Children's Developing Beliefs About Agency and Free Will in an Increasingly Technological World

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ABSTRACT

The idea of treating robots as free agents seems only to have existed in the realm of science fiction. In our current world, however, children are interacting with robotic technologies that look, talk, and act like agents. Are children willing to treat such technologies as agents with thoughts, feelings, experiences, and even free will? In this paper, we explore whether children's developing concepts of agency and free will apply to robots. We first review the literature on children's agency and free-will beliefs, particularly looking at their beliefs about volition, responding to constraints, and deliberation about different options for action. We then review an emerging body of research that investigates children's beliefs about agency and free will in robots. We end by discussing the implications for developing beliefs about agency and free will in an increasingly technological world.

1. Introduction

In the 2014 film *Ex Machina*, a humanoid robot, Ava, traps and kills humans while making her escape to the outside world. These actions are seen as proof that Ava has free will and agency – she is acting of her own volition, her actions are thoughtfully crafted in response to external constraints, and she came to this decision even though she might have decided to do something else. This belief that Ava is a free agent even makes the audience root for her as a sort of hero, deserving of rights generally reserved for humans, as is the case with other robots in movies (e.g., *Wall-E)* and shows ("Westworld").

Robotic technologies are a part of our everyday lives, but in very different ways than the ones in science fiction. We use robot vacuums to clean our

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floors, we ask smart speakers to answer our questions, and we even seek help from robots at the grocery store (Matthews, 2020). In the real world, we seem to treat technologies as an extension of ourselves: as tools to help us complete our goals, remember our important events, or think on our behalf (Clark & Chalmers, 1998). In science fiction, we seem to treat technologies as separate agents: operating with their own goals, remembering events on their own, and thinking for themselves. What would happen if we began to treat the robotic technologies in our own lives not as an extension of ourselves but as separate agents? Would we be willing to do so if robotic technologies were already a common part of our lives from the start?

This last question is more than an interesting novelty, it may be the situation faced by many children in modern society. At a young age, children in the current world are interacting with robotic technologies in every facet of their lives: in their home (e.g., Amazon Alexa, Siri), in their play (e.g., Furbys, FurReal pets), and even in the classroom (Belpaeme et al., 2018; Hashimoto et al., 2013; Wei et al., 2011). Over the first few years of life, children are also developing what will become the foundation for their adult beliefs about agency and free will out of their experiences of interacting with human and non-human agents (Baillargeon et al., 2016; Carey, 1985; Kushnir, 2018; Piaget, 1929). The question, therefore, is whether and how children's developing beliefs about agency and free will apply to technological tools designed to be interactive in agent-like ways. An interesting possibility is that children do not treat such interactive technologies as artifacts or tools used to extend their own capabilities, but as separate agents with their own minds, experiences, feelings, and decision-making capabilities.

In this paper, we explore evidence for this possibility in two parts. We first review the well-established literature on children's developing beliefs about agency and free will – looking at their beliefs about agents acting of their own volition, responding rationally to constraints, and deciding between alternatives. We then review an emerging body of research that investigates children's beliefs about agency and free will in robots. We end by discussing the implications for developing beliefs about agency and free will in an increasingly technological world.

2. Developing beliefs about free will and agency

Beliefs in agency and free will are psychologically interconnected. A common thread that appears in folk-intuitions about agency is the capacity to have free will: we expect agents to have intentions (Gray et al., 2007; Woodward, 1998), to act rationally act towards goals (Opfer, 2002; Rakison et al., 2007), to act autonomously (Johnson, 2003). Likewise, a common thread that appears in different theories and folk-intuitions about free will is the role of the agent: whether the agent's intentions align with their actions (Frankfurt, 1971; Wolf, 1990; Woolfolk et al., 2006), whether the agent can reason rationally or deliberately (Clarke, 2003; Baumeister, 2008; Fischer, 2006), whether the agent can choose between possible alternative courses of action (Kushnir et al., 2015; Nichols, 2004).[1] Furthermore, people attribute more free will to agents that have mental abilities (e.g., self-control, planning, making choices; Gray & Wegner, 2009; Monroe et al., 2014) and conscious experiences (e.g., feel pain, have emotions; Nahmias et al., 2020).

Our folk-conceptions of free will and agency have their origins in infancy and early childhood. This begins with an early ability to detect differences between patterns of motion that signal that an action is internally driven versus externally caused (Rakison & Poulin-Dubois, 2001). For example, 7-12-month-old infants expect that an object's motion must be caused by another moving object or by a human, unless the object's movement is previously shown to be self-generated (Kotovsky & Baillargeon, 2000; Saxe et al., 2005; Spelke et al., 1995). Self-generated movement by an "object" with no other agentic features changes infants' expectations about an object's ontological status, especially when that movement seems uncaused by an external force (such as by a collision with another object; Csibra, 2008; Saxe et al., 2005; Schlottmann & Ray, 2010; Setoh et al., 2013). For example, 6-month-old infants will direct their attention more when an object moves in a goal-directed pattern (e.g., turning towards an object before moving, changing direction) than when the object moves in a fixed pattern (Csibra, 2008; Schlottmann & Ray, 2010) suggesting that they are surprised by an object's agent-like motion.

Within the first year of life, infants also expect the actions of human and non-human agents to be goal-directed. Woodward and colleagues (Buresh &

[1] There is a rich and long-standing discussion in philosophy over whether free will and determinism are metaphysically compatible. For the purposes of this paper, however, we refrain from this debate and instead focus on the folk understanding of free will.

Woodward, 2007; Hamlin et al., 2008; Sommerville et al., 2005; Woodward, 1998; 1999) have consistently demonstrated that 3-13-month-old infants habituated to a person consistently reaching for one object over another encode this action as having an object-directed goal and expect the person to continue to reach for the goal object even when its location has changed. Moreover, by 10-months old, infants infer an agent's goals even when the agent fails to achieve them (Brandone & Wellman, 2009). By the second year of life, toddlers incorporate goal-attributions from failed actions into their prosocial behavior, helping others to achieve their desired outcomes (Meltzoff, 1995; Warneken & Tomasello, 2006). Importantly, control studies show that infants do not make goal inferences about the same action-patterns generated by mechanical (non-agentic) objects (Meltzoff, 1995; Woodward, 1998), confirming that infants' expectations about goal-directed actions are specific to agents.

Additionally, infants expect agents to achieve their goals efficiently (i.e., rationally) in light of constraints. This has been demonstrated in experiments with human actors (Gergely et al., 2002) and in experiments with self-generated moving "objects." For example, Csibra and colleagues (1999) habituated 9-month-old infants to an autonomously moving agent jumping over a barrier to reach the other side. When the barrier was removed, infants were surprised (looked longer at the displays) if the agent continued to jump in the same way to get to the other side. They were not surprised when the agent moved straight ahead to its goal, suggesting that they expected the agent, without the constraint of the barrier, would take the more efficient path.

