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Preschool-age Children's Understanding About a Novel Robotic Toy: Exploring the Role of Parent-child Conversation

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PRESCHOOL-AGE CHILDREN'S UNDERSTANDING ABOUT A NOVEL ROBOTIC TOY: EXPLORING THE ROLE OF PARENT-CHILD CONVERSATION

A dissertation submitted in partial satisfaction
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

PSYCHOLOGY

by

Elizabeth J. Goldman

September 2021

The dissertation of Elizabeth
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Graduate Studies

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Dedication

For my Uncle John who encouraged me to do what I loved and believed in me from day one! Your love for science and education inspired me.

"The important thing is not to stop questioning. Curiosity has its own reason for existing."

-Albert Einstein

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Abstract

Preschool-age children's understanding about a novel robotic toy: Exploring the role of parent-child conversation

Elizabeth J. Goldman

Robotic toys are more and more present in the lives of today's children. The present research sought to address two research questions: (1) How preschool-age children conceptualize a robotic toy and (2) how parents talk with children about the robotic toy. Parent-child dyads were randomly assigned to watch videos of a contingent robot that followed directions (Contingent condition) or a non-contingent robot that did not follow directions (Non-Contingent condition). After watching the videos, children answered questions about the robotic toy (Interview 1), dyads participated in a short conversation, and children answered more questions about the robotic toy (Interview 2). Results suggest that children's judgment of the toy in the first interview was not related to the condition to which they were assigned. However, in the second interview, a significant difference was observed in children's judgment of the communicative ability of the toy. Children in the Contingent condition were more likely to say the toy could hear. During the parent-child conversation, more dyads in the Non-Contingent condition discussed the toy's contingent behavior. This exploratory work provides insight into how parents help their young children make meaning out of their experience with a novel robotic toy.

Keywords: robotic toy, contingency, parent-child conversation, child interview, young children

Preschool-age children's understanding about a novel robotic toy: Exploring the role of parent-child conversation

Technological devices are becoming more accessible and widely used in our society; many types of devices are available for children (Kulakci-Altintas, 2020). Although children are often exposed to technological devices early in life, there is still a lot to be learned about how they conceptualize such devices (Danovitch & Alzahabi, 2013). Of particular interest to the present study are robots. Robots are often designed to be social agents that interact and communicate directly with human users (Ahmad et al., 2017; Breazeal et al., 2016; Kanda et al., 2004). Many of the robots used in the existing research are social robots. A social robot is defined as "an autonomous or semi-autonomous robot that interacts with and communicates with humans by following behavioral norms" (Kanero et al., 2018, p.1).

In the literature, robots specifically designed for children are often referred to as robotic toys. Once rare and expensive, robotic toys are readily available to purchase at multiple price points (Bulgarelli et al., 2018). The present study explored how children conceptualized a novel robotic toy by asking children to respond to interview questions. Additionally, dyads participated in a parent-child conversation which enabled us to examine how parents helped their young children make meaning out of the robotic toy.

Research that examined how children differentiate between living and non-living things sets the foundation for examining how children understand robots. In particular, we can draw on the literature of children’s categorization of ambiguous agents that are not clearly living or non-living. Although adults can easily categorize a robot as non-living, children's understanding of living and non-living is still developing (Carey, 1985). Robots with characteristics of both living and non-living things may be challenging for children to accurately and consistently categorize.

Based on Carey's (1985) theory of conceptual change, children's understanding of living things does not emerge until the late preschool age and develops gradually over a number of years. In addition to asking children categorize something as living or non-living, Carey and her colleagues have investigated the information or features that children attend to when making such a judgement. This research shows that adults and children do not rely on the same features to determine whether something is living or non-living. For example, the features that children see as essential for living things (e.g., psychological capacity) may be unnecessary for adults making such a determination.

Furthermore, Carey highlights that the concept of living things is linked to the child's developing understanding of biology. Following this perspective, preschool-age children's understanding of what it means to be living initially centers around how closely the object in question resembles people (e.g., anthropomorphic); they tend to focus on certain visible features (e.g., having eyes) and indicators of self-propelled movement (e.g., a bird is alive because it flies). For example, Carey (1985) would argue that four-year-olds know little about non-visible things, like internal organs and their functions (e.g., hearts, where babies come from, what makes people and animals grow). By age ten, a new framework for understanding human and animals' internal bodily processes emerges, and a reorganization of the child's concept of animals and living things occurs. As children grow older, their understanding of biological concepts grows and children may provide biological justifications (e.g., eating, growing) for whether something is alive or not For example, starting around the age of ten years, children know that birds can fly and are alive because they can breathe, but airplanes are not alive even though they can fly because airplanes cannot breathe (Carey, 1985).

Previous research that asked children to categorize people, animals, plants, and objects as either living or non-living has given mixed findings. Some evidence supports that this ability emerges as early as five years of age (Inagaki & Hatano, 1996; Pérez Rodríguez, 1985; Piaget, 1929). For example, Inagaki and Hatano (1996) interviewed 4- to 11-year-olds individually and asked the child, “What is an X?” Next, the child answered follow-up questions such as “Is X living?” and “Why do you think X is living or non-living?” The results indicated that most of the 5-year-olds thought that both plants and animals were living things. Additionally, when asked whether plants had similar characteristics to animals, the 5-year-olds responded that plants like animals could grow, needed food and water to survive, and aged before eventually dying. These results were taken to suggest that by 5 years of age, children have developed an integrated concept of living things.

In contrast to the above finding, other studies have shown that children cannot correctly and consistently categorize living things until they are about 9 or 10 years of age (Carey, 1985; Leddon et al., 2008; Ochiai, 1989; Richards, 1989; Venville, 2004).

For example, Leddon et al. (2008) tested children at 4 to 10 years old in a short categorization game at their schools. Children were shown 17 cards; each card featured a picture of a person, animal, plant, or object. The experimenter showed children the cards one at a time and asked them, "What is this?" and "Is X alive?" Their results indicated that the 9- and 10-year-olds classified plants as living things but did so inconsistently; this includes children who had discussed this same concept in science classes. Leddon et al. (2008) found that although children this age could articulate what they had learned in the classroom, they did not apply this information in real-life reliably.

To better understand how children conceptualize a robotic toy, which can be ambiguous for children, the present study built on Carey’s (1985) approach by investigating the type of information children rely on to judge whether something is living or non-living. Additionally, the present study explored how parents might provide scaffolding to draw children’s attention to relevant information in making such judgments. Prior reports indicated that children often use information such as movement, growth, the ability to take food or water, the concept of illness, and reproduction, to determine whether something is living or non-living (Ochiai, 1989; Opfer & Siegler, 2004; Richards, 1989; Richards & Siegler, 1986; Stavy & Wax, 1989). As the following review will show, knowing information about the object in question sometimes leads to successful categorization and sometimes not.

