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Influence of phylogenetic proximity on children's empathy towards other species

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Empathy is an essential social skill that develops progressively during childhood. Although mainly studied in the context of human intra-specific interactions, it also extends towards other species. Various factors influence the strength of empathy towards other species, including phylogenetic distance. The present study aimed to examine if this parameter also affects children's empathy towards other species. Three hundred and eight children - aged 5 to 12 years old- were given an empathic choice test on an extended photographic sample of organisms, followed by a scale measuring their empathic tendencies towards human peers. Results highlighted that children's empathy towards other living beings decreased with phylogenetic distance, and that this trend strengthened as age increased. Interestingly, presence of animals in the household tended to be positively related to children's empathy towards their peers. Comparison with data collected in previous studies revealed that although the effect of phylogenetic distance was stronger in adults than in children, no difference was observed compared to adults with autism spectrum disorder (ASD), except for human beings. This research sheds new light on children's empathy towards other species and provides elements to consider for their sensitization to animal welfare and wildlife protection, as well as new insights on the specific status that animals can have for people with ASD.

Despite the considerable body of studies investigating empathy, no clear consensus on its definition has been reached yet. It is however commonly considered that empathy refers to an emotional response that stems from the understanding of others' emotional state, or as an emotional response that is similar to what another person is currently feeling or is expected to feel in a given situation[1]. This skill plays a crucial role in social interactions and affiliative behaviours[2,3]. It allows behavioural regulation and adaptation during social interactions according to others' emotional states, and promotes the expression of prosocial and positive social behaviours, while inhibiting the expression of negative and antisocial behaviours[4–7]. Conceptualizations of empathy in psychology emphasize on the distinction between two main dimensions of empathy: affective empathy, which corresponds to feeling and sharing others' emotional states, and cognitive empathy, which corresponds to the ability to understand and mentalize others' feelings and emotions (notably its causes and consequences)[8,9].

The perception action model (PAM)[10,11] proposes an interesting perspective on empathy. In this model, empathy is conceptualized as a shared emotional experience arising from the perception of others' emotional states, and resulting in the feeling of a similar emotion. According to this model, this sharing of a similar emotion results from the automatic activation of representations of the emotion when perceiving others emoting. Such activation is believed to be facilitated by common brain areas involved in perception and action (i.e., "mirror neurons"). Interestingly, this model stresses that empathy should be increased by the perception of similarities with others (either morphological, physical, behavioural or psychological), as it would facilitate the activation of the emotional representations and of common brain areas (in particular, mirror neurons). For example, it has been demonstrated that an increased physical self-resemblance is associated with an increase in spontaneous mimicry of emotional facial expressions[12].

Although human empathy has been mainly conceptualized and studied within an intra-specific focus (i.e., human towards human), this ability is not restricted to intra-specific interactions. Indeed, humans can show empathic responses to the emotional states of other species, as well as concern for their well-being[13,14]. Studies

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on this topic have notably demonstrated that emotional contagion is present when humans look at or listen to animals in specific emotional states. For example, human participants show empathic responses as well as variations in physiological response parameters (i.e., skin conductance and electromyographic activity) when exposed to short video clips of both humans and animals in distress[15]. This ability could lie, in particular, in our ability to decode and identify emotional signals emitted by animals (e.g., emotional, facial, and vocal expressions), which has been demonstrated towards various species (e.g., *cats*[16,17]; *dogs*[18,19]; *Macaques*[20,21]. Interestingly, the reverse relationship also has been explored in some domesticated species, with animals also showing signs of emotional contagion to human emotions. For example, Huber et al. (2017) demonstrated that after hearing a negatively valenced human sound (i.e., human crying), dogs displayed more behaviours indicative of arousal and negatively valenced states[22]; further, while using a stress-inducing situation (i.e., the Trier social stress test), Katayama et al. (2019) showed that dogs displayed changes in heart rate variability (HRV) that positively correlated with the changes in HRV of their owner exposed to a stress inducing situation[23]. In line with these elements, it is worth pointing out that studies show that a link exists between human intra- and inter-specific empathy. Indeed, higher empathy towards other humans seems to be related to higher empathy towards animals[15,24–27]. For example, whereas individuals with violent and antisocial behaviours, and/or high levels of psychopathy, have lower levels of human empathy and higher levels of callousness[28,29], it is interesting to note that such type of individuals with violent and antisocial behaviours towards humans are also more likely to have a history of animal abuse[30,31].

From a developmental point of view, rather than being completely innate, human empathy develops progressively from early childhood. First signs of affective components of empathy can be observed within the first few days of life, with newborns already showing manifestations of emotional contagion[32]. Components of cognitive empathy progressively emerge, and by 12 months of age, children are able to anticipate others' emotions based on their actions. Then, by 18 months of age, children are able to adapt their behaviours towards others, according to the emotions their actions may generate, as well as to display prosocial behaviours, such as comforting behaviours, notably in response to others' distress or expressions of pain[33–35]. From 3 years of age, children's empathy can be measured though more classic tests, relying on tools such as vignettes or stories depicting social scenarios followed by questions[36]. Children's empathic skills, along with their expressions of prosocial behaviours, will then continue to develop and gain in complexity, notably as they go through and accumulate social experiences, but also as their cognitive abilities and social skills increase[5,37]. Of interest, children also show empathy and concern towards animals in general (for a review, see Young et al., 2018[38], and children's acts of cruelty towards animals have also been shown to be related to current and later antisocial behaviours towards other humans[39,40]. This link between animal empathy and human empathy in children, is also further reinforced by studies demonstrating that children growing up with pets show better empathic skills towards other humans[41,42]. However, little is known about the development of empathy towards animals and the factors that may influence children empathy towards other species.

