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Seven questions on perceiving and understanding other minds

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Abstract

In this paper we ask and try to answer seven questions, some bigger than others, on perceiving and understanding minds in others: (1) Do humans, animals, and artificial agents have minds? Objectively and subjectively speaking? (2) How do we perceive and understand these other minds? (3) How are other minds represented in the brain? (4) Is the perception of minds in other species or artificial agents not just mere anthropomorphism? (5) Is it important how the other looks? Does it matter if the other is human-like (e.g., robots) or cute (e.g., animals)? (6) Does it matter at all if you think an agent has a mind on how you view yourself and others? And finally, (7) where does it all end? What methods and techniques, perspectives or approaches does the field need to answer these and future questions? Together, the answers to these seven questions suggest that minds are grounded in sociality and people judge minds on the capacity to feel and think, with a distinct neural network supporting this. There is emerging evidence on the flexibility thereof in terms of activity to diverse minds and presence of this network across species. Mind perception and anthropomorphism are distinct at the conceptual, psychological, and neural level, and beliefs and other top-down effects are more important than just the visual appearance of an agent. Reports on threat to human identity, intergroup effects, as well impact on group dynamics, show that

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there are clear inter- and intrapersonal consequences of mind perception. Future research should use an interdisciplinary approach embracing different disciplines, from comparative psychology to linguistics, employing multi-method assessments of mind perception in interactive, embodied, everyday social situations, capturing the inter- and intrapersonal consequences thereof, to provide further answers on these and other questions.

Keywords
anthropomorphism, mentalising, mind perception, social cognition, theory of mind.

1. Introduction

Minds, we all have them, or at least we believe we do, but do other people, animals, or robots have them as well? Does it matter if they do? How is the mind of others construed in our own mind? What factors influence this? The goal of this paper is to ask and try to answer these and other questions on the perception and understanding of other minds. To answer these questions, we integrate findings and perspectives from psychology, neuroscience, biology, artificial intelligence, social robotics, and philosophy. Before we ask and answer the seven questions, we acknowledge that our interest in mind perception is by no means unique. Mind perception has been a topic of scholarly and scientific inquiry across history, distant (e.g., Kant, 1785) and recent alike (e.g., Searle, 1994).

Over several decades scholars and scientists from different disciplines have studied and written about mind perception extensively, with — and this list is by no means complete — important and influential papers coming from the fields of psychology (e.g., Gray et al., 2007; for a review see Waytz et al., 2010a), neuroscience (e.g., Fletcher et al., 1995; Goel et al., 1995; for a review see Koster-Hale & Saxe, 2013), biology (e.g., Premack & Woodruff, 1978; for a review see Call & Tomasello, 2008), artificial intelligence and social robotics (e.g., Chaminade et al., 2007; for a review see Wiese et al., 2017), and philosophy (e.g., Dennett, 1971; for a review see Perez-Osorio & Wykowska, 2020). In the current paper, we combine these and other accounts, including our own (Hortensius & Cross, 2018; Diana et al., 2024), together with recent empirical findings to reflect on the current state of thinking on mind perception. By no means is the list of seven questions we ask in this paper complete, they merely reflect questions that we have been thinking and working on over the last couple of years. Our answers to the questions are meant to be to the point, opinionated, and might therefore be perceived as controversial. Having said that, let's ask the first question.

2. Question 1: Do humans, animals, and artificial agents have minds?

Questioning whether other entities have minds is far from abstract: it shapes to how we treat fellow humans, how we build technology, and how we engage with the nonhuman world, from trees to animals and artificial agents such as robots and AI chatbots (Waytz et al., 2010a). But how do we know, or think we know, that they do have minds? A useful way to approach this is by distinguishing between subjective and objective assessments of minds. This means highlighting the differences between how minds are *attributed* by observers and how they may be *grounded* in observable evidence.