For example, Ochiai (1989) found that knowing information about the object in question does not always result in correct categorization. Ochiai (1989) asked 6-

year-olds to judge whether something was living or non-living by asking the child "Does object X have property Y?" Despite attending to the characteristics that distinguish living and non-living things (e.g., grows, dies, eats, feels pain, thinks, wants something, moves, breathes, reproduces, feels happy, etc.), many 6-year-olds in this study judged the sun, clouds, thunder, and robots to be alive. These results suggest that children do not always correctly judge an object to be living or not, even if they attend to relevant information and characteristics. Thus, the knowledge of such information is not necessarily a good indication of children's understanding of living things, specifically concerning younger children.

Richards and Siegler (1986) also investigated what information children use to determine whether something was living or not. Children at 8 to 11 years old were asked to write down their response to the question, "Can you tell me how things that are alive are different from things that are not alive?" Rather than writing down their response, children under eight years of age were asked to respond to the same question verbally. The results indicated that children at seven years and younger were able to name information and characteristics associated with animals; however, they failed to do so with plants. Children older than eight years of age listed information and characteristics that applied to both plants and animals (e.g., eat, breathe, die). The oldest children in the study (10- and 11-year-olds) emphasized other information and characteristics: the ability to grow, having feelings, needing water, and being made of cells. Consistent with Carey's (1985) theory, these results suggest that children's understanding of object information and characteristics became more elaborate with age and is typically not consistently accurate until the middle childhood. In summary, young children typically use visible information or characteristics to justify why they believe something is living or not living. In contrast, older children tend to rely on other more complex or abstract information and characteristics that are not visible (e.g., grows, dies, feels pain, thinks, reproduces; see Ochiai, 1989; Richards & Siegler, 1986). The present study aims to examine if these developmental differences emerge when examining children's conceptualizations of robots.

Research has also investigated the role of past experiences on children's abilities to distinguish living from non-living things. For example, Medin et al. (2010) recruited 4- to 10-year-old children from three different cultural communities (rural Native American, rural European American, and an urban population from a diverse magnet school). These communities were chosen to highlight the different experiences children were likely to have. Children were presented with a color photograph of 16 different items (e.g., animals, humans, plants, and objects), were asked to identify the target item in question by name, and finally were asked whether each item was a living thing. Crucially, their day-to-day experiences with animals (e.g., whether they owned a pet, went hunting, went fishing, or had visited a zoo) were taken into account. Medin et al. (2010) found that the 4- and 5-year-olds from the urban population relied heavily on human-centered reasoning (e.g., anthropomorphic justifications), a pattern similar to the previous findings. However, this pattern was not observed in rural Native Americans or in rural European Americans of their sample. These findings show the importance of experience, as children in both the rural Native American and rural European American groups reported higher levels of day-to-day experiences with animals than urban children. Additionally, the belief systems held by the community (e.g., the importance of animals as a valued food source via hunting, fishing, or farming) influenced children's reasoning of living and non-living things. Thus, prior experiences and conversations can play an important role in how children interact and make meaning out of their interactions with ambiguous things like a robotic toy.

When evaluating whether something has animate or inanimate qualities, children also rely on the similar set of features and their prior experiences (Chernyak & Gary, 2016; Itakura et al., 2008; Opfer et al., 2004). Research on animacy stemmed from Piaget’s observation that young children tend to regard inanimate objects as having sensations, emotions, and intentions. He called this early understanding “animism” (Piaget, 1929) and proposed a series of developmental stages that children progress through to develop an understanding of consciousness, leading to children's concept of life. In the first stage, children believe that all things are conscious; in the second stage, children believe that things that can move are conscious; in the third stage, children presume that things that can move on their own accord are conscious; and finally, in the fourth stage, children believe that consciousness is restricted to animals. According to Piaget, children do not reach this final stage until they are 11 to 12 years old. As such, children initially apply consciousness broadly to all things; with more experiences, they revise this initial view of what type of entity has consciousness by focusing on whether it can move on its own. Based on this view, objects need not be alive to possess animate qualities. It remains unclear whether young children would attribute animacy to ambiguous objects, like robots.

Indeed, research has shown that young children including infants already make a distinction between animate and inanimate objects (Gelman et al., 1983; Luo, 2011; Luo & Baillargeon, 2005; Poulin-Dubois et al.,1996). They tend to rely on self-propelled movement, in addition to physical appearance, to make their judgment about animacy (Carey, 1985; Massey & Gelman, 1988; Richards & Siegler, 1986). For example, babies at 9 months of age have been shown to discriminate between animate and inanimate by motion cues (Rakison & Poulin-Dubois, 2001). Children's understanding of animacy can provide fruitful insights into child-robot interactions because robotic toys are often ambiguous in terms of their animacy. Animate qualities help convey intentionality and are commonly seen in ambiguous agents like robots (Breazeal et al., 2016; Itakura et al., 2008; Johnson et al., 1998).

Plants are an interesting example used frequently in the literature as a useful testbed when it comes to understanding how children categorize ambiguous things. Plants are alive but do not saliently move on their own and thus are more challenging for children to attribute animacy to (Leddon et al., 2008; Richards & Siegler, 1986; Stavy & Wax, 1989). Richards and Siegler (1986) found that kindergartners saw almost no common qualities between animals and plants, and they consistently miscategorized plants as non-living. Furthermore, in many Western communities, children under ten years of age would still categorize plants as non-living (Richards, 1989; Stavy & Wax, 1989; Tao, 2016; Villarroel & Infante, 2014). The presence or lack of animate qualities is something children take into account when making these faulty judgements.

In addition, children's prior experiences interacting with or learning about ambiguous things, like plants, vary. To investigate these varying experiences, Hatano et al. (1993) asked kindergarteners, second graders, and fourth graders from Israel, Japan, and the United States to classify things as living or non-living. Specifically, children were asked whether people, animals, plants, and inanimate objects were living things. The results indicated that children of all three ages and from all three countries knew that people, animals, plants, and inanimate entities were different types of things that had different characteristics and properties. Interestingly, children were the least accurate at regarding the characteristics and properties of plants. In their sample, the Israeli children were the least likely to classify plants as living things, and the Japanese children were the most likely to attribute qualities of living things to inanimate objects. This research highlights children's different experiences and varying levels of exposure to relevant biological information from media coverage and school instruction.

As summarized above, although alive, plants have ambiguous qualities in regard to their animacy and are often miscategorized by young children. As demonstrated in prior research, children do not always attribute animacy to living things like plants. It remains unclear whether they would attribute animacy to non-living things that exhibit some autonomous characteristics, like robots. Past research has converged to show that object information and characteristics can be used in children's evaluation of animacy (Chernyak & Gary, 2016; Itakura et al., 2008; Opfer et al., 2004). We hope to connect this wealth of developmental research with robotic technologies used by young children.

Research by Jipson and Gelman (2007) has investigated children’s ontological understanding of various ambiguous objects, including a robotic dog. Children between 3 and 5 years of age saw videos of the ambiguous objects before responding to interview questions (i.e., Can this one think?, Can this one feel happy?). The results suggest that young children use biological (i.e., It eats) and perceptual (i.e., Can it see?) properties to differentiate ambiguous objects from one another. Children granted more biological properties to the robotic dog than the starfish. Children also referenced the perceptual properties that the robotic dog had. This suggests that animate qualities can be attributed to non-living entities. More research is needed to understand what information children use when forming their conceptualization of ambiguous things, like robots. The present study builds upon this work by asking children to additionally offer justification for their interview responses in the attempt to better understand what type of information children use to support their conceptualization of a robotic toy.