Both adults' and children's empathy towards animals is not equivalent towards all animal taxa. Some species raise more empathic responses and protection concerns than others[43]. Studies on this topic have identified different factors that exert an influence on our interest, attraction and empathy towards animals. First, some of the animal's global physical characteristics can have an influence, such as its size, or type of body covering (e.g., skin, scales, feathers, hairs), as well as the presence/absence or even shape of some body parts[44–46]. For example, children are more attracted to and engage in more physical contact with small and medium sized dogs than with micro and large dogs[47]. Presence of infant-like morphological features (e.g., large forehead, large and low-lying eyes, short muzzle) are also known to be associated with stronger empathy, as well as with attraction and care behaviours towards the animal[13,48–50]. In addition to the characteristics that are specific to the animal species, factors specific to the human observer can also affect ones' empathy and behaviours towards animals. We can notably mention variables, such as the individual's experiences with animals, but also the individual's cultural background[50,51]. The age of the individual can also be cited, because it has been observed that a lower age, particularly for young children, is associated with a poorer ability to recognize an animal's emotional states (e.g., for canine facial expressions[51–53], which may ultimately affect empathic abilities towards animals.

However, another recently identified parameter exerting an influence on human empathy towards animals is the phylogenetic proximity of the species with humans. Indeed, empathic responses appear to be more important for taxa that are more closely related to our own species[54–56]. In their study exploring this effect, Miralles et al. (2019) performed an online test on a sample of 3509 adults from the general population[57]. This test included a stimuli set of 208 photographs with 52 different species covering a range of 24 different monophyletic lineages (clades), all representing distinct phylogenetic distances from humans. During the test, the adults were exposed to a series of 22 pairs of photographs, and for each pair, had to indicate the animal, among the two possible choices, they felt they were better able to understand the feelings and emotions. Results showed that adults' empathic responses were significantly predicted by the species' phylogenetic distance with humans; meaning, that the more a species is phylogenetically close to humans, the more we are empathic towards it. This result can notably be interpreted in light of the PAM, as being due to the fact that species that are phylogenetically less distant with humans share more similarities with us (i.e., physical, behavioural or cognitive similarities), which ultimately facilitates empathic perceptions towards them[10,11], cf. notion of Anthropomorphic stimuli by Miralles et al., 2019[57]. In a second study, Miralles et al. (2022) replicated this experiment, using the exact same protocol and set of stimuli, on a sample of adults with autism spectrum disorder (ASD)[58], i.e. a neurodevelopmental disorder characterized by deficits in communication and social interactions, including empathic skills difficulties[59–61]. Interestingly, results from adults with ASD are very similar to that of adults from the general population, with empathy scores significantly decreasing with phylogenetic distance relatively to humans. However, their empathy scores for humans (i.e., *Homo sapiens*) are markedly lower, scoring our species as low as cold-blooded vertebrates; consistent with previous studies demonstrating that, for individuals with ASD, decoding animals' mental states is easier than understanding and/or decoding human beings[62–71].

That said, to date, no study has yet investigated the links between phylogenetic proximity and empathy towards animals in children. We therefore do not know whether a similar phenomenon to the one observed in adults is also present in children. Furthermore, based on the PAM, the effect of phylogenetic distance on empathic preferences towards other species is supposed to be based on a greater sharing of similar characteristics with closely related species. However, from a theoretical point of view, if this effect is based on a similarity rule, then it should be similar in children, and should not be affected by an individual's age or experiences with animals. However, as previously mentioned, studies have shown that our empathic abilities are the result of a progressive development. Furthermore, previous studies also suggest that our interactions and experiences with animals have an effect on our ability to successfully decode their affective states, and therefore could modify our empathic skills towards them. In particular, this dichotomy between the PAM and the above-mentioned research raises an important question about the effect of phylogenetic distance on empathy towards animals: is this phenomenon innate and fixed, or acquired and permeable to developmental and experiential influences?

To fill these gaps and answer these questionings, the present work proposed to investigate children's empathy towards animals and its variations in a phylogenetic comparative framework. Maintaining continuity with previous studies[57,58], the present research aimed to replicate the same test of empathy towards animals, but this time, on a sample of neurotypical children. The stimuli used (i.e., set of photographs) were similar, but restricted to chordates (i.e., mostly vertebrates, plus two tunicates species). The procedure applied was also similar, and consisted of an online application, presenting random pairs of photographs, all being as representative as possible of the chordates' phylogenetic diversity. Some minor adjustments were, however, made to make the experimentation more suitable to children: a reduction in the number of species (i.e., from 52 in previous studies to 35 in the current study), the number of clades (i.e., from 24 to 18) considered, the exemplification of the manipulated concept, and the addition of 2 training pairs of photographs. For each pair, participants had to indicate the one corresponding to their answer to the following question: "I feel like I'm better able to understand the feelings or the emotions of [choice among a pair of pictures]". The present experiment involved 308 children participants from the general population and without any diagnoses of neurodevelopmental disorder, aged between 8 and 12 years-old, and whose results have been compared with those obtained in previous studies, on both adults from the general population (1134 participants) and adults with autism (202 participants).

Given the possible impact of various family parameters (e.g., socio-economic status, presence of siblings)[72–75], as well as presence of pets in the household[40,41] on children's empathic development, such influences on the effect of phylogenetic distance on children's empathy towards the animal were also considered. Additionally, knowing that previous studies have shown a relationship between empathy towards humans and empathy towards non-human animals[15,24], children participants also had to complete a standardized scale measuring their empathic skills towards their human peers (i.e., other children) (the Basic Empathy Scale for Children or BES-C; Bensalah et al., 2016[37]. This additional measurement was performed to explore if children's intra-specific empathic skills (i.e., empathy towards other humans) had an influence on the effect of the phylogenetic distance with respect to their inter-specific empathy (i.e., empathy towards other species).

Results

Influence on phylogenetic distance on children's empathic choices towards species

The probability of a given species to be chosen decreased according to its phylogenetic distance relative to humans, compared to the alternative species (Fig. 1).