Subjective assessment captures how people perceive and attribute mental states to others. Such judgments are shaped by appearance (Abubshait & Wiese, 2017), behaviour (Waytz et al., 2010b; Abubshait & Wiese, 2017), and context (Abubshait et al., 2021; question 2), and people are not always accurate in these judgments. For instance, people underestimate the minds of animals even when receiving evidence for the presence of mental capacities in these animals (Leach et al., 2023b). These biases raise a key challenge: our perception of others' mind is not always tied to their actual mental capacities. Objective assessments on the other hand captures the functional criteria that indicate the presence of a mind, independently of human biases or impressions. Such criteria may include evidence of specific cognitive performances (Emery & Clayton, 2004), self-recognition (Plotnik et al., 2006), or symbolic communication (Swan & Goldberg, 2010). Among these, sociality stands out as particularly important, since minds are revealed most clearly in reciprocal, adaptive interactions with others. It is even hypothesised that consciousness emerges from the mechanisms underlying the perception and understanding of other agent's (interactive) behaviour (Graziano & Kastner, 2011).

Human cognition is deeply social. From early infancy, we show sensitivity to others' gaze and gestures and later develop theory of mind to infer others' thoughts and intentions (Tomasello, 2014). Through shared attention, cooperation, and cultural learning, our minds are most clearly expressed to others in social interaction rather than isolation. A similar picture emerges in the animal kingdom. Many animals demonstrate the possibility of minds through social behaviours: apes collaborate in coordinated tasks (Melis et al., 2006), corvids re-hide food when they have been observed (Emery & Clayton, 2004), and whales synchronize when avoiding predators (Senigaglia et al., 2012). Such cases illustrate that social interaction often provides an alternative window into cognitive capacities, even when these are otherwise difficult to measure. They are a telltale of an agent's mind.

Artificial agents are increasingly evaluated through this same social lens. Popular culture reflects this intuition: fictional robots and real AI chatbots alike appear to have a mind not (only) because of their computational power, but because they demonstrate social capacities by forming relationships, showing emotions, and coordinating with others (Breazeal, 2003; Broadbent, 2017). Similarly, agents capable of adapting to human behaviour or sustaining a reciprocal social exchange demonstrate a form of social intelligence (Breazeal et al., 2016). This perceived sociality is central in attributing minds to artificial agents (Hortensius & Cross, 2018; Jastrzab et al., 2024). Sociality thus may function both as a test and as a design goal: an agent is perceived as having a mind to the extent that it participates meaningfully in interaction. But there is another route as well. Rather than focusing exclusively on how robots and other artificial machines engage with humans, researchers are now studying how they interact with one another (Rahwan et al., 2019). As we have argued previously (Diana et al., 2024), robot–robot interaction offers a bottom-up path to understand sociality. Restricting robots' social behaviours to those that can be expressed in human–robot interaction may constrain the broader potential of this technology. Sociality can arise through different mechanisms, as shown by its independent evolution in diverse organisms such as insects, cephalopods, and mammals. Rather than attempting to model complex social behaviours from the get-go, some researchers are investigating whether social behaviours may emerge spontaneously under certain conditions (Avila-Garcıa & Cañamero, 2004; Khan & Cañamero, 2018). Allowing simple robots to coordinate, cooperate, or compete freely with one another, creates opportunities to study how complex social outcomes might emerge from simple mechanisms. This interdisciplinary and evolutionary perspective might offer direct insights into the relation between sociality and the appearance of minds.

So, do humans, animals and artificial agents have minds? If we answer this question based on observable evidence, focusing on sociality should be the way forward. Minds, whether human, animal, or artificial, are revealed not only in isolation but in the ability to share the world with others. From this perspective, the question is not simply who has a mind, but how different kinds of minds express themselves in the social interactions that sustain them.

3. Question 2: How do we perceive and understand other minds?

Besides the debate if objectively speaking an entity has a mind, the question is how we subjectively attribute minds to the wide variety of agents we encounter in everyday life. Over three decades ago, Dennett (1988) proposed that an intentional entity is simply one that can be usefully predicted by ascribing intention to it. If the application of intention is reasonable, there is no further questioning of whether the entity truly has beliefs or intentions. An entity is intentional if one perceives it to be. But where does our initial desire to make internal attributions to different agents stem from?

