book “Alone Together”, Turkle (2011) argued that anthropomorphism creates authentic simulation but an inauthentic connection. This can lead to a "crisis of authenticity" where children may prefer the simplified companionship of a robot over the messy, demanding nature of human friendships. Moreover, Kahn and Shen (2017) argued that robots constitute a new ontological category, comprising entities that are neither alive nor not alive. Children, especially the youngest, may struggle with this distinction, which can significantly impact their understanding of both biological and moral boundaries. With this in mind, we believe that it is important to understand what factors may potentially modulate children's anthropomorphism towards robots, so that it will be possible to take them into account when designing robots that are thought to interact with them.

This is still more important in pre-adolescents, who experience a change in their anthropomorphic attributions, as viewing robots as human-like agents (rather than as mechanical artefacts) might contribute to their cognitive, ethical, and social development. In other words, the practical relevance of anthropomorphising robots for pre-adolescents lies in their ability to facilitate social interactions and cognitive development; indeed, by attributing human-like traits to robots, they can engage more meaningfully with these technologies, leading to a better understanding and acceptance. Moreover, anthropomorphising robots can serve as a bridge between the real and the digital world, helping them to navigate the complexities of both technology and social interactions (Kühne and Peter, 2023; Stanja, Meier, and Krugel, 2025).

With reference to the pre-adolescence period, we chose to examine *cultural* factors that determine anthropomorphism towards robots. Indeed, during pre-adolescence, anthropomorphism seems to be no longer just a "developmental stage"; it becomes a culturally-oriented behaviour. For example, if children around the globe have similar conceptions of robots, older children (pre-adolescents) begin to exhibit significant variations based on their cultural upbringing (Kahn and Schen, 2017). In a recent systematic review, Stanja et al. (2025) noted a Western bias in prior work and explicitly advocated for cross-cultural approaches to understand how children's and adolescents' concepts of mind vary with cultural norms, since they critically modulate anthropomorphic beliefs towards social robots and chatbots. Overall, culture seems to be an important factor in the anthropomorphising of robots by pre-adolescents.

It is important to note at this point that a study on how culture affects anthropomorphism must address significant methodological issues. The concept of ‘culture’ itself lacks a universally agreed definition, and cultural phenomena are studied using a wide range of theoretical approaches and methodological frameworks: Baldwin and colleagues (2006) compiled 313 definitions of culture adopted in various disciplines, including psychology, sociology, linguistics, anthropology, political science and philosophy. However, in addition to the problem of defining this complex theoretical construct, a study on the relationship between culture and anthropomorphism must rely on a specific operationalisation. Roselli and colleagues (2025), based on a systematic review of the literature on the subject, have argued that most studies adopt a relatively shallow and probably anachronistic operationalisation of culture that analyses it in terms of national or, more broadly, geographical areas (see also Papadopoulos and Koulouglioti, 2018, for an integrative review). Based on this operationalisation, studying how culture affects anthropomorphism involves comparing how people living in different parts of the world perceive robots: this methodological choice reflects the assumption that people living (or born) in different countries or geographical areas will have different cultures. A geographical operationalisation of culture can be seen, for instance, in the work of Li, Rau and Li (2010), who suggest that people from Eastern countries (e.g. China and Japan) and Western countries (e.g. Germany) have different perceptions of a robot's likeability, engagement, trustworthiness and satisfaction levels during human-robot interaction tasks. Similarly, Spatola et al. (2022) showed that Western participants were more likely to see the robot as human-like than East-Asian participants, who were more likely to attribute mental states to the robot. They therefore suggested a less anthropocentric and more function-oriented view of the robot's mind in East Asian participants, which significantly shapes the way individuals interact with robots. Another study examining changes in perception of a social robot after interaction found that Australians had more positive perceptions of a Japanese female robot than Japanese people did, and perceived the female robot as more anthropomorphic (Haring et al., 2014a). Along similar lines, Bartneck (2008) demonstrated that Americans exhibit a greater preference for anthropomorphic robots than Japanese individuals. All these studies essentially operationalise culture in geographical terms.

Some studies adopt a seemingly different characterisation of cultural differences, for example in terms of differences between countries with an individualistic orientation and those with a collectivistic orientation. A case in point is Rau, Li and Li (2009), who suggested that people from collectivist countries (such as China) prefer implicit communication with robots, whereas people from individualist countries (such as Germany) prefer more explicit and straightforward communication. But it is clear that, if the experiments ultimately compare participants from different Western and Eastern countries, the attribution of non-geographical traits, such as the individualism or collectivism of inhabitants, is a methodologically parasitic gloss on an operationalisation of 'culture' that is still substantially geographical.

The study described here is based on the idea that this operationalisation of culture may overlook important phenomena, particularly within the HRI domain. It is clear that many different cultures can be found within the geographical borders of Western and Eastern countries, suggesting that culture cannot be construed so rigidly. The most obvious alternative is to abandon the 'culture = country' equation and distinguish between different cultures based on individual indicators. One example would be to operationalise culture based on the level of individualism/collectivism, conceived as an individual trait, without any further reference to geography: in this case, a culture would not be identified by living within certain geographical boundaries, but by having certain levels of individualism/collectivism. These two approaches can produce different representations of the world's cultures because they group people in different ways.

Interestingly, sets of indicators that are useful for this project can be identified in that very literature that, from the second half of the 20th century, attempted to characterise cultural differences between countries (as clarified below, this study will adopt a few of these indicators without considering geography as a proxy for culture). In this literature, culture is conceptualised as a collective phenomenon comprising meanings and associated behavioural patterns (Bruner, 1990; Markus and Kitayama, 2010) shared by people from the same country. For instance, Trompenaars and Hampden-Turner (2011) posited significant cultural differences between nations and developed the Seven Dimensions of Culture model, which is based on the value orientations people encounter in their relationships, particularly in business and management contexts. Similarly, Hall used three major frameworks to categorise national behaviours: how much 'context' is required to understand a message (1976); how different countries perceive and use time (1959); and how people of different nations differ in their comfort level with physical distance (1966). While these studies ultimately suggest that different countries have different cultural profiles, they use indicators that could potentially be employed to study cultural differences *within countries*, an idea that will be explored further in this work.

The most widely cited and used model for understanding national differences is Hofstede's Cultural Dimensions Theory (2001; 2011). This theory uses statistical analysis to identify how national culture influences the values and behaviours of its members. Initially, the model identified five dimensions (Power Distance, Individualism vs. Collectivism, Masculinity vs. Femininity, Uncertainty Avoidance and Long-Term Orientation), but this was later expanded to six with the addition of Indulgence vs. Restraint. Using this framework, Remland and colleagues (1991) demonstrated that the proxemic and haptic behaviours of individuals vary across countries. For instance, Dutch dyads tend to maintain greater distance than French and English dyads, while French dyads tend to be less proximate than English dyads. Still using Hofstede's dimensions, another study showed that the recognition of facial expressions of emotion differs between Western and Eastern countries: for example, some negative facial expressions are less easily recognised among Eastern groups than Western ones (Jack et al., 2009). While these studies end up establishing correlations between geographical areas and the phenomena under investigation, using individual indicators based on Hofstede's dimensions can reveal that certain phenomena of interest to the HRI community are not so much correlated with national borders as with certain transnational or intranational clusters in the multidimensional space defined by those indicators.

Indeed, the existing literature suggests that there may be other reasons *besides nationality* for cultural differences in anthropomorphism, such as historical and religious background. The following non-HRI example illustrates this point: Shaman et al. (2018) assessed participants' attribution of anthropomorphic properties to God in three domains (psychological, biological and physical), as well as their religious beliefs and engagement in religious practices. Interestingly, the results showed a negative relationship between religiosity and the attribution of human-like psychological properties to God, such that the more people engage with their religion, the less they think of God as having a human-like mind. Returning to HRI, adopting non-geographical individual indicators (such as Hofstede's cultural dimensions) may reveal generalisations that would otherwise be overlooked by considering culture solely in geographical terms.

In summary, there are reasons to investigate how pre-adolescents specifically anthropomorphise robots and the ways in which cultural factors (conceived in non-geographical terms) shape this phenomenon. As the reconstruction so far suggests, focusing on pre-adolescence and relying on a non-geographical characterisation of culture are novel elements of this work compared to the literature on human-robot interaction dealing with robot anthropomorphism. The next two sections outline the tools employed and the key methodological choices that led to the results presented and discussed in the final sections.