By the time infants enter their second year of life, they can also make inferences about intentions that are irrational, or, at least, inefficient. That is, when an agent acts seemingly inefficiently towards a goal without any constraints, 12- to 18-month-old infants infer that the action is intentional (Carpenter et al., 2005; Gergely et al., 2002). In one example, 14-month-olds who saw a person turn on a light with her forehead imitated both the action and the outcome, but only if the person's hands were free when she acted (Gergely et al., 2002). When the person's hands were physically constrained while she turned the light on with her head, infants reproduced the outcome more efficiently with their own hands. Similarly, 12- and 18-month-olds would imitate an inefficient "hopping" motion if they saw an adult play with a mouse making a "hopping" motion, but not if the play had an obvious end goal (the mouse being put inside a house; Carpenter et al., 2005).

Together, these examples show that pre-verbal infants and young toddlers have the basic understanding of agency – they expect agents' movements and actions to be intrinsically caused (voluntary), they infer goals and intentions, and they consider both possibilities for, and constraints on, agents' ability to accomplish goals. These expectations may form the basis of our folk-intuitions about human agency and freedom as adults. Indeed, studies show that some of the same visual and intentional cues elicit immediate perceptions of agency as well as rich inferences about intentional, mental, and emotional states as we get older (Heider & Simmel, 1944; Opfer, 2002; Ratajska et al., 2020).

Beyond infancy, increased knowledge of mental states such as beliefs, desires, and intentions, is accompanied by changes to children's beliefs about agency and free will. By age 4, children, like adults, have a view of freedom of choice that references both rational responses to constraints and the availability of alternative options for acting. Four-year-olds know that situational constraints (physical, mental, social and moral) can limit one's options for acting (Chernyak et al., 2013; 2019; Kushnir et al., 2015; Kushnir, 2018). For example, 4-year-old children think that one cannot choose to fly in the air (a physical constraint), act against one's own desires and beliefs (a mental constraint), or choose to not follow a norm or moral rule (a social constraint).

As children get older, their beliefs in free will begin to look more like adult folk-beliefs in that they begin to appreciate that people make *decisions* by deliberating between multiple motivations (Kushnir, 2018; 2022). For example, 4-year-olds think that desires necessarily cause actions – a person is not free to resist tempting foods or overcome strong fears (Kushnir et al., 2015). Increasingly with age, however, children allow for the possibility that one can choose to act despite one's immediate desires or emotions, perhaps by having an alternative (e.g., conflicting) desire. Similarly, while 4-year-old children believe that people have to follow moral and social norms, older children view moral and normative actions as decisions one makes, and thus decisions one is responsible for (Chernyak et al., 2013; 2019). One result of these changes is that older children place value on moral decisions that involve personal cost (e.g., decisions in which the alternatives were beneficial to the self; Starmans & Bloom, 2016; Zhao & Kushnir, 2022). Another is that they place value on autonomy-granting actions more generally (Zhao et al., 2021a).

These developmental changes in free-will beliefs are accompanied by a host of other advanced understandings of mind and emotions that occur around the same age (Atance & Meltzoff, 2005; Bélanger et al., 2014; Choe et al.,

2005; Lagattuta, 2005) as well as corresponding improvements in executive functioning and self-control (Davidson et al., 2006; Diamond & Taylor, 1996; Kochanska et al., 1996; Sabbagh et al., 2006; Zelazo & Carlson, 2012). All of these factors contribute to more effective decision-making in both personal and moral domains (Carlson & Moses, 2001; Chernyak & Kushnir, 2013; McCormack & Atance, 2011; Zhao et al., 2021b). Considered together, the body of work suggests that children's changing beliefs about agency and free will are tied to emerging competencies for better (more rational, more deliberate) decision-making.

Another driver of developmental changes to free will beliefs are children's developing ability to imagine unusual, improbable, or immoral alternative actions (Goulding & Friedman; 2020; 2021; Kushnir, 2018; 2022; Shtulman & Carey, 2007; Shtulman & Phillips, 2017). In support of a direct link between imagination of alternatives and beliefs in free will, work has found that, to the extent that children believe in freedom of choice in any given context, children explain how with reference to alternative actions (84% of their explanations take this form) as opposed to general notions of autonomy (only 4% of explanations take this form; Kushnir et al., 2015). Moreover, though rates of *judgments* about free versus constrained actions differ across age, context, and cultures, rates of *explanations* that refer to alternatives are consistently high (Chernyak et al., 2019; Wente et al., 2016; see Kushnir, 2018 for review).

To summarize, developmental research shows that our adult beliefs in agency and free will are based on a psychological foundation formed in infancy and early childhood. This begins with an early-emerging belief about self-generated and goal-directed rational action, and early-emerging notions of choice and constraints on an action (Cisbra et al., 1999; Gergely, et al., 2002; Kushnir et al., 2015; 2018). As children get older, their beliefs about agency include an increasing ability to imagine ways in which actions can be done otherwise, despite psychological and social constraints, and relate to improvements in their own decision-making abilities (Atance & Meltzoff, 2005; Chernyak et al., 2013; 2019; Shtulman & Phillips, 2017; Zhao et al., 2021b).

Thus far, however, most research on children's beliefs about agency and free will has been human-centered. It remains an open question, therefore, whether these beliefs extend to non-human agents.

3. Developing beliefs about robotic technologies

Currently, children in the modern world are interacting with a new type of agent, robotic technologies. Children engage with robotic technologies in various parts of life, demonstrating that robotic technologies are no longer a thing of science fiction, but a commonplace reality. While adults may treat robotic technologies as helpful tools, prior research has found that adults generally do not attribute free will to robots (Flanagan et al., 2021; Monroe et al., 2014; Nahmias et al., 2020; Shepherd, 2015; Young & Monroe, 2019).[2] Investigating whether children apply agency and free-will beliefs to robots, however, is still a relatively new topic.

Similar to children's beliefs about other agents (Csibra, 2008; Johnson, 2003; Opfer, 2002; Rakison et al., 2007; Schlottmann & Ray, 2010), children's beliefs about robot agency depend on whether the robot's actions are self-generated and responsive to the environment. For example, Meltzoff and colleagues (2010) found that 18-month-old infants were more likely to follow the gaze of a robot if it contingently interacted with others. Chernyak & Gary (2016) found that 5- and 7-year-old children ascribed higher emotional and physical experiences (e.g., feeling upset, getting hurt) and moral concern (e.g., should not be harmed) to an autonomously moving robot dog than a remote-controlled one. Zaga and colleagues (2017) found that 8-12-year-old children even said that a non-humanoid robot (e.g., ball shaped robot that has one sensory-input) was more life-like and likable if the robot's autonomous movements were in response to the child's movements.

These studies suggest that when robots behave as agents children treat them as such. Further support for this comes from inquiries into older children's folk-beliefs: for example, 4-15-year-old children believe that different types of robotic technologies (e.g., humanoid robots, robot animals, voice assistants, etc.) have mental abilities (e.g., can think) and have emotional states (e.g., can be upset; Bernstein & Crowley, 2008; Brink et al., 2019; Chernyak & Gary, 2016; Girouard-Hallam et al., 2021; Kahn et al., 2012; Jipson & Gelman, 2007). Furthermore, the extent to which children think robots have minds and emotions are most predictive of children thinking that such robots are more human-like (Flanagan et al., in press).

[2] Adults are willing to treat robots as human-like agents in certain scenarios, like when a robot acts unexpectedly or when participants have to make their judgments in a short time (see Fiala et al., 2014; Fussell et al., 2008; Salem et al., 2013; Short et al., 2010).