According to attribution theory (Heider, 1958), we aim to predict and explain our (social) environment, to get from variance to invariance. We try to distil motives, emotions, and beliefs (the invariance) out of the stream of behaviour (the variance). The need of predicting the environment is one of the most pressuring causes of mind perception (White, 1959). We predict because we need to. As we are highly familiar with predicting behaviour and states of other people, attributing humanlike intention to an entity can make its actions and states feel more predictable (Epley et al., 2007; Waytz et al., 2010a.b). The readiness to ascribe intention, or a mind, to an entity may therefore depend on the entity's properties such as its complexity and predictability (Waytz et al., 2010b) or ability to make eye contact (Khalid et al., 2016), increasing our need to make sense of it (Epley et al., 2007). In line with Dennett (1988), the perception of a mind seems to lie in the eye of the beholder. Beliefs (Gervais, 2013), need for social connection (Epley et al., 2007), cognitive load (Kelemen & Rosset, 2009), and even diets (Ioannidou et al., 2024), they all influence people's judgement of other agents' minds. Lonely people may be more motivated to perceive a social mind even in inanimate objects (Epley et al., 2007), while a high cognitive load may prevent people from seeking more complex explanations for the observed behaviour (Kelemen & Rosset, 2009).

Two questions underpin the mapping of diverse minds: Can it act? and Can it feel? In humans, perceiving a mind or intention in an entity seems to intuitively depend on an entity's score on those two dimensions which have been famously termed by Gray et al. (2007) as agency and experience. Other scholars use similar labels to refer to the proposed dimensions of mind perception, distinguishing between competence and warmth (Fiske, 2018), intention and pain (Gray et al., 2012), or a moral agent and a moral patient (Olson, 2016). Similarly, in the process of dehumanization, outgroup members may be ascribed less human uniqueness (characteristics separating humans from animals, e.g., perceived morality) or less human nature (characteristics shared between humans and animals, e.g., perceived emotionality) (Haslam, 2006; Loughnan & Haslam, 2007). While humans are generally perceived to possess higher levels of agency and experience, non-human entities, such as animals and technological devices, are seen as more ambivalent, scoring lower on either experience or agency (Gray et al., 2007, 2011; Gray & Wegner, 2009).

This of course, does not mean that people hold one static view. Perception of minds are flexible (Khalid et al., 2016; Wieringa et al., 2024) or differ between explicit and implicit measures (Li et al., 2022). This context-dependency of mind perception is well visible in the harm-made effect: when minds are perceived to be intentionally harmed, the perceived ability to experience pain increase (Ward et al., 2013; Wieringa et al., 2024). Whether we treat another entity with care and sympathy in the face of pain or whether we hold it accountable for its wrongdoings depend on our subjective perception of whether its actions and states can be usefully explained by ascribing experience and agency to it.

4. Question 3: How are other minds represented in the brain?

While asking people to rate minds of other agents on a scale can be a way to measure mind perception directly via self-report, we can further investigate the phenomenon by measuring brain activity while people perceive and understand other minds. Researchers have long been intrigued by the neurobiological basis of mind perception (Frith et al., 2003), and over the last three decades a relatively clear picture has appeared on how minds are represented in the brain (Gallagher & Frith, 2003; Saxe et al., 2004; Schurz et al., 2017). There is compelling evidence for the involvement of several key regions, comprising the medial parts of the prefrontal cortex, bilateral temporoparietal junction, and precuneus, collectively termed the theory of mind or mentalising network, which are activated in humans across various tasks and paradigms that involve the perception and understanding of other minds (Carrington & Bailey, 2009; Schurz et al., 2014). Regions of this network are activated not only during traditional false belief tasks (e.g., “Does Charlie know where the ball is?”), but also while making judgements on personality traits of people (e.g., “Can Charlie be nervous?”), or when playing strategic games (e.g., rock, paper, scissors) (Schurz et al., 2014, 2017). When looking at overlapping patterns, Schurz et al. (2014) found that the right temporoparietal junction showed the most robust activation across different tasks related to mind perception, a finding supported by other studies (Saxe & Wexler, 2005; Gobbini et al., 2007).