2. Aim of the study

The present study aimed at investigating whether, and how, individuals' cultural profile affects their tendency to anthropomorphise robots. Specifically, we meant to expand the concept of culture beyond its well-established overlap with individuals' national culture, intended as the set of values that are predominant in a given country/region. Conversely, we sought to address a critical gap that, in our view, affects cross-cultural research, especially in the HRI field: the need to measure cultural values at the individual level, rather than at the national level, and to explore their potential relations with individuals' tendency to anthropomorphise robots.

To do so, we focused on a specific age range, i.e., pre-adolescents (11-14 years-old). As mentioned in the Introduction, our choice was motivated by several factors, e.g., the practical relevance that anthropomorphic attributions to robots have for this age range (for instance, in terms of better understanding and acceptance of technology) and the lack of evidence in the current literature exploring the link between the pre-adolescence stage and the tendency to anthropomorphise robots.

Therefore, we asked participants (a sample of pre-adolescents) to fill out a series of questionnaires that, in the existing literature, are well-known and used to collect information about participants' cultural values (a detailed description of these questionnaires is reported in the Methods section below). This was made to ensure that we obtained a comprehensive overview of participants' cultural profile, without reducing culture to mere nationality-based identity. Note that all these questionnaires were selected and, where possible, adapted to the age range of our participants, to rigorously take into account their age as a crucial factor affecting our methodological choices. In parallel, we operationalised participants' tendency to anthropomorphise robots as their performance in two well-established tasks borrowed from experimental and social psychology: the Implicit Association Test (IAT) and the Cyberball ball-tossing game (a detailed description of both is reported in the Methods section below). As for the questionnaires, also the IAT and the Cyberball were adapted (for example, in terms of duration and type of stimuli, as detailed below) to take into account the participants' age range. Indeed, they were thought to be interesting and engaging tasks to perform for pre-adolescents, using a vocabulary (in the case of the IAT) that was as suitable and understandable for the participants' age and knowledge as possible.

Here, it is worth noting that verbal measures, such as self-reports and questionnaires, are currently the most common method to assess users' attribution of anthropomorphism to robots (Damholdt et al., 2023; Li and Huang, 2025), especially when exploring their relationship with participants' culture (Roselli et al., 2025). Without disregarding the use of explicit measures, which sometimes show more advantages than implicit measures (Corneille and Gawronski, 2024), and which we have anyway used to collect information about participants' cultural values (i.e., the cultural questionnaires), we aimed to extend the current HRI knowledge about anthropomorphism towards robots by complementing existing findings. Therefore, we decided to use less frequently used methods to assess users' anthropomorphism towards robots, i.e., implicit measures. Specifically, we decided to use two behavioural measures that, in our view, might be able to capture two relevant dimensions of anthropomorphism towards robots: (1) the strength of participants' association in memory between the concept of "robot" and the attribute "anthropomorphic" (as measured by the IAT), and (2) their tendency to socially include a robot (as measured by the Cyberball).

We hypothesised that, if participants' cultural profile affects their tendency to attribute anthropomorphic traits to robots, we would find a relationship between their ratings on the cultural questionnaires and their performance at both the IAT and the Cyberball tasks. Specifically, we expect that if participants' cultural values include a tendency towards collectivism, orientation towards others, and preference for novelty, then we should observe a positive relationship with their likelihood of anthropomorphising robots. On the contrary, we would expect a negative relationship for an individual having an opposite cultural profile. Our hypothesis is supported by existing evidence in the literature, showing that individuals having collectivistic values are more likely to anthropomorphise robots, i.e., having a more positive and anthropomorphic view of robots as compared to people having more individualistic values (Kaplan, 2004; Li et al., 2010; Lee et al., 2012; Haring et al., 2014b; see also Lim et al., 2021 and Roselli et al., 2025 for more extensive review). However, we are not able to formulate more precise hypotheses about, for example, the dimensions of culture (i.e., the subscales of the questionnaires) potentially relevant for anthropomorphism towards robots, as, to the best of our knowledge, no previous studies have investigated the relationship between culture and anthropomorphism towards robots with the instruments that we selected.

3. Materials and Methods

Participants. Eighty-five middle school students participated in the study (Age Range = 11 to 14 years old, M_{Age} = 12.62, SD_{Age} = 0.86, 39 males, 46 females). All participants had normal or corrected-to-normal vision. The study was approved by the Local Ethical Committee (the University of Milano-Bicocca's ethical committee; Prot. N. 0487981 – UOR: 003406) and conducted in accordance with the standards outlined in the 2013 Declaration of Helsinki. Before the beginning of the experimental session, both students and their parents/legal guardians provided written informed consent. They all participated voluntarily, and they were naïve to the purpose of the study.

Apparatus and Stimuli. Participants completed the cultural values questionnaire by accessing a dedicated Google Form, which was created by the experimenters and sent to participants before the experimental sessions. Questionnaires were all administered in Italian, which was either the native language or the fluent language of all participants. Participants completed all the questionnaires either by using laptops provided by their schools or their personal smartphones, whose visualisation was optimised for instructions, questions, and ratings scales.

Exploring the existing literature about the instruments to collect information about people’s cultural values, we decided to administer the following.

Cultural Values Scale (CVS; Yoo et al., 2011). It is a 26-item scale measuring people’s cultural values at the individual level. CVS is based on Hofstede’s original five-dimensional measure of cultural values (2011) as the dominant metrics of culture. That said, the goal of CVS is to overcome the primary limitation of Hofstede’s original Value Survey Module (VSM; Hofstede, 1994), which was designed to measure culture at the national level. Conversely, CVS allows for measuring an individual’s orientation on Hofstede’s dimensions, avoiding the interpretation of country-level relationships as applying to individuals. Out of the five CVS subscales, we decided to administer only two subscales: (1) Masculinity (vs. Femininity), and (2) Collectivism (vs. Individualism) subscales. The former (1) refers to the degree to which an individual values traditionally masculine traits, such as achievement, assertiveness, and material success, over traits traditionally associated with femininity, such as nurturing. The latter (2) refers to the degree to which an individual prioritises the welfare and goals of the group (e.g., family) over self-interest and individual rewards. Our decision to administer only these subscales and to exclude the other three

(Power Distance, Uncertainty Avoidance, and Long-term Orientation) was the following. The three subscales that we excluded did not fit our age range, which is a crucial issue to consider in terms of the construct irrelevance (validity of the questionnaire). Indeed, if the items of one or more subscales are outside the lived experience of the targeted age group, for example, because they relate to professional career priorities or long-term financial planning, the scale is no longer measuring cultural values, but only participants' hypothetical guessing. In other words, introducing items that participants cannot meaningfully answer introduces a systematic error (noise). That said, since the CVSCALE dimensions are theoretically and statistically orthogonal (Yoo et al., 2011), the selective use of subscales does not compromise the validity of the dimensions being measured, allowing us to administer only those items that participants can answer. The CVS shows adequate reliability, validity, and across-samples and across-national generalizability (Yoo et al., 2011). Since the current literature does not offer a validated Italian version of the CVS, we used a forward-backward translation.

Portrait Values Questionnaire (PVQ; Schwartz et al., 2001). PVQ was originally developed to assess individuals' personal values according to Schwartz's Theory of Basic Human Values (1992). Here, it is worth noting that the PVQ is primarily a tool for measuring individual-level values (i.e., what a person cares about). However, it is also recognised as a cultural value questionnaire, since Schwartz himself (2012) argued that those values are used to characterise cultural groups and societies. In other words, he suggested that basic human values are the "vocabulary" of a culture, so that when aggregating PVQ scores, the result is a set of underlying value priorities that dictate a group's laws, norms, and institutions (Schwartz, 2012). Thus, when an individual uses the PVQ to describe themselves, the average profile of a group reveals the prevailing value emphasis of that group. In this sense, culture is defined beyond nationality, i.e., by how different groups prioritise certain values over others (Schwartz, 2006). Therefore, in the context of our study, PVQ was used to assess whether, and how, potential changes in these basic human values (within individuals of the same country) relate with their attribution of anthropomorphic traits to robots.