The present study was also motivated by the work of Kahn et al. (2012), who used an interview to assess how children judged the “Robovie” robot. After observing an interaction where the robot voiced objections after being locked in a closet, Kahn and colleagues (2012) found that children (between the ages of 9 and 12 years) believed the robot had mental states, was a social being, and deserved fair treatment.

Furthermore, their results suggest that children viewed the robot as a unique ontological category, in between living or non-living.

Following the above research, the present study interviewed children after they had observed an interaction between the robot and an adult. Specifically, we hope to address how children conceptualize robots and how parents provided some scaffolding in this process. Parent-child conversation is a fruitful way to look at how children's conceptualization is socially construed. Prior work has examined how parents use conversation to guide their child's attention to the most relevant information (Gelman et al., 1998; Jipson & Callanan, 2003; Jipson et al., 2016; Kelemen et al., 2005).

For example, Jipson et al. (2016) investigated the role of parent-child conversation in children's thinking about robots. Parents and their 3- to 5-year-old children talked about a robotic dog together. The findings indicated that parents and their children referred to the robotic toy using both animate (e.g., biological, sensory) and artifact properties (e.g., human made) Additionally, parental talk influenced children's reasoning about the properties that were not easily identifiable by visual cues. The results suggest that parent-child conversation can affect how children conceptualize an ambiguous robotic toy and parents can help their children focus on certain qualities.

Contingency

Although many qualities can indicate animacy (e.g., autonomous movement, contingency, goal-directed actions), the present study focused on contingency.

Contingency is the idea of reacting to a partner's behavior, actions, or speech (Breazeal et al., 2016; Martínez-Miranda et al., 2018). For example, in interactions with others, social partners listen and respond to each other to keep the exchange going. Children expect and experience contingency in their everyday lived experiences. Focusing on contingency in the investigation of children's understanding of robots is timely and relevant for many reasons. Through lived experiences, we know that a technological device never works perfectly all the time, and robots are no exception. When interacting with a robot, we can experience lags (delays in response time) and glitches. Additionally, the level of contingency differs from device to device. In other words, some robots may behave more contingently than others. Thus, contingency provides an interesting testbed in examining children's concept of robots.

Indeed, previous research has shown that contingency is one of key qualities children consider when determining whether something is animate or inanimate (Opfer et al., 2004; Zogza & Papamichael., 2000). In research by Johnson et al. (1998), 12-month-old infants interacted with either an adult (person condition) or a brown asymmetrical object (object condition). In the person condition, the adult either responded contingently by saying naturalistic phrases (e.g., "really" or "um") or behaved non-contingently (e.g., refrained from speaking at all). In the object condition, children interacted with a brown object that either (1) had a face or did not have a face and (2) behaved contingently (e.g., made sounds) or did not engage in contingent behavior (e.g., did not make any sounds). The results showed that the 12-

month-olds shifted their gaze and attention based on the object’s action in every condition except for the object condition in which the object did not have a face and behaved non-contingently. Both facial features and contingent behaviors were identified as important for communicating intention. In the above study, it is hard to tease apart whether the infants focused on the object's behavior (contingent or non-contingent) or the object's facial expressions (present or not present).

Are children also affected by contingency in their view about a robot? Previous research has compared how children react to a robot that behaves contingently and a robot that behaves non-contingently. Peca et al. (2016) examined whether infants at 9 to 17 months viewed the “Keepon” robot as a social agent after they had observed the robot interact with an adult. The infants observed a scripted conversation between the Keepon robot and an adult. Half the infants saw an interaction where the robot responded contingently, and half saw an interaction where the robot responded non-contingently. During the contingent conversation, Keepon responded to the adult by producing sounds and motions. Infants then participated in turn-taking, where Keepon made sounds and motions and then waited for the infant to respond. The results show that infants in the contingent condition initiated the Keepon robot more than infants in the non-contingent condition, suggesting that infants in this age range rely on contingency to determine whether they conceptualize a robot as more of a social agent than an inanimate object.

Similarly, in a study by Meltzoff et al. (2010), 18-month-old infants observed a human-like robot interact with an adult experimenter. Half the infants saw a social interaction where the robot and the adult exhibited contingent responses (e.g., in turn-taking). Half observed an interaction where little communication between the experimenter and the robot occurred. Infants who observed the social interaction wanted to look at what the robot was seeing and shifted their attention to the desired target accordingly.

Like infants, preschool-age children also treat a contingent robot differently than a non-contingent robot. In research by Breazeal et al. (2016), children at 3 to 5 years old interacted with two "DragonBots" robots. The DragonBot had colorful fur, dragon wings, and big eyes. One of the robots was contingent (looked at the child, appeared engaged), and the other robot was non-contingent (looked away, appeared disengaged). Children were encouraged to have a conversation with the robot by telling the robot about their favorite animal. The robot then discussed its favorite animal (a novel animal unlikely to be familiar to the children). More children asked the contingent robot for information about the novel animal. The results suggest that children were more willing to treat a robot as knowledgeable (e.g., asking for more information) and to maintain the interaction with the robot if it exhibited contingency.

Contingency may be especially important for children to judge how well a robot can effectively communicate with others. As seen in the above literature, infants and children had longer and more frequent interactions with a robot that behaved contingently than they did with a non-contingent robot. Children made efforts to sustain interactions they had with contingent robots but did not do so when interacting with non-contingent robots. Robots that exhibit contingent behavior appear to make social interactions more meaningful for both infants and children. The existing literature thus provided a glimpse at how children respond to contingency in both objects and robots. Young children’s experience with robots is not always a solo activity. Thus, it is important to examine the collaborative experience and its contributions to how parents help their young children make meaning out of their experience with ambiguous robotic toys.

The Present Study

Takes the sociocultural perspective (Vygotsky, 1962) and building on the existing research, the present study sought to (1) examine how children conceptualize an ambiguous robotic toy and (2) explore the meaning-making process that parents and their children engage in when encountering the robotic toy for the first time. Parent-child dyads watched videos of a researcher interacting with a novel robotic toy. We manipulated contingency while keeping in mind that other characteristics and behaviors could play a role in children's understanding of animacy. In the videos, the researcher gave the toy a direction, and the robotic toy's responsiveness (e.g., contingent, or non-contingent behavior) was varied across two conditions: Contingent (the robotic toy followed directions) and Non-Contingent (the robotic toy failed to follow directions). After the dyads watched the videos of the robotic toy interacting with the researcher, children answered a few questions about the robotic toy on their own. Then, the dyads watched a video of the robotic toy failing to complete a task (e.g., the toy was unable to stack the blocks). Next, the dyads talked about the toy together. Finally, children answered a few more questions about the robot.