But does this network activate for non-human minds? One robust way to localise regions of the theory of mind or mentalising network is by showing a short animation film that triggers the viewer to think about the mental states of a cloud and stork (Jacoby et al., 2016), suggesting that this network is involved in attributing minds beyond humans. Indeed, this network also seems to activate for cartoons (Fletcher et al., 1995), social animations (e.g., Heider and Simme-like animations, computer-generated animations, Schurz et al., 2014, 2017), gadgets (Waytz et al., 2010b), dogs (Spunt et al., 2017), and artificial agents, such as robots (Özdem et al., 2017; Jastrzab et al., 2024; for a review, see Hortensius & Cross, 2018). If the network is activated for a diverse set of minds, is it also selective for specific minds? If we take the comparison between human and robot minds as an example, we see inconclusive results. Some research showed less (Krach et al., 2008; e.g., Chaminade et al., 2012) or similar activation (e.g., Dubal et al., 2011; Hogenhuis & Hortensius, 2022) for robot compared to human minds. While this empirical evidence helps to understand the flexibility of this network to some extent, researchers have almost exclusively compared the activation of these brain regions for two agent categories. Of course, the level of selectivity we see depends on the comparison category, and contrasting just activation patterns does not provide the level of detail needed (Henschel et al., 2020). Future research should therefore involve various comparison categories simultaneously, such as artificial agents, pets, objects, or even plants, and new analytic techniques to better understand the neurobiological basis of mind perception and human social cognition in general (Henschel et al., 2020; Cross & Ramsey, 2021).

So far, we have solely looked at if the neural network underlying mind perception is active when *humans* observe other minds. But we must acknowledge the influential paper by Premack and Woodruff (1978) on mental states attributions in chimpanzees, and ask whether this network, or perhaps other regions, are active in other species. By investigating mind perception in other species, we gain insight into the evolution of mind perception at the behavioural and neural level. While research on this topic is still emerging, behavioural evidence suggests that aspects of mind perception or theory of mind can be observed in several species, including chimpanzees and other great apes, as well as monkeys like macaques, and birds like corvids (Call & Tomasello, 2008; Krupenye & Call, 2019). Although progress in this area is slow, partly because of the difficulty of testing this behaviourally and the reliance on human-centric tasks, neuroimaging offers new ways of answering this question. For instance, the predictability of social situations modulates activity in the middle superior temporal cortex of macaques, similar to the modulation of temporoparietal junction activity in humans (Roumazeilles et al., 2021). This region shows similar connectivity profiles in macaques as in humans (Mars et al., 2013), potentially suggesting a similar neural mechanism across species.

Neuroscience research with dogs is a promising direction for a better understanding of the evolution of mind perception, and importantly less invasive compared to neuroscience research with macaques. Dogs are ideal test subjects. They can be trained to lie still in an MRI scanner (Berns & Cook, 2016), and due to the highly developed social abilities resulting from the long history of domestication, companionship dogs have high-level social skills, including high sensitivity to human communicative cues (Miklósi et al., 2004; Huber, 2016). Results from these neuroimaging studies show that distinct regions in the dog brain support social cognitive processes (Boch et al., 2024), for instance with selective neural activation to faces and bodies (Boch et al., 2023), and to familiar scent of humans (Berns et al., 2015). While neuroimaging studies on mind perception in dogs are awaited, recent studies investigated how dogs recognise other social agents, such as by attributing animacy or agency (Tauzin et al., 2016; Abdai et al., 2017). This comparative psychology approach combining novel non-invasive neuroimaging tasks that are both high in ecological validity and are transferable across species, promises to provide new insights into the neural representation of mind perception.

5. Question 4: Is the perception of minds in other species or artificial agents just mere anthropomorphism?

When a person states to see a suffering dog or a cautious corvid, other people can respond with the claim that the person engages in anthropomorphism: attributing humanlike characteristics to nonhuman animals, agents, and objects. This, what some scholars call overestimation of minds (e.g., Wynne, 2004), can be viewed as the opposite of what Frans de Waal (1999) calls anthropodenial, the belief that humans and animals do not share these characteristics of a mind. Ultimately, this is where objective and subjective mind perception interact. While in the past stating that a dog suffers would be considered anthropomorphism, these days most people would agree with the notion of suffering in dogs. Else they might be accused of anthropodenial or even speciesism. The objective assessment of this capacity (e.g., the presence of C fibres and brain regions responsive to pain in humans and dogs), could influence the subjective perception of this capacity. So conceptually one could say that anthropomorphism is a matter of (mis)alignment between objective and subjective mind perception.