Belief in robot agency may have positive consequences for children's learning. For example, though studies have shown that children's language development does not advance from watching television or engaging with non-interactive media (Anderson & Pempek, 2005; DeLoache et al., 2010), toddler's vocabulary skills can improve when taught by a robot displaying agentic behavior (Movellan et al., 2009). Similarly, preschoolers learn new words and facts from robots (Breazeal et al., 2016) especially robots they consider human-like (Brink & Wellman, 2020). Preschoolers will even refer to a robot's non-verbal cues to learn new words (Westlund et al., 2017). Four to 6-year-old children will also imitate a robot's irrelevant actions to achieve a goal (i.e., overimitation) as an indication of non-linguistic cultural learning (Sommer et al., 2020). These studies suggest that when children view robots as agents, they learn from them as if they are knowledgeable teachers (though not always on par with humans, see Sommer et al., 2020).

Recent work has also demonstrated that children are willing to treat robots as social and moral partners. Children of all ages think that it is wrong to harm robots (e.g., yell at, hit, leave in a closet, e.g., Chernyak & Gary, 2016; Girouard-Hallam et al., 2021; Kahn et al., 2012; Sommer et al., 2019; Reinecke et al., 2021). Toddlers will prosocially help a robot attain goals (Martin et al., 2020). Preschoolers socially interact with robots as they do with humans, such as greeting them, taking turns, and even sharing secrets (Bethel et al., 2011). Three to 6-year-old children will also seek a robot's help during conflict (Shen et al., 2018).

Importantly, prior work suggests that children's beliefs about robots change with age: young children are more willing to treat robots as agents, while older children treat robots more like inanimate objects. For example, while 3- to 6-year-old children believe that robots can experience physical sensations such as hunger and pain (Brink et al., 2019; Jipson & Gelman, 2007; Reinecke et al., 2021; Sommer et al., 2019), 7-to 15-year-old children deny that robots have these physical experiences (Bernstein & Crowley, 2008; Kahn et al., 2012). Similarly, age-related changes have been found in social learning: 4-5-year-old children believe that voice assistants are capable of providing personal information (such as the date of a friend's birthday) while 7-8-year-old children are only willing to ask voice assistants for factual information (Girouard-Hallam & Danovitch, 2022). Furthermore, 7-15-year-old children think it more wrong to harm a biological agent (e.g., human or dog) than a robot (Kahn et al., 2012; Sommer et al., 2019), while 4- to 6-year-olds view harming robots and harming

biological agents as almost equally immoral (Reinecke et al., 2021; Sommer et al., 2019).

Our own work has identified similar age-related changes in children's free-will beliefs about robotic agents. In a recent study, Flanagan and colleagues (2021) asked 5-7-year-old children and adults to predict a robot or human child's behavior in a number of scenarios. Children and adults were initially told about an agent, robot or human, who consistently played science games because it was programmed to play them (robot agent) or because he likes to play them (human agent). Children and adults were then shown the agent with a science game and a history game. Children and adults were asked which game they thought the agent would play. Without any constraints, children and adults expected both agents to play the science game rather than the other game.

Critically, the study introduced two contexts that could potentially constrain the agent (robot or human) from playing the science game: a physical constraint (the science game being broken) and a social constraint (playing with someone who does not like science games and cries when she plays them). When the science game was broken, children, but not adults, expected the robot to play another game, going against its programming (Flanagan et al., 2021). Expectations differed even more under social constraint. When presented with a scenario in which playing science games causes emotional harm, adults expected the human to be responsive to the moral circumstances but not the robot (Flanagan et al., 2021). Children, on the other hand, were unsure what the robot would do – half of the children expected the robot to play another game (that is, to be responsive to the moral consideration) and the other half of the children expected the robot to continue to follow its programming. These results suggest that, in contrast to adults, some young children expect robots to be responsive to physical and moral circumstances, even when this results in going against their programmed behaviors.

The age-related changes in children's free-will beliefs above referenced humanoid robots. These robots are used in laboratories (Brink & Wellman, 2020; Kahn et al., 2012; Martin et al., 2020; Sommer et al., 2019), but are not commonly part of children's ordinary experiences. Thus, children's beliefs about humanoid robots might simply reflect a lack of familiarity, or the fact that humanoid robots display both behavioral and perceptual features in common with human beings.

To address these limitations, we investigated 4-11-year-old children's beliefs about two common household technologies – the Roomba vacuum and

Amazon's Alexa – in comparison to a humanoid robot – the Nao robot (Flanagan et al., in press). Children were told that each technology was programmed to perform a neutral action within the technology's capabilities (e.g., cleaning the bedroom floor for Roomba, answering science questions for Alexa, playing a science game for Nao). For each action, children were asked whether the technology had to do the programmed action or if the technology could choose to do an alternative, unprogrammed action (e.g., clean the kitchen floor for Roomba, answer history questions for Alexa, play a history game for Nao). We found that younger children (4-7-year-olds) were more likely to believe that the technologies could choose to go against programming than older children (8-11-year-olds). Younger children were also more willing to believe that robotic technologies can choose among alternatives in moral situations than older children. In the same study (Flanagan et al., in press), children were told about a morally harmful action caused by each robot doing its ordinary (i.e., programmed) behaviors. Again, younger children were more likely to say that the robots could have chosen not to perform the harmful action. In contrast, older children were more likely to say that the robot had no choice because of its programming limitations.

Moreover, we found that children's judgments about the robots' choices in morally harmful situations were related to their judgments that the technologies had other human-like qualities (Flanagan et al., in press). Specifically, children who said that the robots could cause intentional harm were also more likely to say that the robots had physical sensations and emotional experiences (e.g., feeling pain, getting upset) and mental abilities (e.g., the ability to think, the ability to know good from bad). These links between judgments about human-like qualities and about the ability go against their programming held across technology types (Roomba, Alexa, and the humanoid Nao).[3]

The age-related decrease in children's beliefs about robots' ability to make decisions (rather than being programmed) stand in contrast to an age-related *increase* in children's beliefs about human decision-making capacities. As reviewed above, by age 6 or 7 children believe that human agents have the ability

[3] These connections between agency beliefs and free-will beliefs have parallels in recent work with adults. When robots are described without agentic capabilities (e.g., as calculating, as being pre-programmed, or as processing), adults do not attribute free will to robots (Nahmias et al., 2020; Young & Monroe, 2019). When robots are described with agentic capabilities, such as having experiences and mental abilities, adults are more willing to attribute free will to robots.

to deliberate and choose among alternatives rather than having actions be determined by constraints (Chernyak et al., 2013; Kushnir et al., 2015). There are several possible reasons for this developmental trend. For example, there may be a domain general change in our beliefs about non-human entities that applies to our judgments about their agential abilities. As such, just as children are less likely to attribute agentic features to robots as they get older, children's attribution of agentic features to animals and spiritual beings also declines with age (Jipson & Gelman, 2007; Lane et al., 2014; Shtulman, 2008; Wilks et al., 2021).