Specifically, we administered a short version of PVQ, which was validated in Italian by Danioni and Barni (2018). It is a self-report scale composed of 21 portraits of a person and his/her objectives and aspirations, which implicitly reflect the importance of a value. The original 10 values of Schwartz's theory are grouped into 4 high-level dimensions, which in turn are organised along two different axes. The first axis is (1) Openness to change (values: self-direction, stimulation, and hedonism) vs. Conservation (values: security, conformity, and tradition). The former emphasises people's tendency towards autonomy, novelty, and excitement; conversely, the latter emphasises people's preference for stability, maintenance of the status quo, and adherence to social norms. The second axis is (2) Self-transcendence (values: universalism, and benevolence) vs. Self-enhancement (values: power, and achievement). The former highlights people's concern for the well-being of others, society, and nature. Conversely, the latter emphasises people's pursuit of personal success, social status, and gratification.

Based on this, the item "It is important for him/her to be rich. S/he wants to have a lot of money and expensive things" describes a person for whom the value of self-enhancement is important. Respondents' values are inferred from their self-reported similarity to the subject described, since they have to answer the question "How much like you is this person?" (Danioni and Barni, 2018). Many studies supported the reliability and validity of the PVQ cross-culturally (Schwartz, 2012).

In addition to CVS and PVQ, we added other non-geographical cultural measures. Specifically, participants were asked whether, besides their culture of origin, they identified with another or more cultures. If they responded positively, they were asked to fill out two scales measuring their degree of acculturation. The term *acculturation* is used to describe the process of change that occurs when two ethnic or cultural groups come into contact with each other for a long time (Berry, 2005; Liebkind, 2006). The first scale (i) measures, through four questions, individuals' attitudes towards minority culture maintenance and inter-ethnic contact as described by Nigbur and colleagues (2008). For example, participants were asked how important it is for them to celebrate their own holidays, to speak the language of their country of origin, and to eat their traditional food. The second scale (ii) is an adaptation of the Strength of Identification Scale (SoIS; Barrett, 2006). Specifically, participants' Italian identity was measured through questions asking to what extent they considered themselves members of the group in question (Italians), how proud they were to belong to the group, how important it was to them to be a member, and how they felt about being a member.

Last but not least, we administered the Waytz Instrument, which measures individuals’ likelihood of attributing anthropomorphic traits to robots (i.e., intentions, desires, emotions, and moral values; Ruijten et al., 2019). Specifically, the Waytz Instrument mostly focuses on cognition-related features of robots, which is more in line with the concept of anthropomorphism that we adopted in our study (the “psychological” anthropomorphism described by Fischer, 2021). Since the Waytz Instrument is a subscale of a larger anthropomorphism questionnaire (Waytz et al., 2010), we used it to double-check whether the IAT and the Cyberball actually capture participants’ anthropomorphic attributions to robots. Specifically, it would be indicated by the positive relationship emerging between the participants’ Waytz score and their performance at the IAT and the Cyberball.

IAT. The IAT was administered directly by the experimenters using laptops (resolution: 2880 x 1800 pixels). For this study, we developed a brief, adapted version of the IAT, inspired by the work of Ciardo and colleagues (2020). In our version, which lasted approximately 5-10 minutes, pictorial stimuli comprised 20 pictures of silhouettes depicting humans (females and males; 10 pictures) and robots (20 pictures). Linguistic stimuli are the ones used in the Godspeed questionnaire (Bartneck et al., 2009), which measures the perception of robots in terms of their appearance-related features (Ruijten et al., 2019). We decided to use the items related to two specific subscales of the Godspeed, namely (i) anthropomorphism and (ii) animacy, since these dimensions matched with the aim and research questions of the study. Since we administered the IAT in Italian, we used the validated Italian version of the Godspeed for the linguistic items (Operto et al., 2021).

Participants performed a short version of the IAT comprising 5 blocks (**Figure 1**). In Block 1, participants' task was to categorise pictorial stimuli, i.e., silhouettes, into human or robot ones. In Block 2, they had to categorise linguistic stimuli into anthropomorphic or non-anthropomorphic. In Block 3, participants categorised both pictorial and linguistic stimuli, which were paired in a congruent manner. It means that both silhouettes and words were presented, and participants were asked to categorise both. The association between the concept and the attributes was congruent, i.e., the same response key was used to categorise congruent stimuli (i.e., left key = robot silhouettes and non-anthropomorphic words; right key = human silhouettes and anthropomorphic words). Notably, "congruent" indicates the association between concepts (human, robot) and attributes (anthropomorphic, non-anthropomorphic) that are presumably easier; in our case, human + anthropomorphic and robot + non-anthropomorphic. Block 4 was identical to Block 1, with the main difference that the association between the silhouettes and the response key was reversed. Finally, in Block 5, both silhouettes and words were presented as in Block 3, but the association between the concepts and the attributes was incongruent (i.e., left key = human silhouettes and non-anthropomorphic words; right key = robot silhouettes and anthropomorphic words).

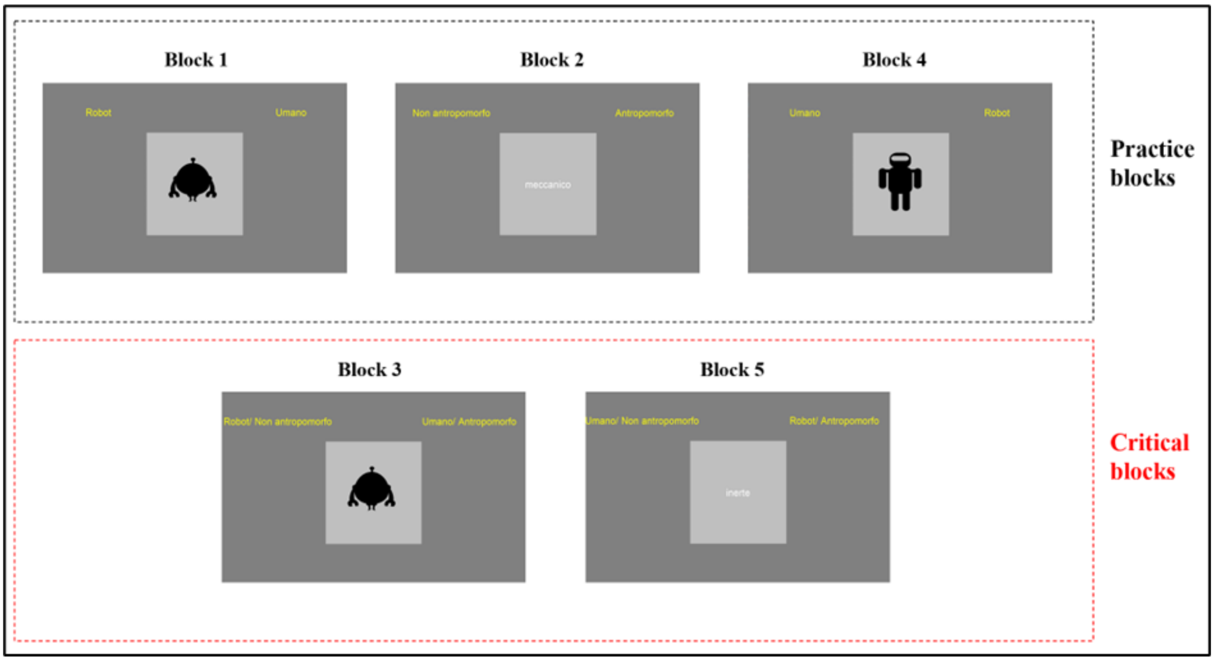

Figure 1. Visual representation of the 5 blocks of the IAT. In the upper line: the practice blocks (Blocks 1, 2, and 4, with 20 trials each), which allowed participants to familiarise themselves with the task and with the associations between concepts and attributes. In the bottom line: the critical blocks (Block 3 = Congruent, and Block 5 = Incongruent), which allowed us to measure the strength of participants' association between the concepts and the attributes. They were both written in Italian, as the IAT was administered in Italian.

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Each trial started with the presentation of a stimulus (a silhouette or a word) in the centre of the screen, with the corresponding response category presented in the left and right upper corners. Responses were executed by pressing the "A" (left key) or the "L" (right key) on a standard QWERTY keyboard. The time given to participants was infinite; however, they were asked to respond as fast and accurately as possible. The inter-trial interval (ITI) was set to 400 ms. In our version of the task, Blocks 1, 2, and 4 (practice blocks) comprised 20 trials each, whereas the two critical blocks (Blocks 3 and 5) comprised 40 trials each. The order of blocks was fixed, but the presentation of stimuli (silhouettes and words) within each block was randomised. Stimuli presentation, response timings, and data collection were controlled using Psychopy v2022.2.3 (Peirce, 2007).