Insights from psychology and neuroscience help to provide further nuances to the overlap between anthropomorphism and other aspects of mind perception, such as mentalising or theory of mind. Do they rely on similar cognitive and neural processes? Both are attribution processes (e.g., Heider, 1958), fulfilling the need to make sense of an uncertain world (Waytz et al., 2010b; Koster-Hale & Saxe, 2013). As we saw previously (question 3), animations with non-human characters consistently activate regions in the theory of mind network (Jacoby et al., 2016; Schurz et al., 2017). Similar regions are also activated when people anthropomorphise (Chaminade et al., 2007; Waytz et al., 2010b; for a review see Hortensius & Cross, 2018) or make judgements on the presence of minds (Wiese et al., 2018). Although anthropomorphism is often seen as either an extension or an analogue of theory of mind (Atherton & Cross, 2018), recent behavioural and neural evidence suggest otherwise (Kühn et al., 2014; Tahiroglu & Taylor, 2019; Hortensius et al., 2021). Regions outside of the theory of mind network are also activated during anthropomorphism, including face-selective brain regions (Kühn et al., 2014), and theory of mind network activity were not related to a person's tendency to anthropomorphise a wide variety of agents and objects in everyday life (Hortensius et al., 2021).

Developmental research helps to clarify this distinction further. The tendency to anthropomorphise and theory of mind ability was not correlated in 5-year-old children (Tahiroglu & Taylor, 2019). Three-year-old children who fail a standardised theory of mind test (Richardson et al., 2018), show brain activity in the theory of mind network in response to viewing a short animation that tiggers mental state attributions of a stork and a cloud, similar to anthropomorphism. Anthropomorphic thinking appears very early in childhood, even before theory of mind is matured: Children for instance frequently engage in imaginative play that involves projecting emotions and goals onto toys or animals, despite not being able to reason about beliefs or intentions in other people (Airenti, 2018; Weimer et al., 2021). This suggests that anthropomorphism may be based more on intuitive processes like perception and emotion recognition, rather than the more complex inferential thinking that is used in theory of mind tasks or situations (Epley et al., 2008). Interestingly, as theory of mind matures into a more complex stage (typically around the age of five), anthropomorphic play tends to decline, suggesting that theory of mind may regulate or inhibit the more automatic, emotionally driven tendencies underlying anthropomorphism (Severson & Lemm, 2016). This indicates that mind perception may originate in anthropomorphism but develops into a dynamic relation between the context and more complex social skills during childhood.

Experience in this context also plays a critical role. People are more likely to perceive familiar animals, like pets, as having minds than unfamiliar ones (Urquiza-Haas & Kotrschal, 2015, 2022). Similarly, exposure to AI can influence whether someone attributes mental states to artificial agents. Children who are exposed to robots more often, might recognise early on that an object does not have emotions, which in turn may reduce mind attribution (Brink et al., 2019; Xu et al., 2025). However, the opposite has also been stated, in which children who have more experience with technology actually attribute more mind to them (De Jong et al., 2024; Kühne et al., 2024). The perception of minds in non-human agents should therefore not be seen as mere anthropomorphism. It stems from a complex interaction between intuitive processes, cognitive development, and contextual experience.

6. Question 5: What is the importance of how the other looks?

The assumption in the literature is that with increasing human-likeness, mind attributions also increase. Related to this, and well known by academics, developers, and the general public, is the uncanny valley effect (Mori et al., 2012). It states that with increasing human-likeness positive reactions also increase, except for a valley where close-but-imperfect human-likeness has a negative effect on reactions, creating uncanny feelings in the observer. While controversial in nature, with some researchers stating that "empirical evidence for the uncanny valley hypothesis is still ambiguous if not non-existent" (Kätsyri et al., 2015: p. 2), a question that remains is what the relationship is with mind perception. Emerging evidence suggests that there might be an uncanny valley, albeit not mediated by how the agent looks, but rather by the mind ascribed to this agent.