For each relative reduction of phylogenetic distance of one million years, the probability to be chosen increased by 1.17 (SE = 0.17) in linear units (logit). Results varied only according to the children's age ($P < 0.001$), but not according to children's sex, living area, participation in extracurricular activities with animals, presence of animal(s) in their household, number of siblings, and parents' level of education (all $P > 0.05$) (Fig. 2 and Table S1). Results indicated that as children's age increased, so did the probability of a given species to be chosen, according to its phylogenetic proximity relative to humans. The empathy score, computed for each species, varied between 0.759 [SEM = 0.025] to 0.078 [SEM = 0.016], and decreased linearly with divergence of time (linear slope: -7.37×10^{-4}, $SE = 0.1 \times 10^{-5}$, $P = 2.6 \times 10^{-9}$).

Interestingly, integration of the children's BES-C empathic scores, as an interaction term in the model, did not improve its prediction of the children's choices. Indeed, the interaction between children's scores to the BES-C and the phylogenetic distance was not significant ($X^2 = 0.31$, df = 1, $P = 0.57$, Table S2).

Comparison between children and adults from the general population

Whereas a main effect of phylogenetic distance was observed, this effect significantly interacted with the type of participants, meaning, that slopes significantly ($X^2 = 77.5$, df = 1, $P < 10^{-10}$) differed between children and adults from the general population: i.e. the influence of phylogenetic proximity on participants' empathic choices was stronger in adults than in children (Fig. 3A, Tables S3A). Additionally, taxa also interacted significantly with phylogenetic proximity, meaning that slopes differed between taxonomic classes (i.e., were lower for taxa that were phylogenetically more distant). However, and most interestingly, a significant second-order interaction was present between phylogenetic distance, taxonomic category, and type of participant, meaning that slope differences between adults and children varied according to taxonomic classes. Slope differences between both groups were stronger for primates ($\Delta = 1.76$), followed by humans ($\Delta = 1.21$), mammals ($\Delta = 1.15$), and finally chordates ($\Delta = 0.56$).

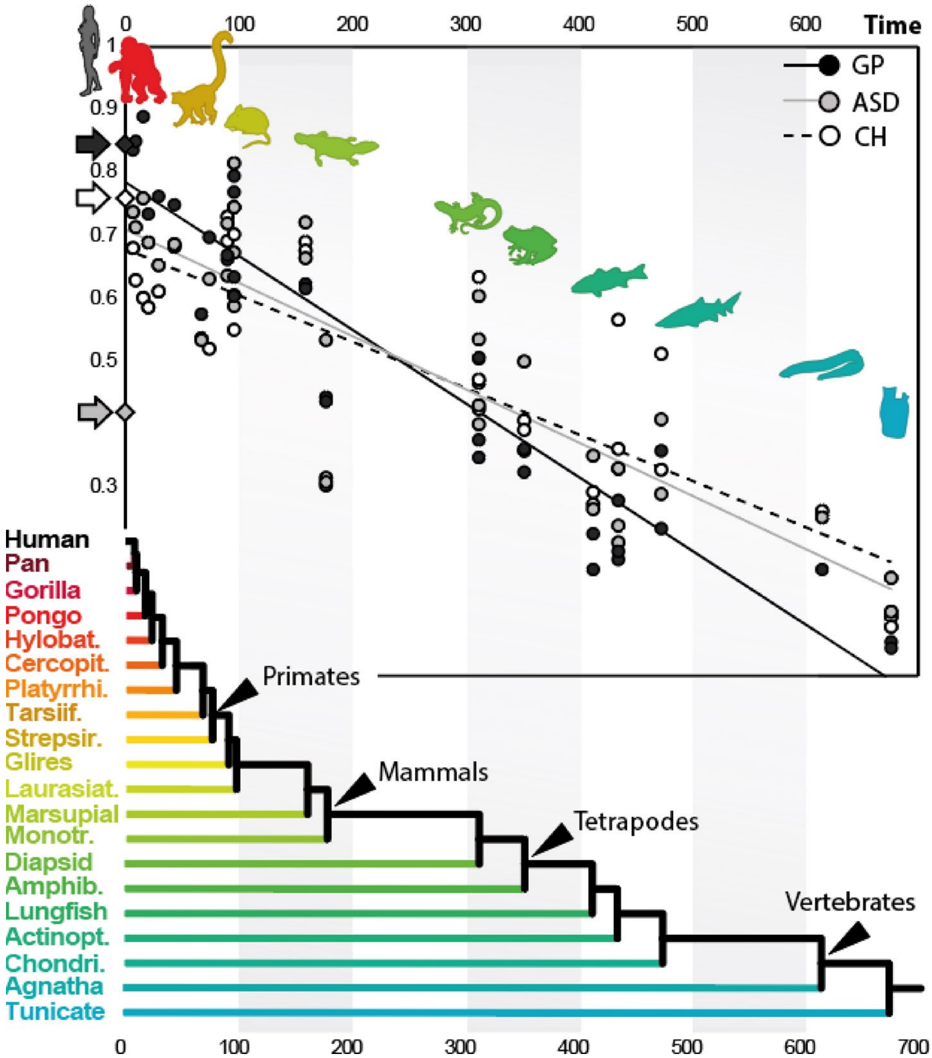

Fig. 1. Empathy scores attributed to each species according to its divergence time (Mya) with humans. The scores correspond to the probability for a given species to be chosen from a pair of species that includes this species and another randomly selected species ($N = 35$ species). Empathy scores attributed by raters in the children focal group (CH), the adults from the general population group (GP), and adults with ASD group (ASD) are represented by circles of white, black, and grey colours, respectively. The scores for the human species are indicated by an arrow with the same colour code.

Comparison between children and adults with ASD

Interestingly, although the main effect of phylogenetic distance was again present, this effect did not significantly interact with the type of participant. Thus, children and adults with ASD's slopes did not significantly differ: the influence of phylogenetic proximity on participants' empathic choices is similar between both groups (Fig. 3B, Table S3B). Taxa did interact significantly with phylogenetic proximity, with lower slopes for more distant taxonomic categories. Also of interest, a significant second order interaction was also present between phylogenetic distance, taxa, and type of participant. Closer investigation of these interactions revealed that slopes significantly differed between both groups, but only for the human taxa: children had a stronger slope compared to adults with ASD (Δ= -1.37). Differences for other taxonomic categories were not significant.