To ensure that participants' responses at the IAT were not biased by a lack of comprehension of the vocabulary, before the experimental session (4 weeks before), we shared with them a list containing all the linguistic stimuli appearing in the IAT, together with the corresponding definition taken from the Treccani Italian Dictionary. Specifically, the list was shared with the teachers, who were asked to read it in class and then ask their students (our participants) whether one or more terms were not clear; if so, these terms were explained until they were fully understood. Before the experimental session, the teachers reported that they did it; moreover, during the completion of the IAT, participants could consult the list anytime, in case they wanted to double-check the meaning of one or more words (the linguistic stimuli of the IAT).

Cyberball. As mentioned above, our version of the Cyberball ball-tossing game (Williams and Jarvis, 2006) involved an embodied humanoid robot sharing the same physical space as the human players (i.e., the participants and one of the experimenters) (**Figure 2**). It was done because the social and physical presence of the robot significantly affects the way participants perceive the robot player (Roselli et al., 2024). During the task, which lasted approximately 5 minutes, participants were instructed to toss the ball as fast as possible to one of the other players, namely the humanoid robot Nao or the other human player. Each time they received the ball, they could freely choose which player to toss the ball to. Conversely, the robot was programmed to equally alternate between the two players (the participant and the other human player), although in a flexible manner. It means that, throughout the task, the number of robot tosses was equal towards the other two players, but it did not rigidly alternate between the two. It was made to prevent participants from understanding the strategy of the robot and potentially adapting to it. The same was true for the other human player (the experimenter), who trained herself to be as unpredictable as possible during the task, i.e., not following the same strategy with all participants and at the same time equally tossing the ball to both the robot and the participant throughout the task. Note that, during further data preprocessing, all participants' files were carefully checked to confirm that the human player (the experimenter) followed the same strategy as the robot, and thus equally tossed the ball to the other two players (the robot and the participant).

For both players, it was made to ensure that their strategy during the game would not have biased participants in choosing one player over the other. Participants performed 100 trials in total, i.e., they received (and tossed) the ball 100 times.

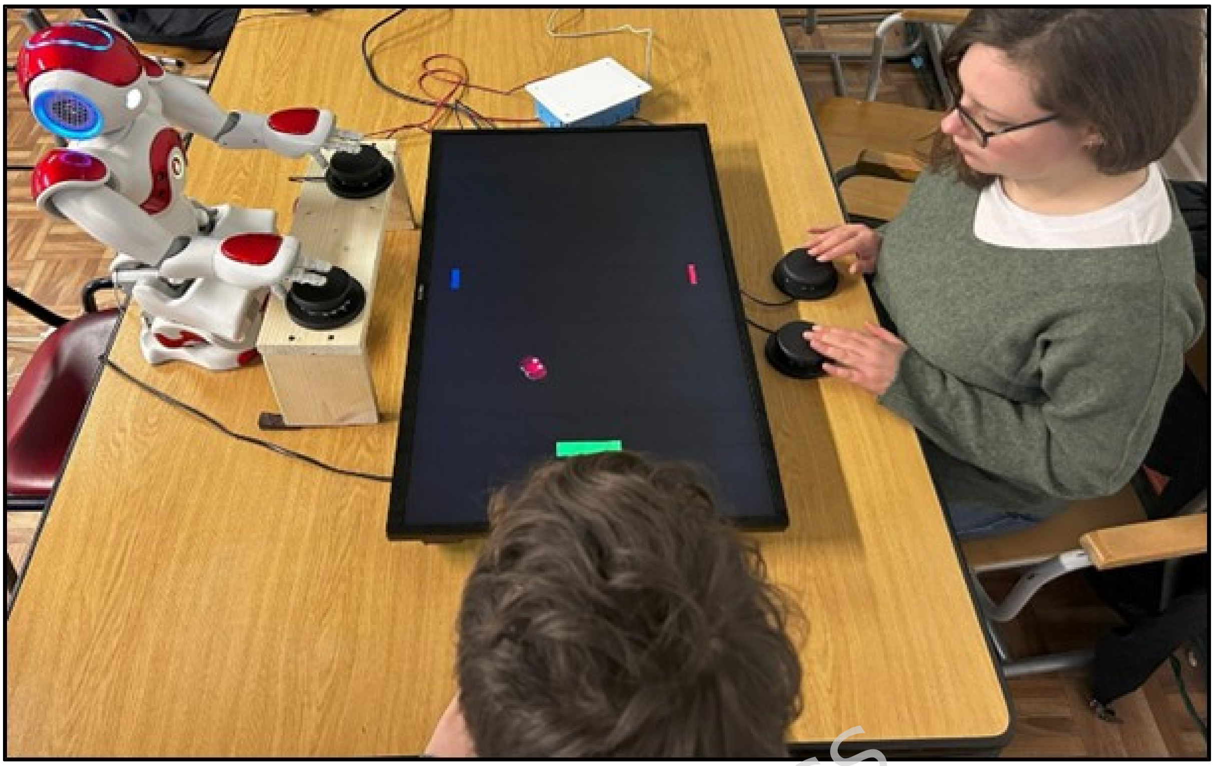

Figure 2. Screenshot of the Cyberball-ball tossing game. The participant (here depicted at the bottom centre of the figure) is instructed that s/he could freely toss the ball to either the humanoid robot Nao (on the left side) or the other human participant (on the right side; informed consent has been obtained to publish the image).

The robot platform. Nao is a humanoid robotic platform. It is 58 cm tall, weighs 5.48 kg, and with its 25 degrees of freedom, it allows for a wide range of motion. For the entire duration of the game, Nao assumed a seating position, with its arms reaching out on top of two buttons used to toss the ball to the other players (participant and human confederate).

During the experiment, Nao performed an initial preparation sequence and a concluding sequence, actively tossing the ball to the players during the game. The computer program (written in Python 2.7 and developed using the pygame library: www.pygame.org) managed the ball-tossing game, robot behaviour, and the resulting data. The software was executed from an HP Omen 015 laptop (32 GB RAM, 1TB SSD). The game interface was projected onto a monitor via an HDMI cable (**Figure 2**). We also relied on an Ethernet cable, connected to the laptop and carefully attached to the robot's, to communicate with the Nao robot (**Figure 2**). Participants played the game using physical buttons connected to an Advantech USB-4750 Digital I/O device, also connected to the laptop. Physical buttons (black in colour) were designed to be ergonomically adequate for both the human players and the robot, and electronically relied on an internal tactile touch push button that recorded participants' response (i.e., when the button was pushed). The robot ball-tossing behaviour was implemented via the NAOqi framework (http://doc.aldebaran.com/2-5/index_dev_guide.html): a motion-control module was developed to execute arm movements (e.g., right- and left-arm pushes) by setting predefined joint angles. The robot was programmed to equally toss the ball to both participants and the human confederate; its decision-making behaviour for tossing the ball was rule-based and pre-programmed, although it had an important element of randomness, as it was informed by an algorithm that relies on the Python random module (https://docs.python.org/3/library/random.html). The algorithm was developed to simulate a random choice to participants, and thus not to give the impression that the robot's behaviour was mechanical and predetermined. For example, the robot could pass the ball to the same participant multiple times in a row, while still retaining a perfect balance of passages between the participant and the human confederate throughout the game. The visual aspect of the game, including the ball movement on the screen (at a constant speed of 25 units/frame) and the player placeholder (a colored bar, which enlarges when the ball reaches the player; each player has their distinct colored bar), was developed through the pygame library (www.pygame.org).

Data, including human reaction times and ball reception counts, was logged into the laptop memory through timestamped .txt files and later further processed into .csv format. The system did not implement explicit gaze behaviour or facial expression of the robot towards participants.

4. Statistical analysis

IAT. Data from 13 participants were excluded from the analysis because they were missing or not properly saved, resulting in a final sample size of $N = 72$.

Afterwards, for the preprocessing, we followed the procedure described by Greenwald and colleagues (2003). First, we considered only the two blocks of interest, i.e., blocks 3 and 5, in which the concepts (human, robot) and the attributes (anthropomorphic, non-anthropomorphic) were congruent or incongruent. Respectively. Then, for each participant, trials with reaction times (RTs) longer than 10 seconds or shorter than 300 ms were considered as outliers and removed (3.22% of the total number of trials). Then, for each participant, RTs of incorrect trials, namely trials in which participants did not press the correct key according to the instructions of the block, were replaced with the mean RT of each block plus a 600 ms penalty.