Moving beyond simple visual-based effects (i.e., human-likeness), this uncanny valley of mind suggests that feelings of uncanniness can be explained by the level of mind attributed to an agent. A study by Gray and Wegner (2012) showed that experience, but not agency, is a crucial factor in feelings of uncanniness. A computer with more attributed experience or a human with less attributed experience evoke more feelings of uncanniness. Similar effects have been found when observing virtual agents (Stein & Ohler, 2017). Transcending a simple screen-based observations of robot faces, a field study in Japan showed that a humanoid compared to non-humanoid robot led to higher levels of uncanniness, but when participants were told that "[…] [r]obots cannot experience love, desire, or any other emotions. Robots are merely a collection of cold silicon circuits", levels of uncanniness decreased for the humanoid robot (Yam et al., 2021). If visual features are not the dominant factor in perception of artificial agents (cf., mindless humans, mindful robots), does the same thing hold for animals?

While speciesism is reflected in mind perception — people not only contrast humans with other animals, but they also distinguish between animals (e.g., mammals versus insects) (Eddy et al., 1993; Leach et al., 2023a) — features across species influence these perceptions as well. Animals that are perceived as more similar to humans (Morewedge et al., 2007; Possidónio et al., 2019), and as more beautiful (Possidónio et al., 2019; Klebl et al., 2021), are rated higher on dimensions of mind perception. Derived from Lorenz's Kindchenschema (1943), one consistent finding is that perception of animals by human observers is influenced by how cute these animals are perceived (Possidónio et al., 2019; Kawaguchi & Waller, 2024). So, the cuter the animals are perceived to be, the higher the capacity to feel (experience) or think (agency) is deemed (Possidónio et al., 2019). Similar to mind perception of artificial agents, here too, top-down influences appear. It matters if you have a plant-based diet (Possidónio et al., 2019; Ioannidou et al., 2024) or have a companion animal (Possidónio et al., 2019). Societal influences are also visible in mind perception of animals. Mapping the usage of descriptions of experience and agency in natural language between 1820 and 2010, Ash, Stammbach & Tobia (2023) showed that from the 19th century till the mid 20th century no differences between domesticated (e.g., cats, dogs, pigs) and wild animals (e.g., birds, fish, chimpanzees) were observed. After passing of legislation and public interest in animal welfare in the 1950s, an increase in descriptions of experience, but not agency, was observed for domesticated but not wild animals. All in all, we can conclude that while visual effects might play a role, they are by no means dominant in the perception of minds of humans, animals, and artificial agents. Top-down or knowledge cues (e.g., beliefs, life-style choices) are more important than bottom-up or stimulus cues (human-likeness of the agent, cuteness of the animal). As this holds across mind perception of humans, animals, and robots, a domain-general mechanism might underlie mind perception, including biases therein. That is, the same general principle might support seemingly distinct processes such as anthropomorphism and dehumanisation (Hortensius & Cross, 2018), and stereotypes (Fiske, 2018).

7. Question 6: Does it matter at all if you think an agent has a mind on how you view yourself and others?

Perceiving a mind in another agent is not one-directional. Indeed, minds are grounded in sociality and therefore perceiving a mind does not only have consequences for the one being perceived but also affects the perceivers themselves. When we interact with an agent that we perceive as intentional, a perceiver understands the interaction as meaningful (Waytz et al., 2010a), an effect that can even ripple outward shifting the dynamics of a whole system (Guingrich & Graziano, 2024). It would therefore be limiting to assume mind perception is one directional and not to model dyadic or group influences. This raises the question of how perceiving a mind in an agent influence how we perceive and react to ourselves and others.

According to Gray et al.'s (2012) dyadic morality framework, once we grant an agent a mind, we assign it either the role of a moral agent with agency or a moral patient with experience. This implies that a mind-attributed-agent can now, for instance, be judged more harshly for a transgression or be empathised with more deeply when wronged. Think about how you would judge a baby, robot, or a politician when judging the action of breaking your favourite item or judging the harm to them when attacked. While this appears in the first place to affect the agent itself, the consequences reach further (Spaccatini et al., 2023): When a robot makes a mistake, and we perceive it as an intentional mistake, we stop seeing it as a mere tool and treat it as an agent responsible for its actions and hold ourselves or others less accountable (Joo, 2024). This, then, reshapes moral dynamics.