Influence of animal presence within the family household on children's intra-specific empathy

Descriptive exploration of children's scores to the BESC-C seemed to indicate that children with animal(s) in their household had higher empathic scores ($M = 18.8 \pm 0.31$) compared to children without ($M = 17.9 \pm 0.46$). Comparison between both groups using a Wilcoxon test indicated a non-significant tendency for both groups to differ on their scores to the BES-C ($W = 11403$, $P = 0.11$). Exploration of the effect of the number of animal's categories present in the household (i.e., cat, dog, exotic pets, farm animals) revealed that this parameter was not predictive of children's scores of empathy towards their peers (R^2=0.004, $F_{(1,301)} = 1.15$, $P > 0.05$). Thus, the

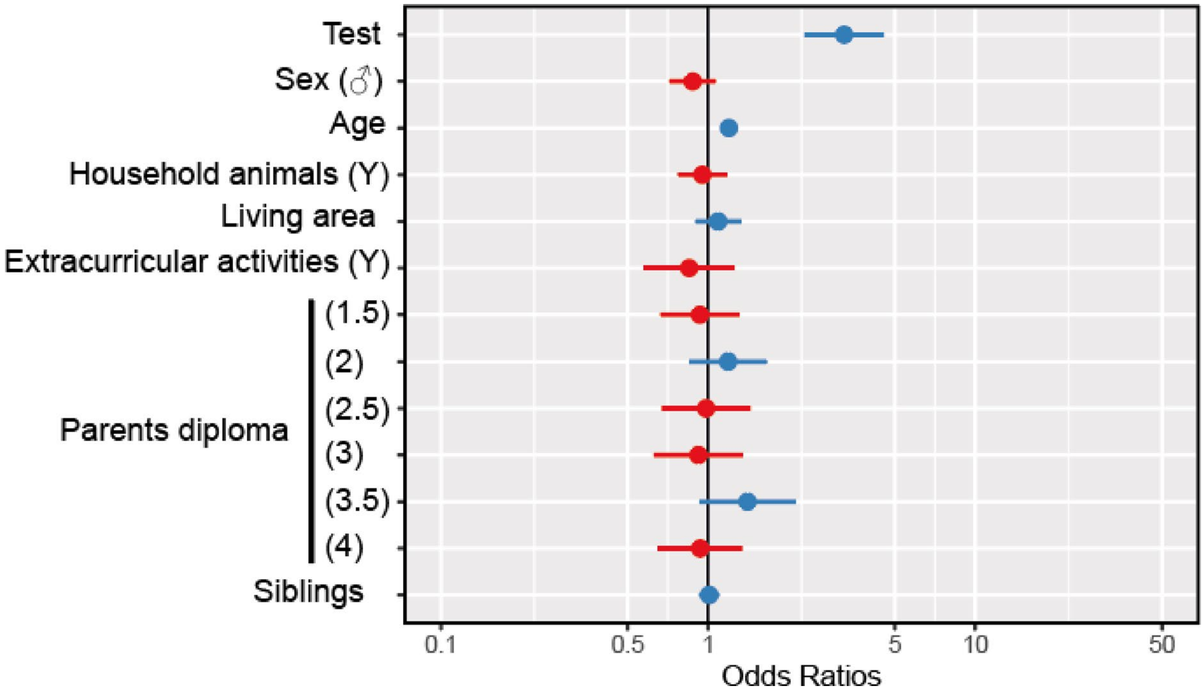

Fig. 2. Effect of participants characteristics on their empathic choices. Odds ratios are represented by dots and 95% confidence intervals by lines. Blue or red dots, respectively, indicate variables linked with an increased or decreased probability of choice for the phylogenetically closest species.

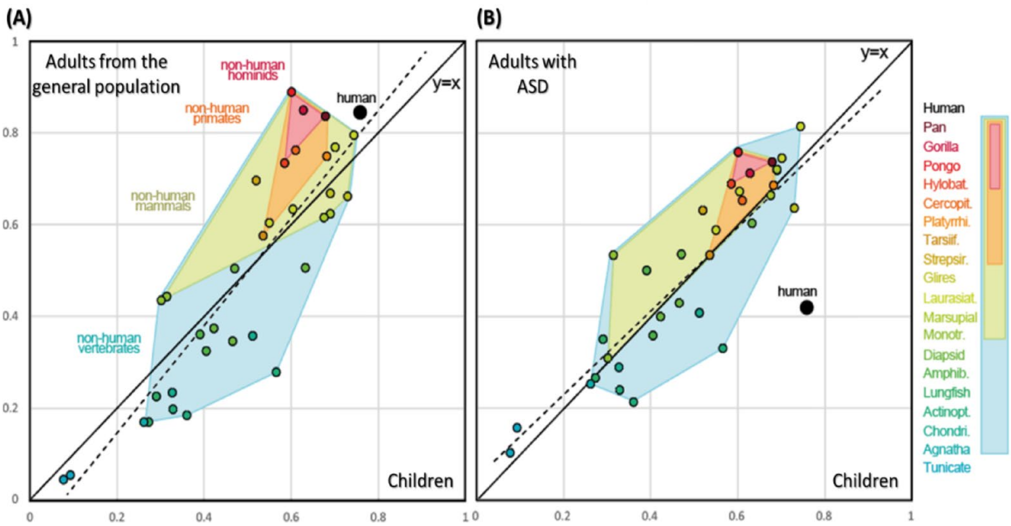

Fig. 3. Empathy scores, per species, between children and the two comparison groups: (**A**) children vs. adults from the general population and (**B**) children vs. adults with ASD. The outlines of the different polygons represent the four main clades nested within each other, whereas their coloured surfaces (excluding the clades they contain) are representing different non-overlapping grades (i.e., subsets of species defined according to the degree of phylogenetic divergence from humans). The position of the human species is depicted as a large black dot.

amount of various animal categories in the household did not seem to be significantly related to variations in children's score to the BES-C.