Last, participants' correct RTs were used to calculate the "raw" IAT bias, i.e., the difference in mean RTs between incongruent and congruent blocks. To facilitate the interpretation of the IAT bias, we calculated the D score, which foresees the standardisation of the raw IAT bias (Greenwald et al., 2003). For each participant, the mean RT difference (the raw IAT bias) was divided by a measure of variability (the standard deviation). This makes the score, which ranges from -1 to +1, interpretable on a common scale, similar to the z-score.

Specifically, if the standardised IAT bias (the D score) is positive, it indicates a stronger implicit association for the congruent combination (robot + non-anthropomorphic); conversely, if it is negative, it indicates a stronger implicit association for the incongruent combination (robot + anthropomorphic). Furthermore, if it revolves around 0, it means that this participant has a weak or null implicit association towards either of the combinations.

Since we aimed to assess whether individuals' cultural values, operationalised as their responses (scores) at the set of cultural questionnaires, predicted participants' tendency to anthropomorphise robots, operationalised as their implicit associations between the concept of "robot" and the attribute "anthropomorphic" (their standardised IAT bias), we performed two multiple linear regressions. In the first regression, we used participants' standardised IAT bias as the dependent measure, and participants' responses (scores) to both the Cultural Values Scale (CSV) and Portrait Values Questionnaire (PVQ) as the predictors. In the second regression, we used participants' standardised IAT bias as the dependent measure, and participants' responses to the acculturation items as the predictors. Since only a subsample of participants completed the acculturation items, whereas the entire sample completed both the CVS and the PVQ, we decided to run two separate models.

Cyberball. Since we aimed to assess whether individuals' cultural values, operationalised as their responses (scores) at the set of cultural questionnaires, predicted participants' tendency to anthropomorphise robots, operationalised as their probability to toss the ball to the robot over the other human participant, we performed two generalised linear mixed models. Data from 11 participants were excluded from the analysis because they were missing or not properly saved, resulting in a final sample size of $N = 74$. In the first model, we used participants' probability to toss the ball to the robot as the dependent variable, and participants' responses (scores) to both the Cultural Values Scale (CSV) and Portrait Values Questionnaire (PVQ) as the predictors. In the second regression, we used participants' probability to toss the ball to the robot as the dependent variable, and participants' responses to the acculturation items as the predictors. As for the IAT, since only a subsample of participants completed the acculturation items, whereas the entire sample completed both the CVS and the PVQ, we decided to run two separate models.

Moreover, as we previously mentioned, we also used the Waytz Instrument (Ruijten, 2019), a subsample of the larger anthropomorphism questionnaire developed by Waytz and colleagues (2010). To double-check whether the IAT and the Cyberball were instruments actually able to capture participants' tendency to anthropomorphise robots, we performed Pearson's correlations between participants' scores on the Waytz and their performance at the tasks, separately for the IAT and the Cyberball.

For both the IAT and the Cyberball, data preprocessing and analysis were executed using R Studio v4.3.3 (R Core Team, 2013) and the software Jamovi v2.5.6, and specifically the GAMLj3 package (General Analyses for Linear Models, v2).

In the following subsections, results are reported in subsections, according to the (1) type of instrument (IAT vs. Cyberball) and (2) the regression model.

5. Results

For a summary of participants' means, SDs, and CVs in the cultural questionnaires and the Waytz, please see **Table 1** below.

	CVS: Collectivism	CVS: Masculinity	PVQ: Openness to Change	PVQ: Conservation	PVQ: Self-Enhancement	PVQ: Self-Transcendence	Acculturation: Minority culture maintenance	Acculturation: Identification (with the host country)
Mean	3.53	2.23	4.32	3.58	3.18	4.43	3.18	3.17
SD	0.56	0.66	0.75	0.76	0.99	0.71	0.65	0.73
CV	15.86%	29.59%	17.36%	21.22%	31.13%	16.02%	20.44%	23.02%

Table 1. Summary of participants' means and standard deviations (SD), reported separately for the questionnaire and each subscale. We also reported the coefficient of variation (CV), i.e., a standardised measure of dispersion (expressed in percentage) that can be used to evaluate whether the variability in participants' responses is low/high. It is the result of (SD/Mean) x 100. The rule of thumb for the interpretation is the following. CV < 0.1 (10%): Very low variability (extreme consensus). CV < 0.3 (30%): Generally considered low to moderate variability. CV > 0.5 (50%): High variability (the group is quite divided).

IAT bias and cultural questionnaires (CVS and PVQ). First, since we had two "sets" of predictors (CVS and PVQ scores), we ran a model comparison to see how much predictive power each set has. Specifically, we compared two regression models: the first model had only CVS scores as predictors, whereas the second model also had the PVQ scores, to assess if adding a new category of information (in this case, PVQ) improves the model's ability to predict the participants' IAT bias. Results showed that the second model showed a significantly better fit (Pr(>F) = 0.01), suggesting that the model including both CVS and PVQ scores significantly predicted the outcomes, i.e., participants' IAT bias (p = 0.01), and improved the percentage of variance explained in the model (adjusted R^2 = 0.14). Moreover, all the assumptions of the model (Linearity, Homoscedasticity, and Normality) were met.

The results of the model showed that the Conservation dimension (PVQ) significantly predicted a decrease in participants' IAT bias (b = -0.19, SE = 0.07, t = -2.56, p = 0.01, 95% CI [-0.04; -2.56]), i.e., the more conservative participants were, the more they tended to anthropomorphise robots. Conversely, the Enhancement dimension (PVQ) significantly predicted an increase in the participants' IAT bias (b = 0.10, SE = 0.05, t = 2.03, p = 0.04, 95% CI [0.02; 0.21]), so that the more participants valued personal achievements and success, the less they tend to anthropomorphise robots (**Figure 3**).

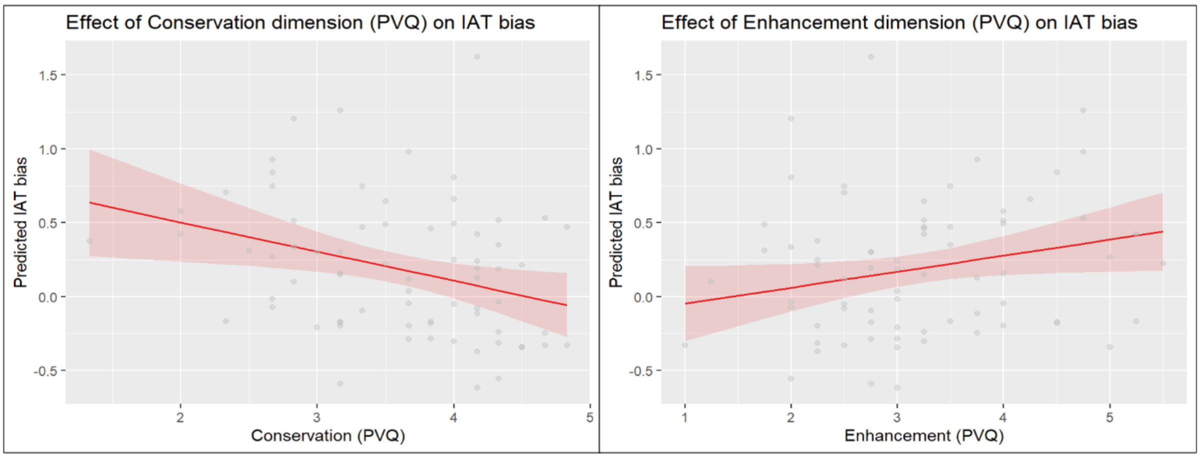

Figure 3. Left panel. Participants' scores on the Conservation subscale of the PVQ, plotted as a function of their standardised IAT bias. Light grey dots represent data points; the red spectrum represents the 95% confidence interval. Note that, according to Schwartz's theory (1992), the Conservation dimension refers to perceived stability, safety, and willingness to preserve the status quo, as well as a preference for order and conformity. **Right Panel.** Participants' scores on the Enhancement (or Self-Enhancement) subscale of the PVQ, plotted as a function of their standardised IAT bias. Light grey dots represent data points; the red spectrum represents the 95% confidence interval. Note that the Self-Enhancement dimension refers to pursuing one's interests, success, and dominance through demonstrating competence and control or dominance over resources.

All the other dimensions of both CVS and PVQ did not significantly predict participants' IAT bias (see **Table 2** below for a summary).