As shown above, contingency could be important for social interactions (Breazeal et al., 2016; Johnson et al., 1998; Meltzoff et al., 2010; Peca et al., 2016). Manipulating the levels of contingency in the robotic toy's behavior may affect how children conceptualize the toy in the present study. Alternatively, the level of contingency in the toy may not exert a significant impact on children's conceptualization for several reasons. First, the robotic toy used in the present study moved autonomously. Both infants and young children have been shown to attribute goals to non-human agents that move autonomously (Luo, 2011; Luo & Baillargeon, 2005; Setoh et al., 2013). For example, Luo and Baillargeon (2005) found that 5-month-old infants interpreted the actions of a self-propelled box as goal-directed. The infants observed the box move toward a cone-shaped object during familiarization and looked longer in test when the self-propelled box approached a different goal object (Luo & Baillargeon, 2005). As the robotic toy in the present study moved autonomously in both conditions, children could conceptualize the toy as animate because the toy moves by itself, regardless of whether it exhibits contingent or non-contingent behavior.

Second, the older children in our study might have arrived with sufficient knowledge that robots are human-made and can be programmed to do different things. Thus, children could attribute the toy's contingent or non-contingent behavior to the toy being programmed to act that way, rather than the toy exhibiting agency through its behavior. Finally, as technological devices are frequently used in our society, children may have enough exposure to technology to understand that robots can malfunction. Thus, children might attribute the robotic toy's low level of contingency, such as time lag or failure to follow directions precisely as a technical glitch or a programming error, rather than the toy choosing to behave non-contingently.

Method

Participants

The sample included 96 parent-child dyads with children ranging from 42 months 3 days to 83 months 14 days (*M* = 62 months 15 days; 48 females, 48 males). The dyads were randomly assigned to one of two conditions: Contingent (*M* = 62 months 15 days; 24 females, 24 males) and Non-Contingent (*M* = 62 months 14 days; 24 females, 24 males). For the Non-Contingent condition, we take into account that a robotic toy may display varying levels of behavior and included two variations of non-contingent behavior: (1) random behavior and (2) almost successful behavior. These varying levels of non-contingent behavior are described in more detail below.

Based on parental report, the children were identified as Caucasian (*n* = 55, 57%), Hispanic and Caucasian (*n* = 13, 14%), and Asian/Pacific Islander and Caucasian (*n* = 11, 11%). The remaining 17 children in our sample identified as other (e.g., Indian, Black, Hispanic) or mixed race/ethnicity. The families were primarily from middle-class backgrounds with reported incomes ranging from less than $15,000 to more than $100,000 (see Figure 1 for the ethnic identities and Figure 2 for the self-reported family incomes of our sample). The majority had a family income over $100,000 (*n* = 64, 67%) and an advanced degree (*n* = 45, 47%) or a college degree (*n* = 39, 41%). The participants were recruited from parenting groups on social media and an existing subject pool. All families participated from the United States, apart from two families who had temporarily relocated during the COVID-19 pandemic (Australia, *n* = 1; Belgium, *n* = 1). Most dyads were from California (61%). A smaller number of dyads came from Washington (6%), New Jersey (5%), Oregon (4%), Maryland (4%), Georgia (4%), Massachusetts (4%) and a few other states.

To examine whether the conversation differed by parental occupation, parents were coded as having either a STEM or a Non-STEM occupation using the US Department of Labor database of jobs to categorize their self-reported occupations from our demographics questionnaire. In our sample, 46 parents (48%) were coded as having a STEM occupation, 46 parents (48%) reported an occupation that was coded as Non-STEM, and four parents opted not to report any occupation. To participate, the families needed to have internet access and a device to join the Zoom meeting. Ninety children (94%) participated with their mother and six children (6%) with their father. Parents were offered a $10 gift card as a gesture of thanks for their participation. Approval for this study was obtained from the Institutional Review Board at the University of California, Santa Cruz (protocol #HS3748, project title: "Children's Understanding About Technology").

Figure 1

The Children's Ethnic Identity, Self-Reported by Parents

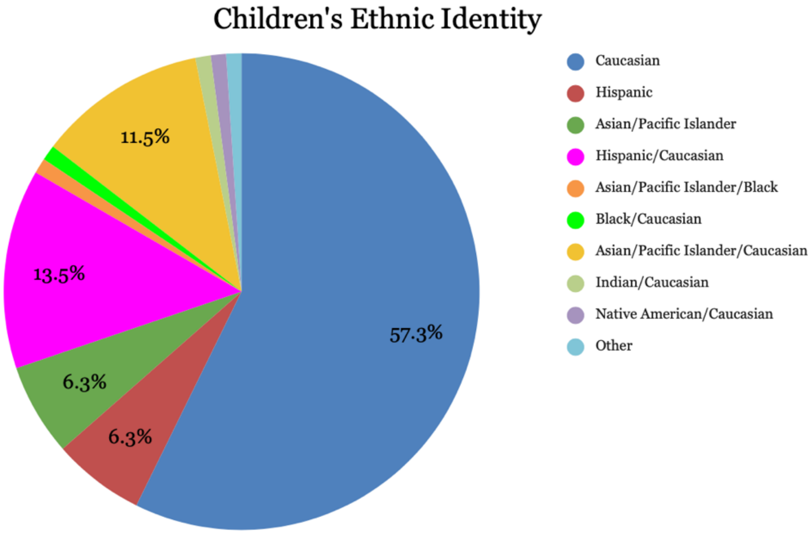
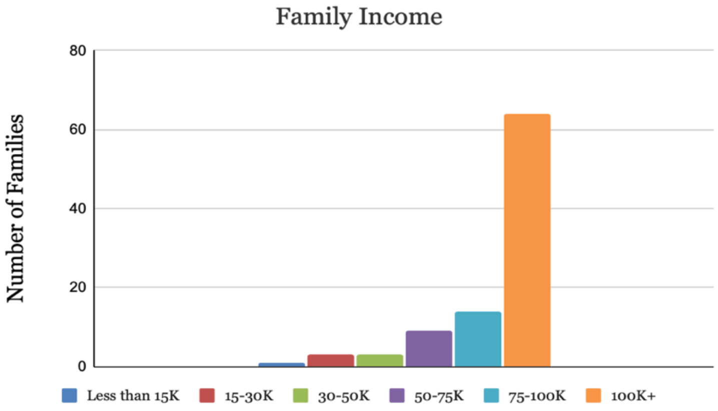


Figure 2

Family Income, Self-Reported by Parents



Procedure

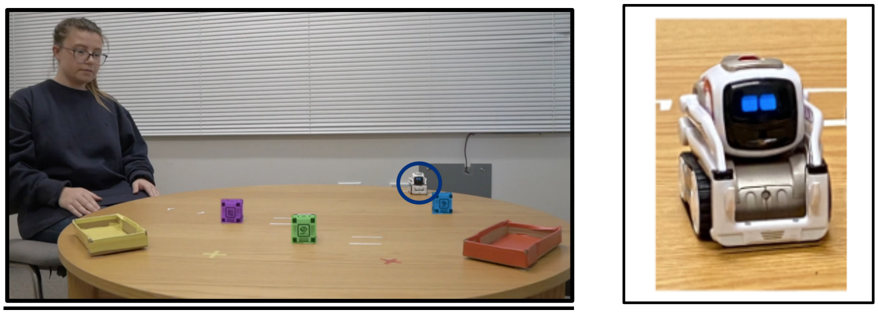
After providing informed consent, the researcher introduced herself to the parent-child dyad. When the parent provided verbal consent to record the Zoom meeting, the parent and child were invited to introduce themselves. Children were asked how old they were and whether they had previous experience with any video conferencing platform (e.g., Zoom, Facetime, Google Hangouts). As it was difficult to see children's gestures on Zoom, parents were asked to explain what their child pointed at if any pointing occurred. Each child watched a series of videos and then participated in a short interview (Interview 1) in which they answered three questions about the toy. Next, they watched another set of videos, had a conversation with their parent, and finally answered another three questions about the toy (Interview 2). In the original study design children would have interacted with the robotic toy in the research lab. Due to COVID-19 the study was moved onto Zoom, which resulted in children watching videos of a robotic toy interacting with a female actor.