Domain general changes, however, may not fully account for the age-related changes in agency beliefs. Culture and experience may play an equally important role. Support for this idea comes from other domains in which children's agency beliefs are guided by adults through cultural experiences. For example, the age at which 3-6-year-old children think that God can do impossible actions depends on their religion, suggesting that how children's religion teaches them about God plays a role in their agency beliefs regarding God (Lesage & Richert, 2021). We suggest similar cultural influences when learning about technology. For example, it may be that as children get older, they gain more knowledge about technologies' mechanical properties, such as how they are programmed, and they begin to view these properties as a constraint on the technologies' actions.

In sum, children's agency beliefs about robots mirror some of children's agency beliefs about humans, and yet diverge in critical ways. When the robot's actions are self-generated and contingent to its environment, children treat it as an agent similar to humans (Bethel et al., 2011; Brink & Wellman, 2020; Chernyak & Gary, 2016; Meltzoff et al., 2010). Furthermore, young children in particular think that robots can respond to physical constraints like humans do (Flanagan et al., 2021). As children get older, however, they begin to believe that programming limits technologies from doing otherwise (Flanagan et al., in press), and this belief continues into adulthood (Flanagan et al., 2021; Monroe et al., 2014; Nahmias et al., 2020; Shepherd, 2015; Young & Monroe, 2019). Importantly, the recent work demonstrates that children and adults are willing to attribute decision-making capabilities to robotic technologies under certain contexts, and when robotic technologies are viewed as more agentic, children and adults are willing to attribute more agency and better decision-making capabilities.

4. Conclusion

While we may not currently have advanced robots like Ava from *Ex Machina* or Wall-E from *Wall-E*, the robotic technologies in our lives nevertheless talk, act, and look like sophisticated agents. Throughout this paper we have argued that children's developing beliefs about agency apply to their interactions with these robots – young children think that robots act of their own volition, can reason rationally, and can choose to do otherwise (Brink & Wellman, 2020; Chernyak & Gary, 2016; Flanagan et al., 2021; in press; Meltzoff et al., 2010). Furthermore, young children interact with robots as if they are free agents – young children help robots achieve their goals, they seek support from robots, and they engage with robots in a variety of ways, including topics that involve personal and factual information (Bethel et al., 2011; Girouard-Hallam & Danovitch, 2022; Martin et al., 2020; Shen et al., 2018). In sum, this work suggests that young children treat robots as separate agents, not as tools that extend their own abilities.

The current literature suggests that young children of today are willing to treat robots as free agents, but will they continue to do so as they get older? There are two possibilities to consider. One possibility is that we believe that to have free will requires being a human agent (Monroe et al., 2014; Nahmias et al., 2020; Shepherd, 2015). Thus, the only cases in which adults attribute free will to a robot are when the robot is described as human-like (Nahmias et al., 2020; Young & Monroe, 2019). Under this possibility, the developmental evidence is interpreted as follows: as children get older, they view robotic technologies as less human-like and more constrained by programming (Flanagan et al., in press) and so they ought to "grow out" of their free-will and agency attributions to robots as they get older. Our data is consistent with this possibility.

However, since our data are cross-sectional (and thus confined to the current moment of time with a single group of children), they do not rule out the possibility that the unique experience of growing up with social and interactive robotic technologies leads to a cultural change in which children of today will continue to view robots as agents who are "free" in some sense (even if that sense is different from how we think about human freedom). Indeed, research has shown that cultural contexts and experiences play a large role in shaping how we conceptualize the agency of non-human species from plants to animals (ojalehto et al., 2017; Richert & Corriveau, 2022; Weisman et al., 2021;

Willard & McNamara, 2019). We even see cultural effects on children's attribution of agency to supernatural beings: for example, children's willingness to attribute free will to God is dependent on their religious upbringing (Lesage & Richert, 2021). Similarly, cultural immersion in interactive technology may influence these beliefs as today's children become adults. More work is needed to investigate these two possibilities.

There are numerous ethical considerations we would have to consider if children are willing to treat robots as free agents, even as they get older. For example, treating robots as free agents would likely influence whether we hold robots morally responsible (Bigman et al., 2019), how we evaluate a robot's decision-making (Awad et al., 2022), and whether robots can or should have rights (Gunkel, 2018). Another ethical consideration to consider is whether treating robots as separate agents as opposed to extensions of ourselves influences how we interact with them. Imagine, in the near future, that self-driving cars become an integral part of our daily lives. What would we take them to be? Would we think of self-driving cars as "tools" (used as a means to our own ends; Clark & Chalmers, 1998) or instead as "teammates" (collaborative partners with shared goals; Salomons et al., 2022)?

Given the discussion above, this question can be viewed through a developmental lens. The adults of today will likely view self-driving cars as "tools" – as a way of extending their own capabilities. For today's adults, self-driving cars perform the function of achieving the passenger's goal of getting somewhere in their car without having to drive themselves. On the other hand, even before they learn how to drive, today's children may view a certain class of interactive technologies as agents. As these children become adults, they may engage with their self-driving cars as separate beings – as "teammates" or collaborators working together towards a common goal of reaching a destination. The quality of the interaction could be markedly different for these new drivers. For them, the car and passenger would communicate their intentions and ideas to each other and trust each other to perform their part of the task in the most efficient way possible.

This example highlights the social and ethical issues that might emerge in the cultural landscape that we are currently creating for our children. How we grow up with technologies – whether we are exposed to technology at a young age, whether we had a lot of technology exposure or not, whether the technologies we use are social or object-like – might influence whether we view technologies as agents, even free agents, or instead as tools, which might also influence

our ethical concerns. This is precisely why it is important to take a developmental and cultural approach when investigating beliefs about free will and agency with robotic technologies.

Treating robotic technologies as agents instead of as tools may present benefits to our own lives. When robots act like collaborative partners – as opposed to tools – children are more engaged (Zaga et al., 2015) and learn more (Chen et al., 2020). Treating robots as agents may also mean that children and adults alike are more likely to forgive robots when they make occasional mistakes. When an Alexa does not set the reminder that you asked for, making you miss your important meeting, you likely will be hesitant to ask Alexa to set future reminders if you treat Alexa as a tool. You may even throw the current Alexa out and buy a new version, hoping that it is better at recognizing voice commands. If you treat Alexa more like an agent, however, you may be willing to find a different solution than throwing it out: perhaps you will ask Alexa why it did not recognize your original voice command, whether there is anything you can do to make your voice easier for it to understand, or whether you can sync your work calendar with Alexa. Children are willing to forgive a human's occasional mistakes (Kushnir & Koenig; 2017; Vaish et al., 2010), so it remains an open question as to whether children forgive robots for occasional mistakes, and whether children's forgiveness might depend on their views about robots' agency.

To be clear, we are not claiming that young children treat every object or piece of technology as a separate agent. Five-year-old children, for example, do not think that computers have mental states, emotions, or experiences (Mikropoulos et al., 2003) and they think that such devices (including tablets and smartphones) are only sources of entertainment (Eisen & Lillard, 2017). Young children also differentiate robotic technologies from other objects: 4-10-year-olds think that robots deserve moral treatment more than toys (Sommer et al., 2019) and 4-5-year-olds think that robots have more mental and perceptual states than toys, objects, and cars (Jipson & Gelman, 2007). Robots, therefore, are unique in that they are objects that can be treated as agents.