Model Coefficients- IAT bias						
Predictor	**Estimate (*b*)**	**SE**	**Lower 95% CI**	**Upper 95% CI**	***t***	***p***
Collectivism (CVS)	0.01	0.09	-0.17	0.20	0.13	0.89

Masculinity (CVS)	-0.11	0.08	-0.29	0.05	-1.35	0.18
Openness to change (PVQ)	-0.12	0.08	-0.28	0.03	-1.50	0.13
Self-Transcendence (PVQ)	0.16	0.09	-0.02	0.36	1.73	0.08

Table 2. Summary of the model coefficients for all the predictors of the model.

IAT and acculturation items. Probably due to the small subsample of participants who completed the acculturation items (N =25), the overall fit of the model with the acculturation items as predictors showed that it does not significantly predict the outcomes, i.e., participants' IAT bias (p = 0.40). Moreover, the percentage of variance explained is extremely low (adjusted R^2 = 0.003).

IAT and Waytz Instrument. Results of Pearson's correlation showed a significant negative correlation between the participants' standardised IAT bias and their scores on the Waytz instrument (r_{60} = - 0.32, p = 0.01, 95% CI = (-0.53; -0.08]) (**Figure 4**).

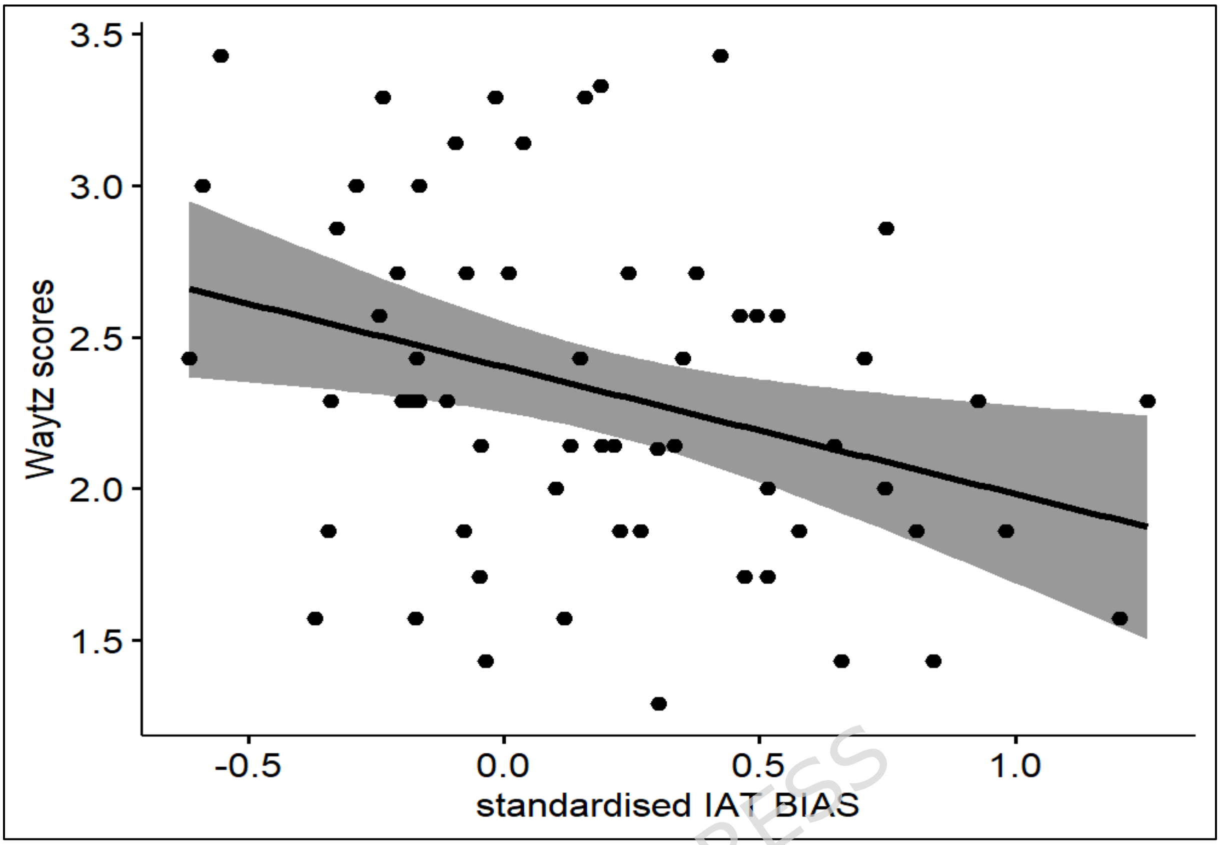

Figure 4. Negative correlation between participants' ratings at the Waytz Instrument and their implicit IAT bias, standardised. Black dots represent participants' mean data points. The grey spectrum represents the 95% confidence interval.

Cyberball and cultural questionnaires (CVS and PVQ). As for the IAT, we first performed a model comparison, since we had two sets of predictors (CSV and PVQ scores). The first model included only CVS scores as predictors, whereas the second model also had the PVQ scores. Results showed that the second model did not significantly improve the model's ability to predict participants' frequency of robot choice at the Cyberball game (Pr(>F) = 0.97). Therefore, we kept the simplest model, i.e., the one including only CVS scores as predictors. The overall fit of the model indicates that it significantly predicts the outcomes, i.e., participants' frequency of robot choice ($p < 0.001$); however, the percentage of variance explained by the model is low (conditional $R^2 = 0.04$). All the assumptions of the model (Linearity, Homoscedasticity, and Normality) were met.

The results showed that the participants' scores on the Collectivism subscale significantly predicted participants' probability to toss the ball to the robot over the other human player (Exp(*b*) = 1.10, SE = 0.04, $z = 2.02$, $p = 0.04$, 95% CI [1.00; 1.20]). The same emerged for the participants' scores at the Masculinity subscale, which had a significant effect on participants' probability to toss the ball to the robot over the other human player (Exp(*b*) = 1.12, SE = 0.04, $z = 2.79$, $p = 0.005$, 95% CI [1.03; 1.22]) (**Figure 5**).

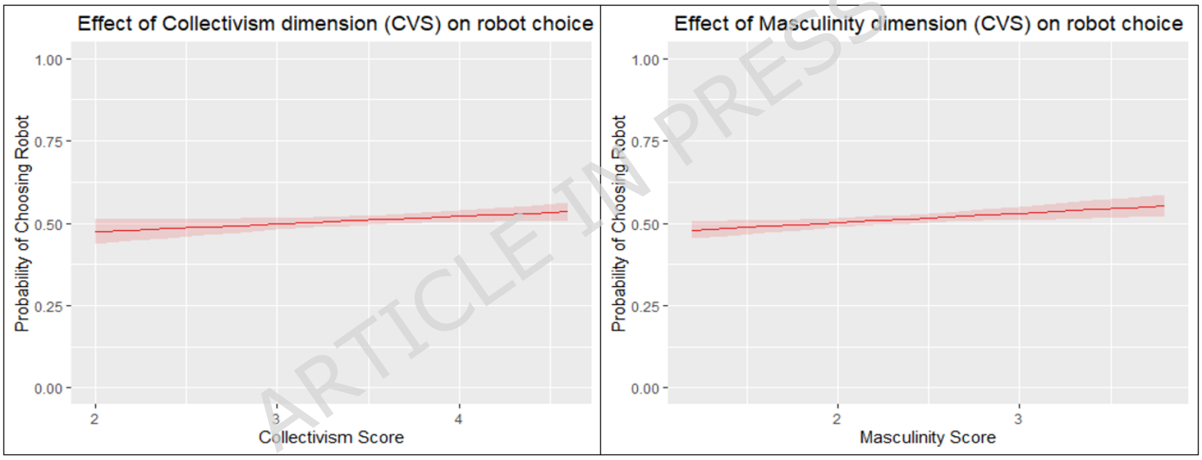

Figure 5. Left panel. Participants' scores on the Collectivism subscale of the CVS, plotted as a function of their predicted probability of tossing the ball to the robot over the other human participant; the red spectrum represents the 95% confidence interval. **Right Panel.** Participants' scores on the Masculinity subscale of the CVS, plotted as a function of their predicted probability of tossing the ball to the robot over the other human participant; the red spectrum represents the 95% confidence interval.

Cyberball and acculturation items. Probably due to the small subsample of participants who completed the acculturation items (N=24), the overall fit of the model with the acculturation items as predictors showed that it did not significantly predict the outcomes, i.e., participants' probability of robot choice (p = 0.52). Moreover, the percentage of variance explained is low (conditional R^2 = 0.003).