Video Set 1

At the beginning of the study, the researcher showed the dyad a picture of the set-up and a picture of the toy (Figure 3) to orient them to objects they were about to see in the videos. While the picture of the set-up was shown, the researcher asked the child to point to each of the objects on the table (e.g., the toy circled in blue, the three blooks, the yellow tray, the red tray, the yellow 'x' marking, and the red 'x' marking). The researcher said, *"[Child's name], there are three blocks on the table. Do you see the three blocks, what color are those blocks?"* and prompted the child to label the color of each of the three blocks. The researcher continued, "*There are two trays, a yellow tray, and a red tray. Do you see the trays? Point to the yellow tray and point to the red tray."* After the child provided confirmation, the researcher drew their attention to the markings on the table by prompting the child to point to each marking, "*There is a yellow x and a red x on the table. Can you point to the x's?"* and then *"The toy is circled in blue. Do you see the toy?"* Finally, the researcher showed the child a picture of the toy and said, *"Let me show you another picture of the toy. This is the toy."* The researcher proceeded by saying, *"Great! we are ready to see the toy (in the video)."*

Figure 3

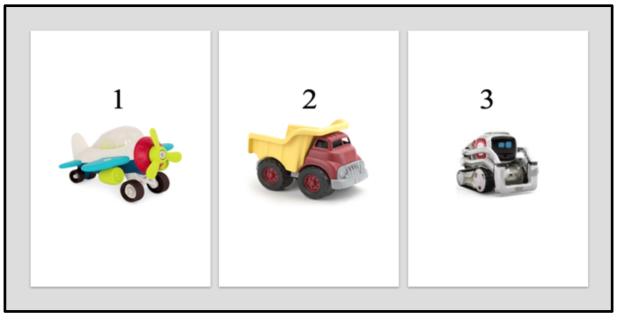
The Photo of the Set-up and a Close-Up Photo of the Toy



Before playing each video, the researcher gave a quick overview of the video to help orient the children, especially those on the younger age spectrum. For example, before the first video started, the researcher said to the child, "*In this video,* *the girl will ask the toy to move to the yellow x*." After the first video, the researcher did a manipulation check to ensure the child had paid attention to the video. The researcher showed the dyad a picture of three different toys (Figure 4) and asked the child to point to the toy they saw in the video. If the child identified the correct toy, the researcher showed the second video. If the child answered incorrectly, the researcher replayed the video and asked the child to identify the toy again. Ninety-nine percent of children correctly completed the manipulation check by identifying the toy correctly on the first attempt. The remaining 1% answered the manipulation question correctly on the second attempt. Once the child had identified the toy correctly, the researcher played the second video. This manipulation check occurred only after the first video.

Figure 4

The Visual Shown to the Dyad to Conduct the Manipulation Check



Each dyad was shown four videos of the toy interacting with a female actor (hereafter "actor"). In each video, the actor gave a direction to the toy. The toy responded with various levels of responsiveness depending upon the assigned condition. See Table 1 for the directions and the toy's responses. The number of words spoken by the actor and the length of each video was similar across conditions. Each video ended with the actor asking, "*What did the toy do*?" Parents were instructed to repeat each question to the child if the child did not respond promptly but otherwise let the child answer the questions on their own.

Table 1

Description of the Directions Given to the Toy and the Toy's Responses by Condition

Video #	Direction	Toy Response: Contingent Condition	Toy Response: Non-Contingent Condition (almost successful behavior)	Toy Response: Non-Contingent Condition (random behavior)
1	*"Come over here to the yellow x."*	Moves to the yellow x	Moves to the red x	Picks up then sets down a block
2	*"Pick up this middle block, please."*	Picks up the correct block	Picks up the wrong block	Moves to a random location
3	*"Put the block on this one."*	Stacks the block on the correct block	Stacks the block on the wrong block	Moves in a circle
4	*"Bring all the blocks here in the yellow tray."*	Places blocks in the yellow tray	Places blocks in the red tray	Picks up a block, stacks it on top of another block.

Contingent Condition. In the Contingent condition, each video began with the actor saying, "*Let's see what happens!"* Next, the actor gave the direction to the toy and pointed at the desired location or object for 2 (s). The toy executed the directions precisely without any deviation and then stopped. For example, in the first video, the actor asked the toy to "*Come over here to the yellow x"* while pointing to the yellow x. The toy responded by moving to the yellow x. When the toy completed its movement, the actor turned to the camera and asked the child, "*What did the toy do*?" with a smile.

Non-Contingent Condition. Half of the dyads in the Non-Contingent condition saw behavior that was almost successful, with the robotic toy displaying only a slight deviation from the given direction. For this version, the videos were almost identical to the videos in the Contingent condition, except for slight but perceivable inconsistency with the directions. For example, in the first video, after the actor asked the toy to "*Come over here to the yellow x,"* the toy would move to the red x instead.

The other half of the dyads in the Non-Contingent condition saw the toy display a more pronounced deviation from the provided direction (random behavior). For example, in the first video, when the actor directed the toy to "*Come over here to the yellow x,"* the toy picked up a purple block and set the block back down again. Another modification was made to further reduce the contingency: A 4-s delay in the toy's response prompted a further prompt by the actor, *"I wonder what happened,"* during which the toy started to move. Thus, for each direction given by the actor, the toy exhibited a sporadic, unrelated behavior with an easily detectable lag. Each time after the toy stopped moving, the actor turned to look at the camera, smiled slightly, and asked the child, "*What did the toy do*?"

Child Interview 1

The first part of the child interview consisted of three main questions: (1) *When the toy moves, does it move on its own?* (2) *Does the toy have feelings like happy or sad?* and (3) *Does the toy think on its own?* These interview questions were selected based on previous research that asked children about animate qualities, including autonomous movement, having feelings, and being able to think (Beran et al., 2011; Brink et al., 2019; Hatano et al., 1993; Tao, 2016; Venville, 2004; Zoga & Papmichael, 2000). For example, Brink et al. (2019) asked children about whether the robot chooses to move, whether it feels scared, and whether it thinks for itself. In the present study, the researcher prompted the child to justify their answer by asking a *"How do you know"* question (i.e., "*How do you know the toy is moving/ not moving by itself,* or *How do you know the toy has/does not have feelings,* or *How do you know the toy can/cannot think"*), to gain more insights into their thinking about the toy. Parents were encouraged to repeat the questions but were instructed to let their child answer the questions independently. If the child refused to respond, the researcher elicited the parent's help. The same process was repeated for all the interview questions.