The purpose of this paper is to draw attention to the emerging literature on children's beliefs about robots as agents and to begin speculating about what this literature suggests. As with any new research program, more work is needed to address these speculations. For example, we are unfamiliar with any work investigating children's conceptual understanding of programming. Investigating what children think programming is and whether this understanding changes

throughout development would help us to understand why a robot's being described as programmed influences children's free-will judgments. Second, there are a variety of ways in which children could be exposed to technology, not all of which are represented in our current research samples. This is particularly important since technological changes are rapid and often unevenly distributed around the world. To further investigate the role of various technological cultures on children's agency beliefs, it is critical that future research takes into account the diversity of technological environments.

The children of today are the adults of tomorrow. While attributing agency of various sorts to robots might strike adults as being a mistake, or as only being possible in science fiction, it appears to be a very natural extension of children's tendency to use multiple cues (such as autonomous motion, contingent interaction, and social behavior) to attribute agency more generally. In this paper, we have shown that children's tendency to attribute agency to robots declines with age – likely because children become more aware that a robot's programming is a constraint on its behavior. However, we suggest the possibility that even when children become aware of such programming, this decline might not be as precipitous as it is now if children continue to engage with sophisticated robots in their daily lives. Instead, it is possible that as young children are forming their beliefs about their own and others' agency while also interacting with robotic technologies, they may begin to reframe their agency beliefs to allow for free, programmed robots. Robots as separate agents, therefore, may no longer be a thing of science fiction, but very soon might be part of our reality.

REFERENCES

Anderson, D. R., Pempek, T. A. (2005). Television and Very Young Children. *American Behavioral Scientist*, *48*(5), 505–522. https://doi.org/10.1177/0002764204271506

Atance, C. M., Meltzoff, A. N. (2005). My future self: Young children's ability to anticipate and explain future states. *Cognitive Development*, *20*(3), 341–361. https://doi.org/10.1016/j.cogdev.2005.05.001

Awad, E., Levine, S., Anderson, M., Anderson, S. L., Conitzer, V., Crockett, M. J., Everett, J. A. C., Evgeniou, T., Gopnik, A., Jamison, J. C., Kim, T. W., Liao, S. M., Meyer, M. N., Mikhail, J., Opoku-Agyemang, K., Borg, J. S., Schroeder, J.,

Sinnott-Armstrong, W., Slavkovik, M., Tenenbaum, J. B. (2022). Computational ethics. *Trends in Cognitive Sciences*, *26*(5), 388–405. https://doi.org/10.1016/j.tics.2022.02.009

Baillargeon, R., Scott, R. M., Bian, L. (2016). Psychological Reasoning in Infancy. *Annual Review of Psychology*, *67*(1), 159–186. https://doi.org/10.1146/annurev-psych-010213-115033

Baumeister, R. F. (2008). Free Will in Scientific Psychology. *Perspectives on Psychological Science*, *3*(1), 14–19. https://doi.org/10.1111/j.1745-6916.2008.00057.x

Bélanger, M. J., Atance, C. M., Varghese, A. L., Nguyen, V., Vendetti, C. (2014). What Will I Like Best When I'm All Grown Up? Preschoolers' Understanding of Future Preferences. *Child Development*, *85*(6), 2419–2431. https://doi.org/10.1111/cdev.12282

Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., Tanaka, F. (2018). Social robots for education: A review. *Science Robotics*, *3*(21). https://doi.org/10.1126/scirobotics.aat5954

Bernstein, D., Crowley, K. (2008). Searching for signs of intelligent life: An investigation of young children's beliefs about robot intelligence. *The Journal of the Learning Sciences*, *17*(2), 225–247. https://doi.org/10.1080/10508400801986116

Bethel, C. L., Stevenson, M. R., Scassellati, B. (2011). Secret-sharing: Interactions between a child, robot, and adult. *Conference Proceedings - IEEE International Conference on Systems, Man and Cybernetics*, 2489–2494. https://doi.org/10.1109/ICSMC.2011.6084051

Bigman, Y. E., Waytz, A., Alterovitz, R., Gray, K. (2019). Holding Robots Responsible: The Elements of Machine Morality. *Trends in Cognitive Sciences*, *23*(5), 365–368. https://doi.org/10.1016/j.tics.2019.02.008

Brandone, A. C., Wellman, H. M. (2009). You can't always get what you want: Infants understand failed goal-directed actions. *Psychological Science*, *20*(1), 85–91. https://doi.org/10.1111/j.1467-9280.2008.02246.x

Breazeal, C., Harris, P. L., Desteno, D., Kory Westlund, J. M., Dickens, L., Jeong, S. (2016). Young Children Treat Robots as Informants. *Topics in Cognitive Science*, *8*(2), 481–491. https://doi.org/10.1111/tops.12192

Brink, K. A., Gray, K., Wellman, H. M. (2019). Creepiness Creeps In: Uncanny Valley Feelings Are Acquired in Childhood. *Child Development*, *90*(4), 1202–1214. https://doi.org/10.1111/cdev.12999

Brink, K. A., Wellman, H. M. (2020). Robot Teachers for Children? Young Children Trust Robots Depending on Their Perceived Accuracy and Agency. *Developmental Psychology*. https://doi.org/10.1037/dev0000884

Buresh, J. S., Woodward, A. L. (2007). Infants track action goals within and across agents. *Cognition*, *104*(2), 287–314. https://doi.org/10.1016/j.cognition.2006.07.001

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.

Carlson, S. M., Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, *72*(4), 1032–1053. https://doi.org/10.1111/1467-8624.00333

Carpenter, M., Call, J., Tomasello, M. (2005). Twelve- and 18-month-olds copy actions in terms of goals. *Developmental Science*, *8*(1), F13–F20. https://doi.org/10.1111/j.1467-7687.2004.00385.x

Chen, H., Park, H. W., Breazeal, C. (2020). Teaching and learning with children: Impact of reciprocal peer learning with a social robot on children's learning and emotive engagement. *Computers & Education*, *150*, 103836. https://doi.org/10.1016/j.compedu.2020.103836

Chernyak, N., Gary, H. E. (2016). Children's Cognitive and Behavioral Reactions to an Autonomous Versus Controlled Social Robot Dog. *Early Education and Development*, *27*(8), 1175–1189. https://doi.org/10.1080/10409289.2016.1158611

Chernyak, N., Kang, C., Kushnir, T. (2019). The cultural roots of free will beliefs: How Singaporean and U.S. Children judge and explain possibilities for action in interpersonal contexts. *Developmental Psychology*, *55*(4), 866–876. https://doi.org/10.1037/dev0000670

Chernyak, N., Kushnir, T. (2013). Giving Preschoolers Choice Increases Sharing Behavior. *Psychological Science*, *24*(10), 1971–1979. https://doi.org/10.1177/0956797613482335

Chernyak, N., Kushnir, T., Sullivan, K. M., Wang, Q. (2013). A comparison of american and nepalese children's concepts of freedom of choice and social constraint. *Cognitive Science*, *37*(7), 1343–1355. https://doi.org/10.1111/cogs.12046

Choe, K. S., Keil, F. C., Bloom, P. (2005). Children's understanding of the Ulysses conflict. *Developmental Science*, *8*(5), 387–392. https://doi.org/10.1111/j.1467-7687.2005.00426.x

Clark, A., Chalmers, D. (1998). The Extended Mind. *Analysis*, *58*(1), 7–19. http://www.jstor.org/stable/3328150

Clarke, R. (2003). *Libertarian Accounts of Free Will*. New York: Oxford University Press.