Cyberball and Waytz Instrument. Results showed no significant correlation between the participants' robot choice and their Waytz scores (r_{58} = 0.17, p = 0.18, 95% CI = [-0.08; 0.41]).

For a summary of the ball tosses towards either of the agents (the other human participant vs. the robot Nao), see **Table 3** below.

	Receiver	
	Human	**Robot**
Counts	3566	3734
%	48.85%	51.15%

Table 3. Summary of all participants' ball tosses during the Cyberball-ball tossing game, reported both as counts and percentages.

6. Discussion

The present study aimed at investigating whether, and how, individuals' cultural profile affects their tendency to anthropomorphise robots, namely, to attribute human-like traits to them. To do so, we involved a sample of pre-adolescents, i.e., middle-school students aged 11-14 years-old. It was made because, as previously highlighted, individuals' age might be critical when examining how they anthropomorphise robots. In this context, pre-adolescents represent an interesting sample of investigation, since they are the middle ground between preschoolers and adults; while for the other two age groups, their tendency to anthropomorphise robots is more well-defined, current HRI evidence involving pre-adolescents does not show a clear trend, i.e., whether they are more or less prone to attribute anthropomorphic traits to robots. Moreover, when investigating factors that might modulate this trend, it emerges that as children reach pre-adolescence (approx. 9–12 years old), their conceptions of robots (and thus their tendency to anthropomorphise them) begin to split by cultural upbringing (Kahn and Schen, 2017).

Therefore, in our study, middle-school students completed a set of questionnaires that, according to the current literature, can capture various dimensions of culture. These questionnaires included items related to individuals' personal cultural orientation (CVS; Yoo et al., 2011) and their personal human values (PVQ; Schwartz et al., 1992, 2001; Danioni and Barni, 2018). Moreover, given the presence of first- and second-generation immigrants, we also considered the degree of acculturation, namely the integration between participants' culture of origin and their host culture (Barrett et al., 2006; Nigbur et al., 2008). While in the HRI domain, a common practice in cross-cultural study seems to fully identify the concept of "culture" with individuals' nationality, in our study, we tried to take a step ahead and look at a broader concept of culture besides individuals' national identity. To do so, we took into consideration other values that, in the current literature, can be identified as cultural besides individuals' belonging to a certain country (e.g., Italy vs. China), to see whether these values could potentially affect people's anthropomorphising tendency towards robots.

Therefore, after completing the cultural questionnaires, participants performed both the Implicit Association Test (Greenwald et al., 1998; 2003) and the Cyberball ball-tossing game (Williams and Jarvis, 2006), both adapted to an HRI context. In our view, these tasks can capture two different but relevant dimensions of anthropomorphism towards robots. Indeed, the IAT measures participants' implicit attitudes towards robots, and specifically the strength of their automatic association between two concepts (human, robot) and two attributes (anthropomorphic, non-anthropomorphic). What we were primarily interested in was the strength of the association "robot + anthropomorphic": the smaller the semantic distance (i.e., faster reaction times when pairing "robot" and "anthropomorphic"), the stronger the participants' implicit tendency to ascribe anthropomorphic traits to robots. The Cyberball measures the participants' tendency to socially include the robot in a ball game (Hartgerink et al., 2015; Hay et al., 2023). It would be indexed by the probability of tossing the ball to the robot over the other human player during the game. The reasoning behind it is that, if participants frequently toss the ball to the robot, they are applying human social norms (and specifically, the norm of inclusion), and thus a form of *de facto* anthropomorphism. However, we wanted to experimentally check whether the IAT and the Cyberball actually capture anthropomorphism towards robots, and thus participants also completed the Waytz Instrument (Ruijten et al., 2010). It measures the extent to which people attribute human-like, anthropomorphic traits to robots.

To assess whether participants' cultural values affect their tendency to anthropomorphise robots, we performed multiple linear regressions, separately with the IAT bias and the Cyberball frequency of robot choice as dependent measures.

Regarding the IAT, we did not observe any significant relationship between participants' cultural values and their tendency to anthropomorphise robots, except for (1) a negative relation between the IAT bias and the PVQ Conservation dimension, and (2) a positive relation between the IAT bias and the PVQ Self-Enhancement dimension. Concerning the negative relation (1), what emerged is that the more participants showed a preference for stability, order, and conformity, the more negative their IAT bias, i.e., the stronger their implicit association between the concept of "robot" and the attribute "anthropomorphic". In other words, the more participants showed conservative traits, the more they tended to anthropomorphise the robot. This result is somewhat surprising, as one might more easily expect the opposite relationship: namely, the more conservative participants, the stronger tendency to see robots as purely mechanical, non-anthropomorphic entities. However, one potential explanation might be the following. According to Schwartz's theory of basic human values (1992), people who score higher in the Conservation dimension prioritise social order, safety, and the status quo. For this reason, they tend to be more sensitive to things that are perceived as "unnatural" or "out of place". That said, when describing anthropomorphism towards non-human entities (including robots), Epley and colleagues (2007) emphasised that it is driven by three main determinants. One of them is called *effectance motivation*, that is, people's desire for control as well as for uncertainty avoidance. By combining this information, one possibility might be that, since people scoring higher in Conservation have a strong need for predictability and security, to reduce their discomfort towards robots (which are objects, but in the IAT are potentially presented like subjects), they tend to humanise the robot. As a consequence, we observed the participants' negative IAT bias (more anthropomorphising) as a function of higher scores in the Conservation dimension. Another potential explanation might be that, in the popular culture, robots are usually presented as highly humanised entities (think of cartoons and TV series, which pre-adolescents could be very exposed to). Therefore, individuals who have a stronger preference for stability might be more attached to the idea of robots as "humanised entities", which might explain the negative relationship that we observed. However, since we did not collect any information regarding the degree of our participants' exposure to popular culture involving robots, our explanation is very speculative and needs to be further tested in future studies.

The other significant finding is that the positive relationship between the participants' IAT bias and their scores in the Self-Enhancement dimensions of the PVQ; in other words, the more individuals prioritise values such as values and personal achievement, the less they tend to anthropomorphise robots (i.e., the stronger the association robot + nonanthropomorphic). The logic behind this might be the following. When individuals view the world through the lens of pursuing personal interests and success over others, they might categorise entities based on their "use-value". That said, a robot seen as a "machine" is a predictable tool as compared to when it is seen as a human-like entity, i.e., as a social agent that (as a human) might more likely have unpredictable behaviour. Moreover, self-enhancement traits seem to be negatively correlated with both prosociality and empathy (Caprara et al., 2012). Therefore, people who score higher in the Self-Enhancement dimensions might lack the "prosocial bridge" to see a machine as possessing human-like traits. However, as for the negative relation that emerged between the IAT bias and the Conservation dimensions, our interpretation is speculative and needs to be further assessed (for example, by evaluating participants' prosocial and empathy traits).

However, in our view, it is meaningful that, among all the dimensions examined, the only two revealing a significant relationship with the IAT bias are (1) Conservation and (2) Self-Enhancement. Indeed, during the transition to adolescence and adult life (as in the case of our participants), both values tend to increase and to be prioritised more than in childhood. For example, in pre-adolescence, stability and following the social norms (Conservation) are highly valued, as children are deeply embedded in family and school structures that usually reward maintaining order (Döring et al., 2017). A similar increase was also in the Self-Enhancement dimension, as highlighted by Vecchione and colleagues (2020).

Overall, our IAT results shed light on two important aspects that, in our opinion, deserve attention (especially in the context of future studies). First and foremost, besides the two dimensions discussed above, no other dimensions of our questionnaires (CVS, PVQ, and acculturation items) resulted in a significant relationship with participants' IAT bias. It might be surprising, especially for the dimensions of the CVS (Collectivism vs. Individualism and Masculinity vs. Femininity), which many HRI studies showed to be related to anthropomorphism towards robots (see Lim et al., 2021; Roselli et al., 2025 for reviews). It might be explained by the fact that those studies involved adults, who represent a completely different age range (in terms of emotional, cognitive, and social development) as compared to pre-adolescents, who were the target of our study. However, it might also be that, in our study, we did not consider all the cultural but non-geographical factors (i.e., cultural values that go beyond nationality) that might potentially have an impact on pre-adolescents' tendency of anthropomorphising robots. For example, their religious affiliation, since religion provides a narrative for what is good and bad. MacDorman and Entezari (2015) highlighted that children raised in Abrahamic traditions (Christianity, Islam, Judaism) often view the "human soul" as a unique, God-given trait, which can lead to a "Uncanny Valley" effect when interacting with robots. Conversely, children from Animist or Shinto backgrounds are often more "anthropomorphically fluid," as their religious culture suggests that "spirits" can reside in inanimate objects (the "Kami" concept), leading to higher and more positive anthropomorphism. Similarly, Carbis (2021) showed that children's religious beliefs are a strong positive predictor of their tendency to attribute human-like qualities to non-human entities; interestingly, it is a more significant factor than the parents' level of anthropomorphism, suggesting that the religious framework provides children with a specific mentalising toolkit.