Video Set 2

Next, the dyads saw another set of videos, which were identical across conditions. In the first video, the toy picked up the purple block and attempted but failed to place the block in a tall green container. Children were asked, *"What is it trying to do?"* and "*If you and your mom/dad were in the room with the toy, what* *would you do?"* In the second video, the toy picked up the purple block and stacked it on the green block. Then, the toy picked up the blue block and attempted but failed to stack the blue block on top of the purple one. Again, children were asked, *"What is it trying to do?"* and "*If you and your mom/dad were in the room with the toy, what would you do?"* The data from this part of the study was not analyzed for the dissertation.

Parent-Child Conversation

Once the dyad completed their discussion about the previous video, they discussed what they had seen so far for about 3 minutes. The conversation phase was structured to include two segments. In the first segment, the dyad was instructed, "*Talk about the toy together*." In the second segment, the researcher showed the dyad video # 2 and prompted the dyad to "*Talk about what the toy did when the girl asked it to do something*."

Child Interview 2

After the parent-child conversation, the second part of the child interview was administered. Children were asked three questions: (1) *What makes the toy go?* (2) *Does the toy hear what the girl in the video says?* and (3) *What kind of toy is this?* The first interview question (*"What makes the toy go?")* was a follow-up to a question asked in Child Interview 1 ("*Does the toy move on its own?*"). Although these questions were not identical, they focused on the same concept (i.e., the toy's ability to move). The second interview question (*"Does the toy hear what the girl in the video says?")* examined the toy's ability to communicate with others. Because the toy used in the present study did not speak or make sounds in any of the videos, the question focused on whether the toy could hear. Finally, the third question ("*What kind of toy is this?")* asked children to label or categorize the toy to gain insight into children's categorical understanding about the toy. As with the questions in Interview 1, all the Interview 2 questions are variations of questions used in prior research (Fouquet et al., 2017; Hatano et al., 1993; Tao, 2016; Venville, 2004; Zogza & Papamichael, 2000). For each interview question, the child was prompted to justify their answer after the researcher asked the *"How do you know"* question (i.e., "*Does the toy listen to the girl? Does the toy follow directions?* or *Have you seen toys like this before?"*). Parents were encouraged to repeat the questions but were instructed to let their child answer the questions independently. If the child refused to respond, the researcher elicited the parent's help. The same process was repeated for all the interview questions.

Materials

The materials (Figures 5 and 6) included a table (W 48 in x H 22 in), including a small robotic toy (L 4.25 x W 2.5 x H 2.5), three blocks (L 1.75 x W 1.75 x H 1.75), two trays (L 8.0 x W 4.0 x H 1.0), and a container (L 3.5 x W 3.5). In the following section, the positions of the materials are described from the dyad's point of view. In Video Set 1, the purple block was 17.5 inches from the front of the table, the green block was 12.25 inches from the front of the table, and the blue block was 21 inches from the front of the table. The yellow tray and the red tray were identical in size and located on opposite sides of the table (L 8.0 in x W 4.0 in x H 1.0 IN). The yellow tray was on the left side of the table near the seated actor, and the red tray was on the right side of the table. Both the red and the yellow tray were 3 inches from the front of the table. There was a yellow x on the left side of the table and a red x on the right side of the table. The x's were 10.5 inches apart, were made of colored tape, and were approximately 7 inches from the front of the table.

Figure 5

Materials Used in the Study

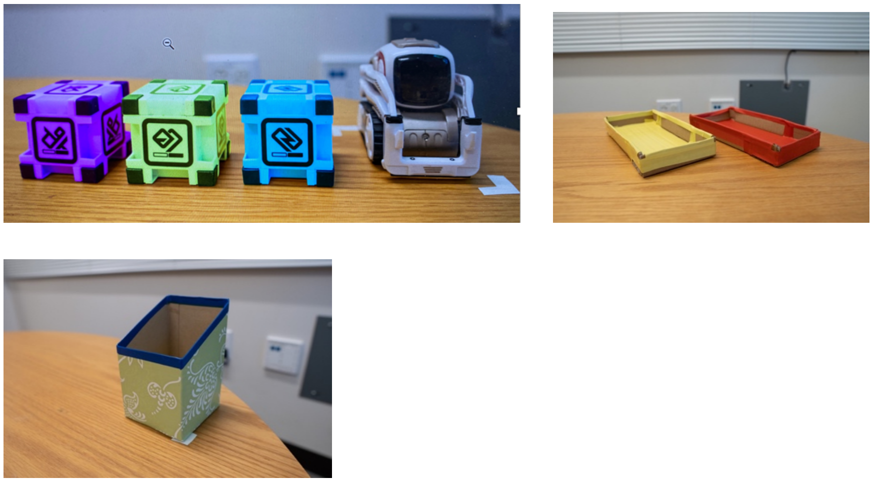


Figure 6

Aerial View of the Stimuli in Video Set 1 and 2

Results

Coding

A coding scheme was developed to code children's justifications to the interview questions in Child Interviews 1 and 2. A similar coding scheme was used to code the conversation topics that came up during the parent-child conversation.

Child Interviews

The coding scheme for children's justifications in the interviews initially included five codes (external, mentalistic, like me, contingency, and no answer), which were based on previous research (Fouquet et al., 2017; Hatano et al., 1993; Ochiai, 1989; Tao, 2016; Venville, 2004; Zogza & Papamichael, 2000). For example, Foquet et al. (2017) used a code called perceptual properties (e.g., visual, movement, perception), and we renamed this code in our coding scheme to be external to differentiate between external features (e.g., ears, eyes) and perceptual capacities (e.g., the ability to hear or see). Iterations of reviewing the present data set motivated the addition of three additional codes (mechanistic, human-machine relation, and categorical). The new ‘mechanistic’ code enabled us to distinguish between external features (e.g., eyes, face) and mechanistic features (e.g., wheels, batteries). The ‘human-machine relation’ code allowed us to examine the interaction between the robotic toy and the actor, while the ‘categorical’ code enabled us to look at the labels or pronouns children used to refer to the toy. Table 2 lists the definitions and examples of the eight codes.

Table 2

Coding Scheme for Child Interviews

Code	Code Definition	Example
External	Features (e.g., eyes) and actions (e.g., stacking blocks), something visible the child observed in the video	I saw it in the videos. It was moving by itself.
Mechanistic	Mechanical features (e.g., batteries, wheels) includes programmed	Because it has batteries.
Human-machine Relation	Interplay between the robot and the girl, possible or future interaction between the robot and the participants	A person is telling it where to go.
Contingency	Includes instruction following, does the toy listen, does the toy do what it is asked	When the lady tells it to do something, it does the opposite.
Categorical	Driven by how the child labels or categorizes the robot	Because it's a toy.
Mentalistic	Think, feel, know, decide, feel, includes agency	I think he was feeling mad that he had to pick up heavy blocks.
Like Me	Associate the robot with an internal human-like quality (e.g., heart, brain), compares the robot to humans	Yea, it's thinking with a brain.
No Answer	Restating the question without elaborating, explaining, or providing justification	He is a toy. Toys do not think.