Discussion

At the intersection of developmental psychology and evolutionary biology, the present research proposed to explore if phylogenetic distance has an impact on children's empathy towards animals. Our results highlighted that the children presented an overall trend in their empathic preferences, towards non-human animals, that is similar to what has been previously observed in adults from the general population[57]: like them, children's empathy scores towards species significantly decreased with the phylogenetic distance relative to humans. Thus, children's empathy was not equivalent towards all living beings; it fluctuated from one species to another, and the phylogenetic distance separating the target species and our own species appeared to be a determinant factor, even for children. In light of the PAM, this effect could be interpreted as originating from a more important share of similarities with species that are more closely related to humans, compared to more distant species (see also the notion of anthropomorphic stimuli, in Miralles et al. 2019[57]. Indeed, more behavioural and morphological traits inherited from our common ancestor are shared with species that are less phylogenetically distanced from us, and these shared features gradually decrease as the phylogenetic distance increases[15,56,57]. According to the PAM, this greater sharing of common characteristics with phylogenetically closer species, then results in the facilitation of the activation of mirror neurons (i.e., brain regions common to both felt and observed emotions), thus facilitating the automatic activation of representations of emotions, and *in fine* empathic feelings, towards those species[10,11].

More interestingly, children's age had a significant effect on the influence of phylogenetic distance on their empathic answers, with an increasing effect of phylogenetic distance on their empathy scores as their age increased. Whereas not excluding this model, this effect of age does not find a direct echo with the PAM, because morphological variation with age (from childhood to adolescence) would not result in greater morphological and/or behavioural similarities with phylogenetically less distant species. This result rather encourages us to consider that, instead of being a purely innate phenomenon, the effect of phylogenetic distance on empathy towards animals could be permeable to developmental and experiential effects. Interestingly, this effect of age seems to echo previous studies showing that as children's age increases, so does their accuracy in the recognition of animal's emotions[51–53]. A first interpretation of this effect of age would be that as children grow and develop, so do their cognitive and empathic skills, as well as their experiences with various species, which, in turn, influence their empathy towards animals[1,37,52,76]. Notably, as they grow, children may experience and accumulate greater success in perceiving and interpreting the emotions, as well as sharing of emotional states, of both humans and phylogenetically closer species, while experiencing greater difficulties and failure with more phylogenetically distant species. An alternative hypothesis, that could also be put forward, is that, as children develop and reinforce their empathic skills towards our own species, they would gain in empathic expertise towards humans, but lose in processing sensitivity in the exercise of empathic skills towards animals, as they become more and more specialized for the processing of human information. This could then translate into a modulation and/or reinforcement of this empathic hierarchy, according to phylogenetic proximity, as the child improves its empathic skills towards humans (i.e., as they gain in empathic expertise towards humans, they become increasingly sensitive to human like physical and behavioural signals of emotions). This effect of the development of an expertise for the processing of human signals, to the detriment of animal signals, finds echoes, for example, in the studies of Pascalis et al. published in 2002 and 2020[77,78], who demonstrated that during the first year of life, as children specialize in the processing of faces of their own species (i.e. humans), they become less sensitive and efficient in the processing of faces of other species (i.e. in particular, the recognition/discrimination of identity of primate faces).

Previous studies have shown that human intra- and inter-specific empathy seem to both be related, with individuals with a higher empathy towards conspecifics also showing a higher empathy towards other species[15,24–27], and this occurring even in children[38–40]. Surprisingly, in the present study, children's empathy scores towards their peers (i.e., BES-C scores) did not seem to be related with the effect of phylogenetic proximity on children's empathic answers towards other living beings. Rather than contradicting the presence of a link between empathy towards humans and towards animals, these results highlight that independent of this link, children's empathy towards other species is modulated by the species' phylogenetic distance with humans. Similarly, the presence of pets or animals in the household exert an influence on this phenomenon. Previous research has shown that growing up with pets is related to individuals' actual and later empathic skills and social behaviours[41,42]. In line with these studies, we observed that children growing up with animals tended to have higher scores of empathy on the BES-C compared to children without animals in their household. Having animals in their household could thus be related with children's intra-specific empathy. It is important to note that although the effect of the current presence of a pet in the home was explored, we did not explore if the fact that the child had ever experienced a companion animal in the household had an effect. Exploring the effect of current and previous presence of animals in the household could be of interest for future studies. The present study also explored, for the first time, if the diversity of species children grow up with also plays a role in the development of their empathic skills. The hypothesis was that having different species in the household could provide children with a wider variety of interaction experiences and opportunities to practice their empathic skills, that they may then generalize to human interactions[79–83]. Although we did not observe an effect of the diversity of animals in the household on empathic scores (i.e., BESC-C scores), it is important to note that unlike the present study, which focused on children (i.e., 6 to 12 years old), previous studies investigating the link between the presence of animals and empathic development have mainly been carried out on adolescent and adult participants[41,42]. Although starting at an early age, empathic development continues throughout adolescence and until adulthood[37]; it could therefore be of interest for future studies to investigate this potential influence of the diversity of species in the individual's living environment over a wider age range, to investigate whether this parameter has an influence at more advanced levels of empathic development. Another element that should be addressed is that the BES-C measures human empathic skills by focusing on three distinct components of empathy (i.e., emotional contagion, cognitive empathy and emotional disconnection), whereas the empathic choice test towards different species used in the present study asked participants to choose the target they felt they were "better able to understand feelings and emotions". However, as previously mentioned, empathy is conceptualized as including two distinct dimensions: affective empathy (i.e., feeling and sharing of others' emotions) and cognitive empathy (i.e., understanding and mentalizing of others' emotions)[8,9]. Thus, we cannot exclude that by using this specific question, which addressed participants understanding of other species' emotions, our empathic choice test focused only on aspects relative to cognitive empathy, which could have contributed to the lack of a relationship between children's scores on the BES-C scores and their answers to the empathic choice test. It could be of interest for future studies to consider measuring simultaneously both affective and cognitive aspects of empathy towards animals. Furthermore, it seems pertinent to point out that in the present study, the children were asked about their feelings of empathic capacity towards the animal (i.e., do they feel able to understand the emotions of this species), but were not tested on their effective empathic capacity (i.e., are they able to accurately read and share the emotions of another species). However, it would be of interest for future studies to test children's actual reactions and behaviors in response to animal emotions, as well as to measure their ability to read and recognize the emotions of different species.