Csibra, G. (2008). Goal attribution to inanimate agents by 6.5-month-old infants. *Cognition*, *107*(2), 705–717. https://doi.org/10.1016/j.cognition.2007.08.001

Csibra, G., Gergely, G., Bíró, S., Koós, O., Brockbank, M. (1999). Goal attribution without agency cues: The perception of "pure reason" in infancy. *Cognition*, *72*(3), 237–267. https://doi.org/10.1016/S0010-0277(99)00039-6

Davidson, M. C., Amso, D., Anderson, L. C., Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037–2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

DeLoache, J. S., Chiong, C., Sherman, K., Islam, N., Vanderborght, M., Troseth, G. L., Strouse, G. A., O'Doherty, K. (2010). Do Babies Learn From Baby Media? *Psychological Science*, *21*(11), 1570–1574. https://doi.org/10.1177/0956797610384145

Diamond, A., Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to"do as I say, not as I do". *Developmental Psychobiology*, *29*(4), 315–334. https://doi.org/10.1002/(SICI)1098-2302(199605)29:4<315::AID-DEV2>3.0.CO;2-T

Eisen, S., Lillard, A. S. (2017). Young children's thinking about touchscreens versus other media in the US. *Journal of Children and Media*, *11*(2), 167–179. https://doi.org/10.1080/17482798.2016.1254095

Fiala, B., Arico, A., Nichols, S. (2014). You, Robot. *Current Controversies in Experimental Philosophy*, 31–47.

Fischer, J. M. (2006). Responsiveness and moral responsibility. *My Way: Essays on Moral Responsibility*. New York, NY: Oxford University Press, 63-83.

Flanagan, T., Rottman, J., Howard, L. (2021). Constrained choice: Children's and adults' attribution of choice to a humanoid robot. *Cognitive Science, 45*(10), e13043. https://doi.org/10.1111/cogs.13043

Flanagan, T., Wong, G., Kushnir, T. (in press). The minds of machines: Children's beliefs about the experiences, thoughts, and morals of familiar interactive technologies. *Developmental Psychology.*

Frankfurt, H. G. (1971). Freedom of the Will and the Concept of a Person. *The Journal of Philosophy*, *68*(1), 5–20. https://doi.org/10.2307/2024717

Fussell, S. R., Kiesler, S., Setlock, L. D., Yew, V. (2008). How people anthropomorphize robots. *Proceedings of the 3rd International Conference on Human Robot Interaction - HRI '08*, 145. https://doi.org/10.1145/1349822.1349842

Gergely, G., Bekkering, H. Király, I. (2002). Rational imitation in preverbal infants. *Nature 415*, 755. https://doi.org/10.1038/415755a

Girouard-Hallam, L. N., Danovitch, J. H. (2022). Children's trust in and learning from voice assistants. *Developmental Psychology*, *58*(4), 646–661. https://doi.org/10.1037/dev0001318

Girouard-Hallam, L. N., Streble, H. M., Danovitch, J. H. (2021). Children's mental, social, and moral attributions toward a familiar digital voice assistant. *Human Behavior and Emerging Technologies*, *3*(5), 1118–1131. https://doi.org/10.1002/hbe2.321

Goulding, B. W., Friedman, O. (2020). Children's Beliefs About Possibility Differ Across Dreams, Stories, and Reality. *Child Development*, *91*(6), 1843–1853. https://doi.org/10.1111/cdev.13386

Goulding, B. W., Friedman, O. (2021). A Similarity Heuristic in Children's Possibility Judgments. *Child Development*, *92*(2), 662–671. https://doi.org/10.1111/cdev.13534

Gray, H. M., Gray, K., Wegner, D. M. (2007). Dimensions of mind perception. *Science*, *315*(5812), 619. https://doi.org/10.1126/science.1134475

Gray, K., Wegner, D. M. (2009). Moral Typecasting: Divergent Perceptions of Moral Agents and Moral Patients. *Journal of Personality and Social Psychology*, *96*(3), 505–520. https://doi.org/10.1037/a0013748

Gunkel, D. J. (2018). The other question: Can and should robots have rights? *Ethics and Information Technology*, *20*(2), 87–99. https://doi.org/10.1007/s10676-017-9442-4

Hamlin, J.K., Hallinan, E.V. and Woodward, A.L. (2008), Do as I do: 7-month-old infants selectively reproduce others' goals. Developmental Science, 11: 487-494. https://doi.org/10.1111/j.1467-7687.2008.00694.x

Hashimoto, T., Kobayashi, H., Polishuk, A., Verner, I. (2013). Elementary science lesson delivered by robot. In *ACM/IEEE International Conference on Human-Robot Interaction* (pp. 133–134). https://doi.org/10.1109/HRI.2013.6483537

Heider, F., Simmel, M. (1944). An experimental study of apparent behavior. *The American Journal of Psychology, 57*, 243–259. https://doi.org/10.2307/1416950

Jipson, J. L., Gelman, S. A. (2007). Robots and rodents: Children's inferences about living and nonliving kinds. *Child Development*, *78*(6), 1675–1688. https://doi.org/10.1111/j.1467-8624.2007.01095.x

Johnson, S. C. (2003). Detecting agents. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *358*(1431), 549–559. https://doi.org/10.1098/rstb.2002.1237

Kahn, P. H., Kanda, T., Ishiguro, H., Freier, N. G., Severson, R. L., Gill, B. T., ... Shen, S. (2012). "Robovie, you'll have to go into the closet now": Children's social and moral relationships with a humanoid robot. *Developmental Psychology*, *48*(2), 303–314. https://doi.org/10.1037/a0027033

Kochanska, G., Murray, K., Jacques, T.Y., Koenig, A.L. and Vandegeest, K.A. (1996), Inhibitory Control in Young Children and Its Role in Emerging Internalization. *Child Development, 67*, 490-507. https://doi.org/10.1111/j.1467-8624.1996.tb01747.x

Kotovsky, L. and Baillargeon, R. (2000), Reasoning about collisions involving inert objects in 7.5-month-old infants. Developmental Science, 3: 344-359. https://doi.org/10.1111/1467-7687.00129

Kushnir, T. (2018). The developmental and cultural psychology of free will. *Philosophy Compass*, *13*(11), 1–17. https://doi.org/10.1111/phc3.12529

Kushnir, T. (2022). Imagination and social cognition in childhood. *WIREs Cognitive Science*, e1603. https://doi.org/10.1002/wcs.1603

Kushnir, T., Gopnik, A., Chernyak, N., Seiver, E., Wellman, H. M. (2015). Developing intuitions about free will between ages four and six. *Cognition*, *138*, 79–101. https://doi.org/10.1016/j.cognition.2015.01.003

Kushnir, T., Koenig, M. A. (2017). What i don't know won't hurt you: The relation between professed ignorance and later knowledge claims. *Developmental Psychology*, *53*(5), 826–835. https://doi.org/10.1037/dev0000294