A primary coder coded children's justifications for both Child Interviews 1 and 2. A secondary coder coded 24 out of the 96 dyads, 25% of the sample. Agreement between the primary and secondary coders ranged from 75% to 96% across categories. Inter-rater reliability using Cohen's *k* was moderate to excellent and ranged from .43 to .83 (Landis & Koch, 1977). Reliability disagreements between the primary and secondary coder were resolved through discussions.

Parent-Child Conversation

For each conversation, we identified the first two topics dyads discussed as we wanted to understand what the dyad elected to talk about first. A conversation topic was identified when the dyad changed what they were talking about and switched the topic of their discussion. The coding scheme for the parent-child conversation was similar to the coding scheme used for the child interviews except for the following: (1) the 'no answer' code never occurred during the parent-child conversation and hence was removed, and (2) the 'other' code was added to account for conversation themes that were not covered by the existing codes. Table 3 provides definitions and examples of the Parent-child conversation coding scheme. A primary coder coded each dyad's first and second conversation topics; a secondary coder coded 25% (24 out of the 96 dyads) of the data. The primary and secondary coder were in agreement 92% of the time (44 out of 48 conversation topics), with Cohen's *k* at .62.

Table 3

Coding Scheme for the Parent-Child Conversation

Code	Code Definition	Example
External	Features and actions, something visible the child observed in the video	*Paren*t: What did the robot do? *Child*: It just stacked one block. *Paren*t: And then it started to stack. How many blocks do you think it can- how tall do you think it could build? *Child*: I think he could only build two.
Mechanistic	Mechanical features (batteries, wheels), includes programmed	*Parent:* Um, what else did you think about the toy? How do you think it worked? *Child:* I think it worked because it has, um cuz it has batteries. *Parent:* Yeah, we have lots of toys that have batteries, but they don't do that.
Human-machine Relation	Interplay between the robot and the girl, Possible or future Interaction between the robot and the participants	*Parent:* What would you have it do? *Child:* Help make my bed. *Parent:* You'd have it help make your bed? What else would you have it do? *Child:* Help clean up. *Parent:* Help clean up? Do you think you could train it to do anything? *Child:* Yes. I'll train it how to clean up.
Contingency	Includes instruction following, does the toy listen, does the toy do what is asked	*Parent:* Hey, what did the toy do when she asked it to pick something up? *Child:* Um... it... it listened to her? *Parent:* The toy listens to her? *Child*: Uh-huh! *Parent:* And did it follow her instructions? *Child:* Uh-huh!
Categorical	Driven by how the child labels or categorizes the Robot	*Parent:* Cool, what do you think the toy looks like? *Child:* A robot. *Parent:* Yeah, it's a robot and a truck together, right? *Child:* Yeah.
Mentalistic	Think, feel, know, decide, includes agency	*Child:* Well, guess what I would do? *Parent:* What? What would you do? *Child:* I am interested in seeing if it actually has feelings. *Parent:* You're interested in seeing if it has feelings? *Child:* Yeah. If I got it, I'd be like--oh! What if I see if it has feelings like actual feelings so you would see it if seems mad or sad *Parent:* Uh-huh. *Child:* Like if I say something like I'm going to get rid of the toy. Then it would I see if it--I would check on it to see if it was sad.
Like Me	Associate the robot with an internal human-like quality (e.g., heart, brain), compares the robot to humans	*Child:* it's my turn to ask you a question. *Parent:* Okay. *Child:* do you think it's a boy or a girl. *Parent:* I think it could be either *Child:* I think it's a girl
Other	Linking to other devices or toys the child has seen or possessed	*Parent:* You were telling me - we did have a robot, but it broke. It was our Roomba, and it would clean by itself, but we had to take it back to the store. *Child:* Uh-huh, it broke. *Parent:* It was broken. *Child:* But why didn't umm it clean? *Parent*: It stopped -Why do you think it stopped working? *Child:* It had run out of batteries.

The present research sought to address two main research questions: (1) How do children conceptualize an ambiguous robotic toy and (2) how parents help their children make meaning out of their interactions with robots. In the following sections I will present the results that address these two research questions. Preliminary analysis revealed no significant differences between the two subgroups of the Non-Contingent condition (almost successful and random behavior). Therefore, the subsequent analyses were performed without distinguishing these two subgroups.

Children's Conceptualization

Movement. First, we examined children's thoughts about autonomous movement of the toy. Both Interview 1 and Interview 2 tapped this aspect of the toy, albeit in slightly different ways. Upon being asked "*Does the toy move on its own?*" in Interview 1, the majority of children responded "Yes" ($n = 90$, 94%; see Figure 7). When asked "*What makes the toy go?*" in Interview 2, 70 children (73%) across conditions stated they thought the toy could move because of some type of mechanistic quality (e.g., batteries, wheels, energy; see Figure 8). Specifically, 41 children (43%) said batteries make the toy go, and 15 children (16%) responded wheels. Chi-square tests of independence revealed no associations by "Yes" or "No" responses and condition or age[1], all yielded $X^2 < 1.13$ and ps > .29. Coded justifications also yielded no associations by condition or age, all $X^2 < 3.73$ and ps > .27.

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[1] A cut-off at 63 months, 0 days was selected because it was the median split.