Comparison with data previously collected on adults from the general population by Miralles et al.[57] revealed that although both groups exhibited a significant influence of phylogenetic proximity on their empathic choices, this effect was significantly more pronounced in adults than in children. As for the age effect, this difference between adults and children could, in particular, be explained by differences in the development of empathic skills, in the accumulation of experiences of interaction and empathy towards humans and animals, or in the acquisition of an intra-specific expertise[1,51,52,76–78].

However, one of the most striking results emerged when comparing our sample of neurotypical children to adults with ASD (published in Miralles et al., 2022[58]). Indeed, although neurotypical children significantly differed from adults from the general population, such a difference was not observed when comparing neurotypical children to adults with ASD; meaning, that the influence of phylogenetic proximity on empathy towards animals could be equivalent between both groups. Furthermore, when comparing the two groups for each taxonomic category, the only difference that emerged was for the human species. So, although neurotypical children did not differ from adults with ASD in how phylogenetic proximity affected their empathy towards other species, they did differ in their feeling of empathy towards humans. In the adults with ASD group, the empathy score attributed to *Homo sapiens* (0.419 [SEM = 0.048]) was remarkably lower than in the children group (0.759 [SEM = 0.025]). This difference, specifically for the human species, was consistent with what has been observed by Miralles et al. in 2022[58], when comparing adults with ASD to adults from the general population.

These results are also consistent with previous research highlighting that understanding human beings is more difficult for individuals with ASD than decoding animals (notably demonstrated with mammals), which has been demonstrated for the recognition of facial expressions and potentially the attribution of intentions[63–65]. This particular phenomenon for non-human species for individuals with ASD could notably originate from a relative preservation of skills for the processing of animal targets and their information, but not for humans, which has notably been demonstrated for visual exploration strategies of animal faces[66,67,70,82]. Altogether, these different lines of evidence prompt us to wonder if communication and the social interaction deficits that characterize ASD, instead of being global and general deficits, rather consist in the absence of development of an expertise in the processing of human information, and thus translate into communication and social difficulties that are specific to interactions with fellow humans, but not to those with other species.

More generally, the absence of a difference in slope, between neurotypical children and adults with ASD, as well as the difference in slope in adults with ASD in comparison to adults from the general population (for all taxonomic categories), suggests that although the impact of phylogenetic proximity is stronger in adults than in children, this is not the case when the adult is with ASD. Thus, the degree to which phylogenetic distance affects empathic feelings towards different species seems to be similar in neurotypical children and adults with ASD. This lack of difference between neurotypical children aged 5-to-12 years-old, and adults with ASD, necessarily leads us to wonder what happens in individuals with ASD during their development. Would they show, during their childhood, a phylogenetic gradient of empathic perception toward other species that would be similar to that of neurotypical children, but that would remain stable thereafter, during their development? Or, would they, during their childhood, already show a lower effect of phylogenetic proximity on their empathy towards animals, that would be even lower than that of neurotypical children? A hypothesis that could be proposed to explain these elements would be that, in neurotypical individuals, the development of an expertise in the processing of human stimuli - in our case, for empathic processing - would contribute to an increasingly strong tendency to empathize more towards agents sharing similarities (i.e., morphological and behavioural) with humans. Conversely, in individuals with ASD, the altered development of this processing expertise for human agents could attenuate this tendency to empathize more towards agents sharing common characteristics with humans. To further investigate these questions, a future direction to this study would be to replicate it with a sample of children with ASD, while carefully considering the influence of both their chronological and developmental age on this effect of phylogenetic distance. Similarly, considering the incidence of their degree of expertise and easiness in being empathic towards other humans, with respect to the effect of phylogenetic distance, could also be of interest.

Conclusion

It is now clear that even in children, empathic perceptions and responses towards other living beings fluctuate according to the phylogenetic proximity of an organism, relative to us. Interestingly, it appears that across development and as children grow up, this stronger empathy towards phylogenetically closer species strengthens. However, this strengthening across development could be specific to neurotypical individuals, as the strength of this effect was equivalent between neurotypical children and adults with ASD – except for the human species. While bringing new avenues to investigate, relative to empathic development and the specific status of animals in individuals with ASD, the present research also brings new elements to consider when considering the relationship between children and other living beings. In France, for instance, children's sensitization to animal well-being and respect is part of the National Education program and has been adopted by the French Ministry of National Education since 2021. Considering children's greater difficulty in feeling empathy towards more distant species, and in looking for opportunities to act in consideration with this phenomenon, could prove to be of interest for future studies and programs aimed at raising children's awareness of animal welfare and wildlife protection.

Material & method

Ethics statement

The present research has been conducted in line with French governmental legislation. Its method and protocol have been approved by the research ethics committee of the University of Reims Champagne-Ardenne (reference number: 2022-027/LEP-dev). The European GDPR (General Data Protection Regulation) was fully applied, and this research methodology complied with reference methodologies of the CNIL (French National Commission on Informatics and Liberty). All the parents of the children who participated in this study were informed of the topic of the study, its protocol and methodology, as well as about the processing of personal data and about their rights of withdrawal. All parents provided their written consent, and all children provided their verbal assent prior to each experimentation. All participating children were recruited between February 2023 and April 2024. All data were deidentified.

Photographic stimuli

Species selected by Miralles et al. in 2019 and 2022[57,58] were used, after reducing the taxonomic range to chordates (here, mainly vertebrates, plus two tunicate species), resulting in a diversified set of 35 different species (including *Homo sapiens*). Selected species covered 18 different clades and included species from the Blue sea squirt and Yellow sea squirt (i.e., respectively, *Clavelina caerulea* and *Ciona edwardsi*, both from the Tunicata, divergence time from *Homo sapiens* of 676 million years) up to *Homo sapiens* (i.e., no divergence time). This restriction of species was motivated by the need to increase data density per species considering a relatively reduced number of participants for a non-online experiment involving young children. The choice to exclude species beyond the chordata clade was based on the fact that previous experiments by Miralles et al.[57,58] have demonstrated an inflexion and stagnation of the empathic perception curve that coincides with the basal cordata, or possibly earlier with the emergence of bilaterians.