A comparable shift in dynamics can occur by reconsidering what it means to be human. Attributing a mind to a non-human agent can indeed require individuals to reassess their own identity (Bastian et al., 2012) or even lead to dehumanisation of humans in general (Herak et al., 2020; Shin & Kim, 2020; Rottman et al., 2021). In doing so, it blurs the lines of what has traditionally been considered as uniquely human (Ferrari et al., 2016; Złotowski et al., 2017). First proposed by Ferrari and colleagues (Ferrari et al., 2016), and related to the uncanny valley of mind effect, the threat to distinctiveness hypothesis argues that "too much perceived similarity between social robots and humans triggers concerns because similarity blurs the boundaries between humans and machines and this is perceived as damaging humans, as a group, and as altering the human identity" (Ferrari et al., 2016: p. 2). There is indeed a positive correlation between attributed experience and agency and threat to human identity (Müller et al., 2021), and when exposed to robots high in agency, people devalue the importance of agency as a human trait (Xu et al., 2025), and simultaneously emphasize other characteristics like emotional responsiveness as being more distinctively human (Cha et al., 2020).

Intergroup processes interact with mind perception as well. People show an intergroup mind perception bias: they more readily perceive minds in ingroup compared to outgroup members (Haslam & Loughnan, 2014; Harris & Fiske, 2015). This is a dynamic process and dependent on not only affiliation but also threat by the outgroup (Hackel et al., 2014). We might perceive even a robot as less of outsiders and more as part of our social system (Vanman & Kappas, 2019; Jong et al., 2021). So, can mind perception in one agent, foster behaviours extending to others? Indeed, Dang and Liu (2024) found that attributing a mind to non-human agents when people feel socially secure results in an increased humanising of robots *and* humans suggesting that such attributions can extend beyond one agent category. Similarly, perceiving a mind can increase socially desirable behaviours towards others (Waytz et al., 2010a). Guingrich & Graziano (2024) further argue that mind-attributed agents can act as a social model, as if they were an in-group member influencing perceiver's behaviour and perceptions that carry over into the wider social system. For instance, vulnerable robots can positively influence ongoing conversations within a group (Traeger et al., 2020). To truly understand mind perception, we should therefore look beyond the perceived agent and consider the intra- and interpersonal processes it sets in motions (Sebo et al., 2020).

8. Question 7: Where does it all end? What methods and techniques, perspectives or approaches does the field need to answer these and future questions?

The above answers do not mean that all questions on mind perception have been answered. Far from it, mind perception is very much an active field of study across many different disciplines. It is precisely this interdisciplinary approach we need to provide further and more complete answers. We need to combine psychology, neuroscience, biology, artificial intelligence, social robotics, philosophy, and many more disciplines. These disciplines have different methods, perspectives, and traditions. A clear example of the power of an interdisciplinary approach can be seen in the work by Ash et al. (2023), which combining the disciplines of history, computational-linguistics, and psychology, and provides insights into top-down and bottom-up cues of mind perception. New analytic approaches, such as a Bayesian paradigm (Leach et al., 2023b) or neuroimaging analysis (Thornton & Mitchell, 2018) can help to understand the mechanism of mind perception in greater detail, for example the beliefs held and theories used by individuals. Another promising route is the neuroscience study of social cognitive processes in dogs (Boch et al., 2024). This and studies of other species will answer outstanding questions on the evolutionary nature of mind perception. A greater interdisciplinary integration would allow disciplines to not only influence and inspire each other but would also prevent reinvention of the wheel. Like for any scientific concept, definition issues play a role in mind perception research. In the present paper, we were quite lenient with the use of terms to cover a broad base. That is, we discussed research on mind perception, theory of mind, anthropomorphism, and mentalising. While so far, there is no well accepted nomenclature (e.g., Quesque et al., 2024), and it is unclear if dimensions often used in the literature (i.e., experience/agency, warmth/competence, human nature/human uniqueness) denote the same underlying concepts, an interdisciplinary approach might help provide further clearance.