Regarding the Cyberball, results showed that participants' probability of tossing the ball to the robot (over the other human player) is positively predicted by their scores on the CVS subscales of Collectivism and Masculinity. For the Collectivism subscale, one possibility might be that the more participants esteem collectivistic values (e.g. group harmony, loyalty, and cohesion), the more likely they are to toss the ball to the robot. This result is in line with previous evidence relating the Cyberball paradigm and the CVS (Marchesi et al., 2021), and highlights that what matters for social inclusion of robots is individuals' cultural stance, in the form of a collectivistic stance (rather than individualistic). Moreover, individuals having a collectivistic stance usually show more aversion to ostracism, i.e., they are more sensitive to the negative social dynamics of leaving someone (or something) out. Therefore, it might be that "ignoring" the robot, by not frequently passing the ball to it, might be perceived as a breach in the collective "we". However, we need to be cautious with this interpretation, as it would presuppose to perceive (and thus treat) the robot not as a mere machine but more like a social entity, which we cannot conclude based on the Cyberball data. This needs to be addressed in future studies.

For the Masculinity subscale, participants' higher ratings predicted a higher likelihood of socially including the robot in the game. In this case, one potential explanation might be that, since the Masculinity dimension emphasises values such as assertiveness, success, and task performance/achievement, it might be that choosing the robot reflects a more task-oriented preference. In other words, it might be that the robot was likely perceived as the most competent and efficient tool to achieve the goal (i.e., completing the ball game), and thus that the choice of tossing the ball to the robot rather than to the other human player was driven by the desire for high performance ad maximisation of results, regardless of considerations related to the "social" nature of the robot.

However, it is worth noting that both the effects (the Collectivism and the Masculinity subscales on the participants' performance at the Cyberball) look tiny and, despite their significance, they are around the chance level. Therefore, the above interpretations need to be taken with caution, and further supported (or disconfirmed) by future studies.

Last but not least, participants also completed the Waytz Instrument, which measures individuals' likelihood of attributing human-like, anthropomorphic traits to robots (Ruijten et al., 2019; Waytz et al., 2010). As previously mentioned, we administered it to double-check whether the IAT and the Cyberball were actually measuring anthropomorphism, although in two different forms (the strength of the robot + anthropomorphic association for the IAT, the probability of socially including the robot in the game for the Cyberball). In our view, this would have been indicated by a positive correlation emerging between the participants' Waytz scores and their performance at the IAT and the Cyberball. Interestingly, results showed that the lower the participants' Waytz scores, the more likely they were to see robots as purely machines (as indicated by the stronger preference for the association robot + nonanthropomorphic). However, no significant correlation emerged between the participants' Waytz scores and their frequency of robot choice at the Cyberball game. When using the IAT as the reference measure of anthropomorphism towards robots, as we did in our study, the results of both the IAT and the Cyberball might suggest that the IAT might be more suitable for capturing participants' tendency to anthropomorphise robots. On the contrary, the Cyberball would measure participants' tendency to socially include robots, rather than the extent to which people anthropomorphise them. Potentially, it would also measure the perception of robots as social agents, although this interpretation of Cyberball data has to be further tested.

In our view, it is important to keep in mind the distinction between the two instruments, since it may potentially drive the differences in results obtained with the IAT vs. the Cyberball. The fundamental distinction is that the IAT, as a computer-based categorisation task, captures what people *think*, in the form of unconscious associations; conversely, the Cyberball is a ball-tossing game, which captures how people *act* (in terms of behavioural inclusion). Therefore, it might be that, as in the case of our study, the results differed across the two measures. For example, having a collectivistic stance (being prone to others) would positively correlate with the Cyberball performance because participants care about the robot not being left out by the game. However, it does not produce an effect on their IAT bias, presumably because participants do not think of humans and robots as a collective "we". The same might apply to the Conservation dimension: people having a preference for order, stability and predictability tend to "humanise" the robots because it might reduce their discomfort towards robots; however, since they might not feel comfortable with a mechanical artifact such as a robot, they do not care about including it in the game, and thus it might explain the lack of the Conservation's significant effect on the participants' Cyberball performance.

Another crucial distinction between the IAT and the Cyberball is that the former employed standard pictorial and linguistic stimuli (in our version, the picture of robot silhouettes and words related to anthropomorphism, respectively), and thus it is a purely symbolic task. Conversely, our version of the Cyberball represents a situated social interaction, with an embodied humanoid robot (Nao) physically sharing the same social and physical spaces with the participants, as well as the other human player. According to the "embodiment hypothesis" (Deng et al., 2019), physical robots are perceived as more trustworthy and engaging than disembodied agents (such as 2D pictorial stimuli) because they can leverage social cues like proxemic (personal space) and eye contact, which are more salient in the real world. Previously, Li (2015) also argued that people's attitudes are more positive toward "co-present" robots, i.e., robots that are physically embodied and present in the user's environment, than "tele/present" robots, which are only displayed on a screen.

Given these considerations, when investigating real-time social interactions between humans and robots, embodied HRI paradigms such as our version of the Cyberball might be more suitable instruments; however, combining them with more traditional 2D paradigms such as the IAT might be informative about potential dissociations, and thus extend current knowledge about human mechanisms (e.g., cognitive, social) involved when interacting with robots. Additionally, these implicit measures might be combined with more explicit measures, such as questionnaires (about anthropomorphism) or interviews (about participants' cultural identity), to gain an exhaustive overview of the interplay between culture and anthropomorphism in HRI.

7. Limitations

The study suffers from limitations that it is important to highlight. First and foremost, the IAT has been criticised, as there would not be sufficient evidence to claim that it measures individual differences in implicit social cognition (Schimmack, 2021). Moreover, it is a measure of relative association, which means that the opposition between the two categories has to exist (De Houwer, 2002). In other words, the postulate of the IAT is a symmetrical relation between the concepts. This, however, is not necessarily the case for robots and humans, as they are not necessarily antagonists (Spatola and Wudarczyk, 2021). For example, Rothermund and Wentura (2004) showed an association between Insects + Pleasant and Pseud-words + Unpleasant, suggesting that the associations can appear as the result of the saliency of discriminated materials.

Last but not least, the Waytz Instrument has not been validated for children's and pre-adolescents' samples. However, as described by Ruijten and colleagues (2019), it includes items from the larger anthropomorphism questionnaire (Waytz et al., 2010), which was further adapted to children. However, this latter version resulted in being comparable to the original anthropomorphism questionnaire for adults in predicting the extent to which people attribute anthropomorphism to non-anthropomorphic entities, including robots (Severson and Lemm, 2016).

8. Conclusions

In our view, our findings raise two important issues that deserve more attention in future studies. First, it shows that it might be worth extending the concept of culture beyond the mere participants' nationality. Indeed, our findings demonstrate that, within the same country (Italy), there are differences in participants' cultural stances, as indexed by different scores in the several subscales of the questionnaires. Therefore, in future studies, it should be a good practice to (1) define and operationalise what culture is in the context of a given study, but also (2) capture as best as possible the multi-faceted components of anthropomorphism towards robots, by the use of instruments having different features and thus able to capture various dimensions of the phenomenon.

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Declaration of competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

Authors contribution

CR designed the study; collected and analysed the data; discussed and interpreted the results; and wrote the manuscript. LL designed the study, collected the data, and wrote the manuscript. SL and NZ programmed the Cyberball task, integrated the Nao robot into the experimental protocol, and wrote the manuscript. ED designed the study; discussed and interpreted the results; and wrote the manuscript. All authors revised the manuscript.

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Data availability

A video of both IAT and Cyberball, and datasets used for analyses, are available on the Open Science Framework (OSF) platform, at the following link:

https://osf.io/s7ztb/overview?view_only=83bce06c374e46948d011ba7a8287dd8 (it has been anonymised only for peer review).

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