Each of the 35 species was represented using four distinct photographs of distinct adult individuals to be representative of the phenotypic variability among each species (see Miralles et al., 2019 for details regarding the choice and selection of species and photographs). This led to a total picture set of 140 photographs.

Finally, pictures of four additional species (i.e., hedgehog, elephant, armadillo, sloth) were also considered, and were added to the set of pictures solely for training purposes, prior to test trials.

Procedure

All experiments were carried out in an isolated and quiet room provided by the school or community centre where participants' recruitment took place. Each child was tested individually, and the completion of each test required 15–20 min.

The experiment began by ensuring that each child had a good understanding of the studied concept — empathic skills towards other species. Thus, to illustrate what was meant by "understanding the feelings or emotions of an animal", children were asked to watch short video clips (15–30 s each). These clips, extracted from videos published online by Lauren Thielke from the Human-Animal Interaction Lab at the University of Oregon (https://www.youtube.com/@laurenthielke348*)*, depicted three dogs displaying distinct behavioural and emotional responses during the reunion phase of the Strange Situation Task: one showing a positive and playful reaction to its owner, another displaying a negative and avoidant response, and a third exhibiting a neutral and indifferent demeanour. After watching each clip, children were invited to freely describe what was the dog's emotion in their opinion. It was then explained to them that this ability to correctly guess and read an animal's emotion was what was meant by "understanding the feeling or emotion of an animal".

Following this first step, children's empathic preferences towards various species was tested. The procedure used was similar to the one used in Miralles et al. in their studies published in 2019 and 2022[57,58] to assess empathic preferences, and a similar application was generated and used for the presentation of random pairs of photographs, except for some minor adjustments for adaptation to children participants (i.e., inclusion of training pairs, mouse click performed by the experimenter). Participants were not provided with any specific information about any of the photographed species that may have influenced their choice. For each pair, participants were instructed to designate the species corresponding to their answer to the following question: "Which species do you feel like you are better able to understand the feelings or the emotions of? Is it the [name of the 1st species] or the [name of the 2nd species]?". Participants were then instructed to either point to or name the species corresponding to their answer, without any time constraint. The position of the photograph on the screen (left or right) was randomly ascribed for each pair. Each participant was exposed to 23 consecutive pairs of photographs, including 2 initial training pairs, followed by 18 test pairs, and finally 3 repetition pairs. The two training pairs were always the same: first elephant and hedgehog, then sloth and armadillo. The three repetition pairs corresponded to three pairs randomly selected among those previously presented (excluding the training pairs and the last four pairs already seen). These three repetition pairs were used to estimate participants' judgement reliability. Pictures used for all 18 test pairs were randomly drawn from the set of 35 species, with application of the following constraints for each pair: the two species have to be from distinct clades, and no species can be seen more than once.

Following completion of the task on the platform, children completed the French version of the BES-C (Basic Empathy Scale in Children) with the experimenter[37]. This scale is dedicated to the measurement of empathic skills towards peers in children aged 6 to 11 years old. It includes 20 items focusing on three distinct components of empathy: emotional contagion, cognitive empathy and emotional disconnection (internal consistency: Cronbach's alphas from 0.56 to 0.68 for the three factors, Cronbach's alpha of 0.73 for the whole scale). For each item, children had to refer to their answer using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). To ensure readability for participants, each scale included two smiling faces and two sad faces at each end of the Likert scales. Additionally, participants were instructed to refer to their answer by pointing on the Likert scale, while the experimenter crossed the scale accordingly. The version of the scale (i.e., boy or girl version) was adapted according to the children's sex.

Participants

To be included, children had to respect the following inclusion criteria: the child must be aged between 5 and 12 years old, must be schooled or integrated within an institution which has accepted to participate in the project, and the child's parents or caregivers must have provided their written consent. Children were recruited through elementary schools and community centers in the Grand-Est, Bretagne and Île-de-France regions in France. Recruitment was performed through these schools and structures by transmission of a flyer to the parents inviting them to contact the experimenter if interested in taking part in this study (either via hand-to-hand transmission, email, or parent-teacher contact book). Children were screened for diagnoses of neurodevelopmental disorder upon recruitment using a general information questionnaire addressed to parents, which aimed at collecting general information about their child (i.e., child's age and sex, living environment, participation in extracurricular activities with animals, presence of animal(s) in the household, number of siblings, and parents' level of education).

The final sample of participants consisted of 308 children aged between 5 and 12 years old, including 173 girls, 134 boys, and one child whose sex was not specified on the experimentation platform by the experimenter. All had a mean age of (M ± SD) 8.72 ± 1.47 years old, with an age ranging from 5.47 to 12.13 years old. All were from the general population and were not diagnosed with any neurodevelopmental disorder. Among these 308 participants, 103 did not live in a household with animals, whereas 205 did, among which some owned different species: 124 had a cat, 116 had a dog, 66 had exotic pets (e.g., hamster, bird) and 41 had farm animals (e.g., chicken, horse). One hundred and fifty-three children lived in the countryside, whereas 155 children lived either in urban or suburban areas. None of the children participated in either animal assisted therapy, animal assisted interventions or animal assisted activities; however, 21 participated in extracurricular activities involving animals (e.g., horse riding, dog training). Concerning parents' education, 78 mothers and 107 fathers had a diploma level lower than high school, 86 mothers and 86 fathers had a high school level diploma, 55 mothers and 54 fathers had a diploma level equivalent to a two-year university degree, and 89 mothers and 61 fathers had a diploma level equivalent or superior to a bachelor's degree. The number of children within the family household varied from 1 up to more than 5 children (i.e., 42 participants from a household of 1 child, 133 from a household of 2, 82 from a household of 3, 33 from a household of 4, 5 from a household of 5, and 13 from a household of more than 5 children).