Lagattuta, K. H. (2005). When You Shouldn't Do What You Want to Do: Young Children's Understanding of Desires, Rules, and Emotions. *Child Development*, *76*(3), 713–733. https://doi.org/10.1111/j.1467-8624.2005.00873.x

Lane, J. D., Wellman, H. M., Evans, E. M. (2014). Approaching an understanding of omniscience from the preschool years to early adulthood. *Developmental Psychology*, *50*(10), 2380–2392. https://doi.org/10.1037/a0037715

Lesage, K. A., Richert, R. A. (2021). Can God do the impossible? Anthropomorphism and children's certainty that God can make impossible things possible. *Cognitive Development*, *58*. https://doi.org/10.1016/j.cogdev.2021.101034

Martin, D. U., Perry, C., MacIntyre, M. I., Varcoe, L., Pedell, S., Kaufman, J. (2020). Investigating the nature of children's altruism using a social humanoid robot. *Computers in Human Behavior*, *104*. https://doi.org/10.1016/j.chb.2019.09.025

Matthews, K. (2020, April). *5 robots now in grocery stores show the future of retail.* Robotic Business Review. https://www.roboticsbusinessreview.com/retail-hospitality/5-robots-grocery-stores-now/

McCormack, T., Atance, C. M. (2011). Planning in young children: A review and synthesis. *Developmental Review*, *31*(1), 1–31. https://doi.org/10.1016/j.dr.2011.02.002

Meltzoff, A. N. (1995). Understanding the Intentions of Others: Re-Enactment of Intended Acts by 18-Month-Old Children. *Developmental Psychology*, *31*(5), 838–850. https://doi.org/10.1037/0012-1649.31.5.838

Meltzoff, A. N., Brooks, R., Shon, A. P., Rao, R. P. N. (2010). "Social" robots are psychological agents for infants: A test of gaze following. *Neural Networks*, *23*(8–9), 966–972. https://doi.org/10.1016/j.neunet.2010.09.005

Mikropoulos, T., Misailidi, P., Bonoti, F. (2003). Attributing human properties to computer artifacts: Developmental changes in children's understanding of the animate–inanimate distinction. *Psychology: The Journal of the Hellenic Psychological Society, 10*, 53–64.

Monroe, A. E., Dillon, K. D., Malle, B. F. (2014). Bringing free will down to Earth: People's psychological concept of free will and its role in moral judgment. *Consciousness and Cognition*, *27*, 100–108. https://doi.org/10.1016/j.concog.2014.04.011

Movellan, J., Eckhardt, M., Virnes, M., Rodriguez, A. (2009). Sociable robot improves toddler vocabulary skills. *Proceedings of the 4th ACM/IEEE International Conference on Human Robot Interaction - HRI '09*, 307. https://doi.org/10.1145/1514095.1514189

Nahmias, E., Allen, C. H., Lovell, B. (2020). When do robots have free will? Exploring the relationship between (attributions of) consciousness and free will. In B. Feltz, M. Missal, A. C. Sims (Eds.) *Free will, causality, and neuroscience*. Brill Publishers.

Nichols, S. (2004). The Folk Psychology of Free Will: Fits and Starts. *Mind and Language*, *19*(5), 473–502. https://doi.org/10.1111/j.0268-1064.2004.00269.x

ojalehto, bethany l., Medin, D. L., García, S. G. (2017). Conceptualizing agency: Folkpsychological and folkcommunicative perspectives on plants. *Cognition*, *162*, 103–123. https://doi.org/10.1016/j.cognition.2017.01.023

Opfer, J. E. (2002). Identifying living and sentient kinds from dynamic information: The case of goal-directed versus aimless autonomous movement in conceptual change. *Cognition*, *86*(2), 97–122. https://doi.org/10.1016/S0010-0277(02)00171-3

Piaget, J. (1929). *The child's conception of the world*. London, UK: Routledge and Kegan Paul.

Rakison, D. H., Poulin-Dubois, D. (2001). Developmental origin of the animate–inanimate distinction. *Psychological Bulletin, 127*(2), 209–228. https://doi.org/10.1037/0033-2909.127.2.209

Rakison, D. H., Cicchino, J. B., Hahn, E. R. (2007). Infants' knowledge of the path that animals take to reach a goal. *British Journal of Developmental Psychology*, *25*(3), 461–470. https://doi.org/10.1348/026151006X171893

Ratajska, A., Brown, M. I., Chabris, C. F. (2020). *Attributing social meaning to animated shapes: A new experimental study of apparent behavior*. University of Illinois Press. https://doi.org/10.5406/amerjpsyc.133.3.0295

Reinecke, M. G, Wilks, M., Bloom, P. (2021). Developmental changes in perceived moral standing of robots. *Proceedings of the Annual Meeting of the Cognitive Science Society*, 43. Retrieved from https://escholarship.org/uc/item/8f32d068

Richert, R. A., Corriveau, K. H. (2022). Development of Religious Cognition. *Annual Review of Developmental Psychology*, *4*(1), annurev-devpsych-120920-041303. https://doi.org/10.1146/annurev-devpsych-120920-041303

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., Lee, K. (2006). The Development of Executive Functioning and Theory of Mind. A Comparison of Chinese and U.S. Preschoolers. *Psychological Science*, *17*(1), 74–81. https://doi.org/10.1111/j.1467-9280.2005.01667.x

Salem, M., Eyssel, F., Rohlfing, K., Kopp, S., Joublin, F. (2013). To Err is Human(-like): Effects of Robot Gesture on Perceived Anthropomorphism and Likability. *International Journal of Social Robotics*, *5*(3), 313–323. https://doi.org/10.1007/s12369-013-0196-9

Salomons, N., Pineda, K. T., Adejare, A., Scassellati, B. (2022). "We Make a Great Team!": Adults with Low Prior Domain Knowledge Learn more from a Peer Robot than a Tutor Robot. *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 176–184. https://doi.org/10.1109/HRI53351.2022.9889441

Saxe, R., Tenenbaum, J. B., Carey, S. (2005). Secret agents: Inferences about hidden causes by 10- and 12-month-old infants. *Psychological Science*, *16*(12), 995–1001. https://doi.org/10.1111/j.1467-9280.2005.01649.x

Schlottmann, A., Ray, E. (2010). Goal attribution to schematic animals: Do 6-month-olds perceive biological motion as animate? *Developmental Science*, *13*(1), 1–10. https://doi.org/10.1111/j.1467-7687.2009.00854.x

Setoh, P., Wu, D., Baillargeon, R., Gelman, R. (2013). Young infants have biological expectations about animals. *Proceedings of the National Academy of Sciences*, *110*(40), 15937–15942. https://doi.org/10.1073/pnas.1314075110

Shen, S., Slovak, P., Jung, M. F. (2018). "stop. i See a Conflict Happening.": A Robot Mediator for Young Children's Interpersonal Conflict Resolution. In *ACM/IEEE International Conference on Human-Robot Interaction* (pp. 69–77). IEEE Computer Society. https://doi.org/10.1145/3171221.3171248

Shepherd, J. (2015). Consciousness, free will, and moral responsibility: Taking the folk seriously. *Philosophical Psychology*, *28*(7), 929-946. https://doi.org/10.1080/09515089.2014.962018