So far, most of the tasks used in the research on mind perception are computer-based rating tasks of images of various agents. The focus on ratings during one-off observations of screen-based static face-centric depictions of minds are far removed from the complex long-term interactions we can have with embodied minds (e.g., dogs) or even non-embodied minds (e.g., AI chatbots). Studies measuring mind perception over multiple sessions while participant interact with an agent are a minority (e.g., Laban et al., 2024) and often these measures are reported as secondary (e.g., Cross et al., 2019). The combination of long-term interactions with diverse minds and multiple measures of mind perception (e.g., self-report, behaviour, neural measures) offers an exciting opportunity to answer open questions on the stability and flexibility of mind perception. Next to this, mind perception research should also consider the body. This full embodied approach will steer away from the face-centric approach that has dominated many aspects of science, including mind perception. Most of the research discussed in the article focusses on faces, missing the influence of the body on mind perception. For instance, a focus on the body changes mind perception by increasing perceived experience and decreasing ratings of agency (Gray et al., 2011). While this neglect of the body can be found across the board, several lines of research have successfully incorporated the body in their research, including affective and social neuroscience (Gelder, 2006) and comparative psychology (Kret et al., 2020).

Another key limitation of static, screen-based paradigm is the absence of movement, an essential cue for perceiving agency and inferring actions, as well as an obvious component of real life. Humans are exquisitely sensitive to biological motion. Figures that show faster and goal-directed movements are more likely to be interpreted as intentional (Dittrich & Lea, 1994). Even minimal cues such as shapes moving in intentional ways can evoke attribution of minds and activate core mentalising regions in the brain (Castelli et al., 2000). Importantly, motion is fundamentally embodied: it emerges from physical properties and the dynamics of a body interacting with its

Figure 1. Mind perception across agents and species. Example of an interactive setup from our lab that tests mind perception across agents and species using a mobile neuroimaging setup. A human participant engages in an interaction with another human, AI chatbot, or a Border Collie dog (*Canis familiaris*). Photographs by Dorka Boda. All individuals gave permission for publication of the photographs.

surroundings. In fact, the form, fluidity and quality of movements, coupled with the morphological features of an agent, modulates how strongly observers' attribute traits like animacy, trustworthiness, and likeability to agents (Castro-González et al., 2016). Research in developmental psychology, social cognition, and human–robot interaction highlights the importance of motion for social engagement and the inference of mental states (Lindblom & Ziemke, 2006; Rice et al., 2016; Wykowska et al., 2016). Thus, incorporating motion into interactive, embodied paradigms will be crucial to capture the richness of real-world mind perception. Mind perception during real life situations (e.g., Schweitzer & Waytz, 2021) or interactive paradigms (Figure 1; also see, e.g., Diana et al., 2025) offer direct ways to measure the full complexity of mind perception, including bodies, movement, and long-term effects.

One consequence of the lack of studies of long-term interactions with diverse minds using interactive paradigms or in real-life situations, is the limited understanding of the inter- and intrapersonal consequences of mind perception. Seeing a mind can sometimes be perceived as threat to human identity (Ferrari, Paladino & Jetten, 2016) and can have effects on group dynamics (Traeger et al., 2020; Guingrich & Graziano, 2024). When we look at the pets we can see how they take on different roles and how this can influence group dynamics. While pets first served a utilitarian function, for instance dogs guarding sheep, they can now be part of a household (Gordon, 2017). With the emergency of AI in everyday life, similar developments can be explored (Moore Lorusso et al., 2025). The question is what role these artificial agents, such as social robots and AI chatbots, take. Do we see them similar as pets or more like objects? How does living with these agents over a longer period change this and the inter- and intrapersonal effects? For instance, recent interviews with families point towards a complex interplay between behaviours of family members and the impact of an artificial agent (Geeng & Roesner, 2019). To understand this further, research on mind perception should take a long-term group or system approach to go beyond mere descriptions of the perceived agency or experience of a robot that is human-like or not, by acknowledging the real behavioural consequences of these attributions.

9. Conclusion

We started by asking seven questions on mind perception that we have been interested in over the last couple of years thereby trying to capture both traditional approaches and promising new perspectives. While this article is just a mere sketch of the complexities of research on mind perception, we saw that some phenomena are relatively well understood (i.e., the impact of how a robot looks on mind perception), while other phenomena warrant further investigation (i.e., the inter- and intrapersonal consequences of perceiving a mind). Having covered several scientific disciplines, not surprisingly mostly in the social domain (i.e., social neuroscience, social psychology, social robotics), an interdisciplinary approach will help further the understanding of mind perception and the complex social cascade of it.

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