An additional 38 children participated in the present experiment but were not included for analyses. Among those children, 3 were excluded due to technical difficulties (i.e., online platform fail, protocol inversion, high distractibility of the participant), 5 were excluded due to a diagnostic that may have affected their answers (i.e., ADHD, ADD, language development delay, behavioural disorder, colour-blindness), and 30 were excluded because they did not comply with the consistency criterion to the repetition trials (i.e., more than one inconsistent answer to the three repetition pairs).

To further explore the results obtained on neurotypical children, their results were compared with those obtained in two previous studies: one on adults from the general population (Miralles et al., 2019[57], and one on adults with ASD (Miralles et al., 2022[58]. Comparisons were performed as both studies included all the species considered here, used the same photographs, the same computer application, and the same empathy question. The sample of adults from the general population was reduced to judgements of pairs involving only the species used here, resulting in 10,865 pairs of species evaluated by 1136 participants, with 707 females (62,2%) and 429 males (37,8%), with a mean age of (M ± SD) 37.6 ± 13.17 years old (range 18.1–81.2). The same procedure was applied to the sample of adults with ASD, resulting in 1,889 pairs of species evaluated by 202 participants, with 138 females (68%) and 64 males (32%), with a mean age of (M ± SD) 38.0 ± 10.87 years old (range 18.1–69.5) (for additional details on this sample, see Miralles et al., 2022).

Statistics

As previously mentioned, consistency of participants' answers were verified before performing statistical analysis (i.e., participants' answers to the three repetition pairs could not be inconsistent on more than one pair). Based on this consistency criteria, data from 30 participants have been removed from analysis. Additionally, prior to statistical analysis, answers on pairs of photographs whose evaluation took less than 200ms ($N = 1$) or more than

1 min ($N=63$) have been removed, resulting in a total of 5,197 comparisons. Finally, only for analyses including BES-C scores, three additional participants were removed due to absence of BES-C scores.

Logistic regressions were used to examine if phylogenetic divergence time, relative to humans, had an influence on participants' empathic choices towards the different species. The fact of being chosen or not, for the focal species (arbitrarily the species presented at the left), during the presentation of each pair, corresponded to the binary response variable. Species and raters were considered as random samples from a larger population of interest and were thus random-effect variables in the model. Therefore, a generalized linear mixed model with a binomial error structure was used. For each choice made by a rater, the difference in time of phylogenetic divergence with humans between the focal and the non-focal species was calculated, as provided by timetree.org (cf. Supplementary Material Table S4). The value of this difference was integrated into the model as the main variable of interest (Test). To explore and control for the incidence of different parameters, variables concerning the participants' characteristics were also included in the model as interaction terms with the variable of interest (Test). These variables were the participants' sex (qualitative: male, female), age (quantitative, centred), presence of animals in the household (qualitative: yes, no), living area (qualitative: urban/suburban, countryside), participation to extracurricular activities including animals (qualitative: yes, no), both parents mean level of diploma (qualitative : 1 [level lower than high school], 1.5, 2 [high school level], 2.5, 3 [two-year university degree level], 3.5, 4[equivalent or superior to bachelor's degree level]), number of siblings (quantitative: from 1 to 6, the last corresponding to 6 siblings or more, centred). Significance of each independent variable was calculated by removing it from the full model and comparing the resulting variation in deviance using a Chi-square test, as done with function Anova of the car package.

To explore if children's intra-specific empathy had an incidence on the influence of phylogenetic distance on empathic choices towards different species, a generalized linear mixed model with a binomial error structure was used. The structure of the model and used variables was, in all points, similar to the previous, with the exception that this time children's scores to the BES-C were added in the model, as an interaction term, with the variable of interest. Here also, significance of each independent variable was calculated by removing it from the full model and comparing the resulting variation in deviance using a Chi-square test.

With the aim to determine if the effect of phylogenetic distance on participants' empathic choices varied between children and adults from the general population, or adults with ASD, two additional generalized linear mixed models with a binomial error structure were applied. For the first model, the difference in time of phylogenetic divergence with humans, between the focal and non-focal species, was integrated in the model as the main variable of interest (Test). A taxonomic qualitative variable (taxa) was introduced as interaction terms with the variable of interest, using the following categories: humans (for pairs of pictures with one human), primates (for pairs with at least one non-human primate), mammals (for pairs with at least one non-primate mammal), chordates (for pairs with at least one non-mammalian chordate) (see details in Supplementary Material Table S4). To explore and control for the incidence of other parameters, variables concerning the participants' characteristics were also included as interaction terms: participants' sex (qualitative: male, female) and age (quantitative, centred). Finally, the type of participant (qualitative: children, adults from the general population) was also introduced as an interaction term, and the second order interaction between taxa, type of participant, and variable of interest was also tested. For the second model, the exact same variables and structure were also used, with the exception that this time, the variable of type of participant, included children versus adults with ASD.

Knowing that previous studies have demonstrated that the presence of animals in the family may be beneficial to the development of empathy, scores on the BES-C (i.e., intra-specific empathy) were compared between children living with and without animals in their household using Wilcoxon rank sum test. Additionally, using a linear regression test, the influence of the variety of animals (i.e., number of different animal categories) in the household on children's empathy towards their peers (i.e., BES-C scores) was also explored.

All analyses were performed using R version 4.2.1. with a p-value threshold of 0.05.

Data availability

Data supporting the findings of this work are available within the paper and its Supplementary Information files.

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Author contributions
N.D., A.M., M.G., C.D. and M.R. conceived the project, M.R. conducted the analyses with input from ND, MG and AM. ND coordinated the experimentations and supervised the interns during data collection. AM produced all visualizations. ND drafted the first version of the manuscript, and together with MR, AM, CD and MG, revised and edited the manuscript.

Declarations

Competing interests
The authors declare no competing interests.

Additional information
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