Short, E., Hart, J., Vu, M., Scassellati, B. (2010). No fair!! An interaction with a cheating robot. *5th ACM/IEEE International Conference on Human-Robot Interaction, HRI 2010*, 219–226. https://doi.org/10.1145/1734454.1734546

Shtulman, A. (2008). Variation in the Anthropomorphization of Supernatural Beings and Its Implications for Cognitive Theories of Religion. *Journal of Experimental Psychology: Learning Memory and Cognition*, *34*(5), 1123–1138. https://doi.org/10.1037/0278-7393.34.5.1123

Shtulman, A., Carey, S. (2007). How Children Reason About the Possibility of or Impossible? Improbable Events Extraordinary. *Child Development*, *78*(3), 1015–1032. https://doi.org/10.1111/j.1467-8624.2007.01047.x

Shtulman, A., Phillips, J. (2018). Differentiating "could" from "should": Developmental changes in modal cognition. *Journal of Experimental Child Psychology*, *165*(June), 161–182. https://doi.org/10.1016/j.jecp.2017.05.012

Sommer, K., Davidson, R., Armitage, K. L., Slaughter, V., Wiles, J., Nielsen, M. (2020). Preschool children overimitate robots, but do so less than they overimitate humans. *Journal of Experimental Child Psychology, 191*. https://doi.org/10.1016/j.jecp.2019.104702

Sommer, K., Nielsen, M., Draheim, M., Redshaw, J., Vanman, E. J., Wilks, M. (2019). Children's perceptions of the moral worth of live agents, robots, and inanimate objects. *Journal of Experimental Child Psychology, 187*. https://doi.org/10.1016/j.jecp.2019.06.009

Sommerville, J. A., Woodward, A. L., Needham, A. (2005). Action experience alters 3-month-old infants' perception of others' actions. *Cognition*, *96*(1), B1–B11. https://doi.org/10.1016/j.cognition.2004.07.004

Spelke, E. S., Phillips, A., Woodward, A. L. (1995). Infants′ knowledge of object motion and human action. In D. Sperber, D. Premack, A. J. Premack (Eds.), *Causal cognition: A multidisciplinary debate* (pp. 44–78). Clarendon Press/Oxford University Press.

Starmans, C., Bloom, P. (2016). When the Spirit Is Willing, but the Flesh Is Weak: Developmental Differences in Judgments About Inner Moral Conflict. *Psychological Science*, *27*(11), 1498–1506. https://doi.org/10.1177/0956797616665813

Vaish, A., Carpenter, M., Tomasello, M. (2010). Young Children Selectively Avoid Helping People With Harmful Intentions. *Child Development*, *81*(6), 1661–1669. https://doi.org/10.1111/j.1467-8624.2010.01500.x

Warneken, F., Tomasello, M. (2006). Altruistic helping in human infants and young chimpanzees. *Science*, *311*(5765), 1301–1303. https://doi.org/10.1126/science.1121448

Wei, C. W., Hung, I. C., Lee, L., Chen, N. S. (2011). A joyful classroom learning system with robot learning companion for children to learn mathematics multiplication. *Turkish Online Journal of Educational Technology*, *10*(2), 11–23.

Weisman, K., Legare, C. H., Smith, R. E., Dzokoto, V. A., Aulino, F., Ng, E., Dulin, J. C., Ross-Zehnder, N., Brahinsky, J. D., Luhrmann, T. M. (2021). Similarities and differences in concepts of mental life among adults and children in five cultures. *Nature Human Behaviour*. https://doi.org/10.1038/s41562-021-01184-8

Wente, A. O., Bridgers, S., Zhao, X., Seiver, E., Zhu, L., Gopnik, A. (2016). How Universal Are Free Will Beliefs? Cultural Differences in Chinese and U.S. 4- and 6-

Year-Olds. *Child Development*, *87*(3), 666–676. https://doi.org/10.1111/cdev.12528

Kory Westlund, J. M., Dickens, L., Jeong, S., Harris, P. L., DeSteno, D., & Breazeal, C. L. (2017). Children use non-verbal cues to learn new words from robots as well as people. *International Journal of Child-Computer Interaction*, *13*, 1–9. https://doi.org/10.1016/j.ijcci.2017.04.001

Wilks, M., Caviola, L., Kahane, G., Bloom, P. (2021). Children Prioritize Humans Over Animals Less Than Adults Do. *Psychological Science*, *32*(1), 27–38. https://doi.org/10.1177/0956797620960398

Willard, A. K., McNamara, R. A. (2019, January 1). The Minds of God(s) and Humans: Differences in Mind Perception in Fiji and North America. *Cognitive Science*. Wiley-Blackwell Publishing. https://doi.org/10.1111/cogs.12703

Wolf, S. (1990). *Freedom and Reason*. Oxford: Oxford University Press.

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, *69*(1), 1–34. https://doi.org/10.1016/S0010-0277(98)00058-4

Woodward, A. L. (1999). Infants' ability to distinguish between purposeful and non-purposeful behaviors. *Infant Behavior and Development*, *22*(2), 145–160. https://doi.org/10.1016/S0163-6383(99)00007-7

Woolfolk, R. L., Doris, J. M., Darley, J. M. (2006). Identification, situational constraint, and social cognition: Studies in the attribution of moral responsibility. *Cognition*, *100*(2), 283–301. https://doi.org/10.1016/j.cognition.5.002

Young, A. D., Monroe, A. E. (2019). Autonomous morals: Inferences of mind predict acceptance of AI behavior in sacrificial moral dilemmas. *Journal of Experimental Social Psychology, 85*. https://doi.org/10.1016/j.jesp.2019.103870

Zaga, C., Lohse, M., Truong, K. P., Evers, V. (2015). The Effect of a Robot's Social Character on Children's Task Engagement: Peer Versus Tutor. In A. Tapus, E. André, J.-C. Martin, F. Ferland, M. Ammi (Eds.), *Social Robotics* (Vol. 9388, pp. 704–713). Springer International Publishing. https://doi.org/10.1007/978-3-319-25554-5_70

Zaga, C., De Vries, R. A. J., Li, J., Truong, K. P., Evers, V. (2017). A simple nod of the head: The effect of minimal robot movements on children's perception of a low-anthropomorphic robot. In *Conference on Human Factors in Computing Systems - Proceedings* (Vol. 2017-May, pp. 336–341). Association for Computing Machinery. https://doi.org/10.1145/3025453.3025995

Zelazo, P. D., Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives, 6*(4), 354–360. https://doi.org/10.1111/j.1750-8606.2012.00246.x

Zhao, X., Zhao, X., Gweon, H., Kushnir, T. (2021a). Leaving a Choice for Others: Children's Evaluations of Considerate, Socially-Mindful Actions. *Child Development*, *92*(4), 1238–1253. https://doi.org/10.1111/cdev.13480

Zhao, X., Wente, A., Flecha, M. F., Galvan, D. S., Gopnik, A., Kushnir, T. (2021b). Culture moderates the relationship between self-control ability and free will beliefs in childhood. *Cognition*, *210*. https://doi.org/10.1016/j.cognition.2021.104609

Zhao, X., Kushnir, T. (2022). When it's not easy to do the right thing: Developmental changes in understanding cost drive evaluations of moral praiseworthiness. *Developmental Science*, e13257. https://doi.org/10.1111/desc.13257