Figure 7

Children's Responses to Question 1 of Interview 1

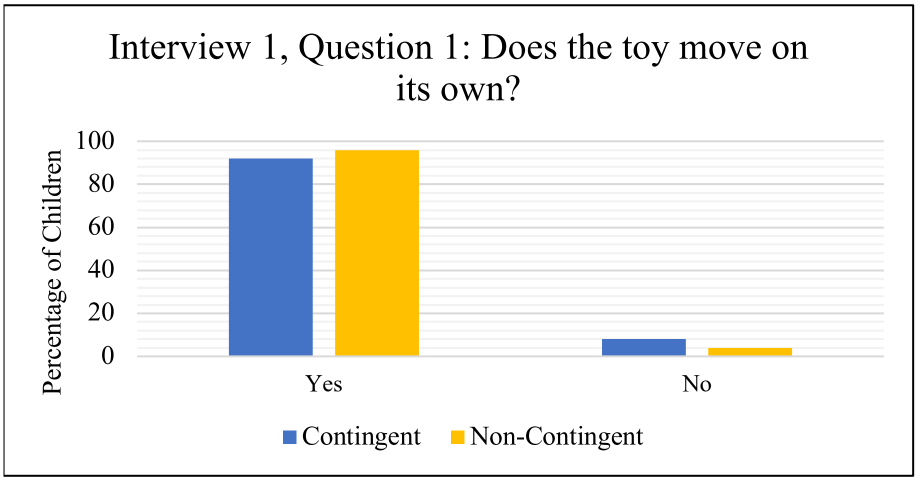
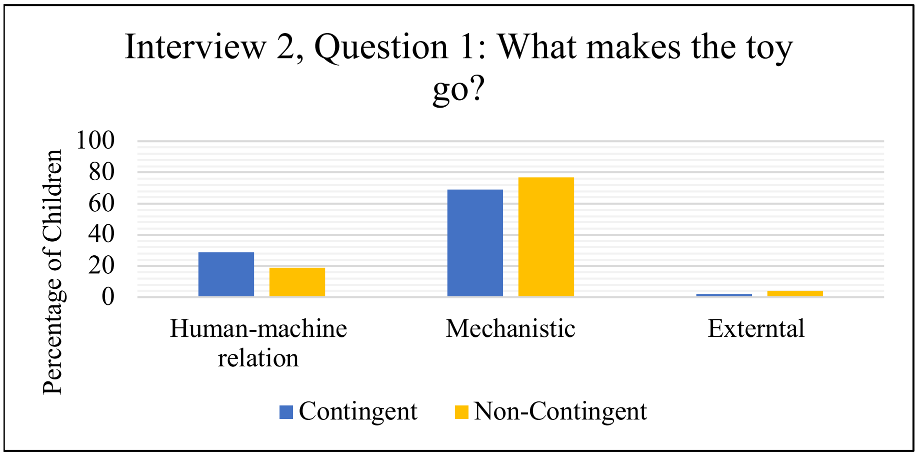


Figure 8

Children's Responses to Question 1 of Interview 2

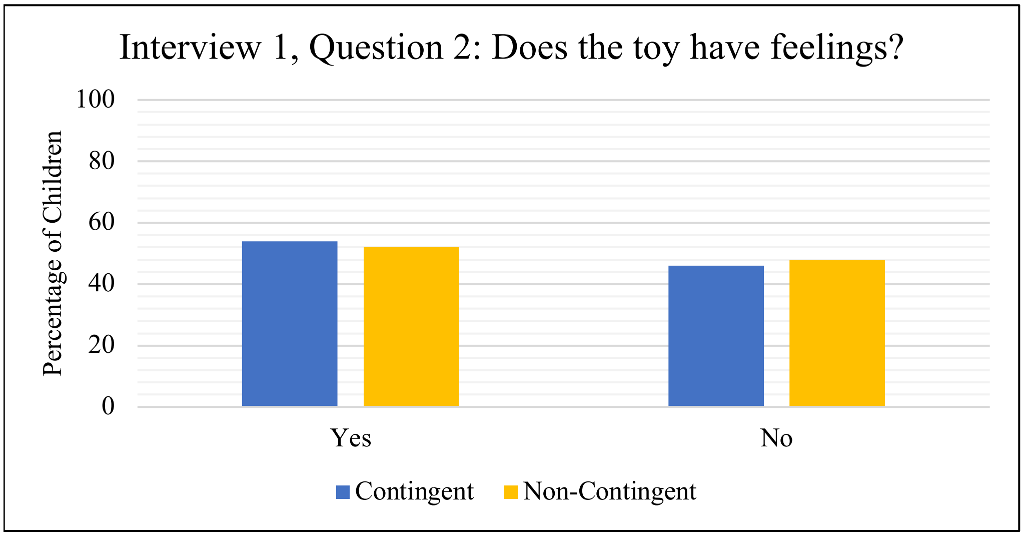


Additionally, children's responses to Interview 1 Question 1 ("*Does the toy move on its own?")* and Interview 2 Question 1 ("*What makes the toy go?"*) were compared to see if children changed their answer or kept their answer the same. Although these questions were not identical, they got at the same concept (i.e., what allows the toy to move). The result indicated that 69 participants (72%) changed their answers. A chi-square test of independence showed no association between condition and the likelihood children would change their response, X^2 (5, N = 96) = 0.00, p = 1.00. Therefore, children, regardless of assigned condition, changed their answers at the same rate.

Mental states. The next area covered by the interview questions examined mental states including emotion and cognition. When asked whether the toy had feelings (Interview 1, Question 2), children were evenly split (Figure 9). Of the 51 children who attributed feelings to the toy, 31 (61%) cited external features (e.g., "It had a face."). In contrast, the 45 children who said the toy did not have feelings tended to provide categorical justifications (n = 21, 47%) (e.g., "It is a toy and toys do not have feelings.").

Figure 9

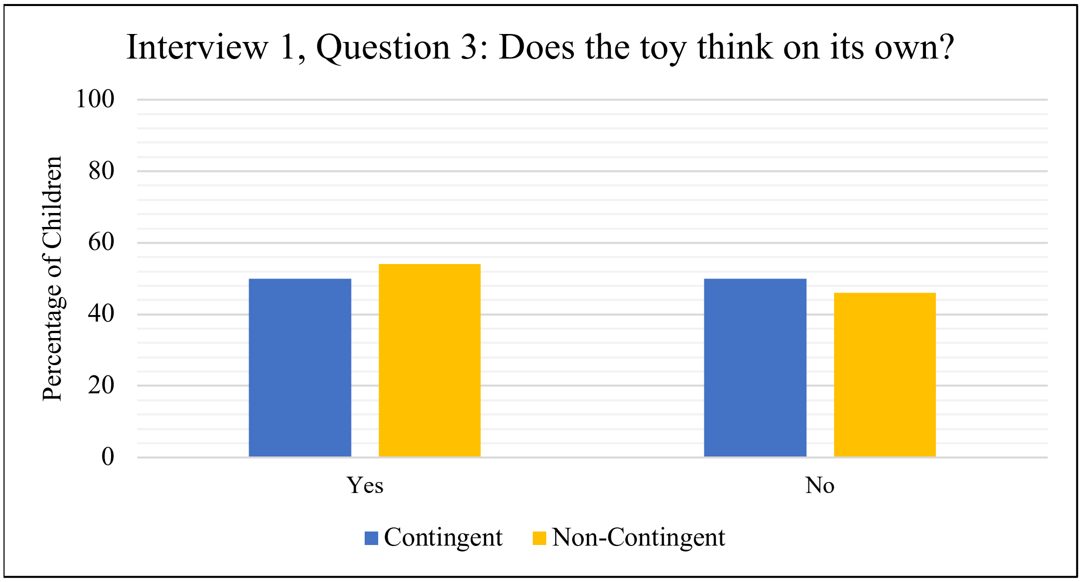
Children's Responses to Question 2 of Interview 1



In Interview 1, we also asked children whether the toy could think on its own (Question 3). Children's responses were evenly split (see Figure 10). Most of the 50 children who said "Yes" justified their response with either contingency (*n* = 16, 32%) (e.g., "The toy did what it was told to.") or external (*n* = 15, 30%) ("It moved by itself.") reasoning. Of the 46 children who responded "No" most supported their response with a like me code (*n* = 11, 24%) (e.g., It does not have a brain."). Chi-square tests revealed no associations of responses ("Yes" or "No") or coded justifications by either age or condition, all $X^2 < 7.57$ and *p*s > .23.

Figure 10

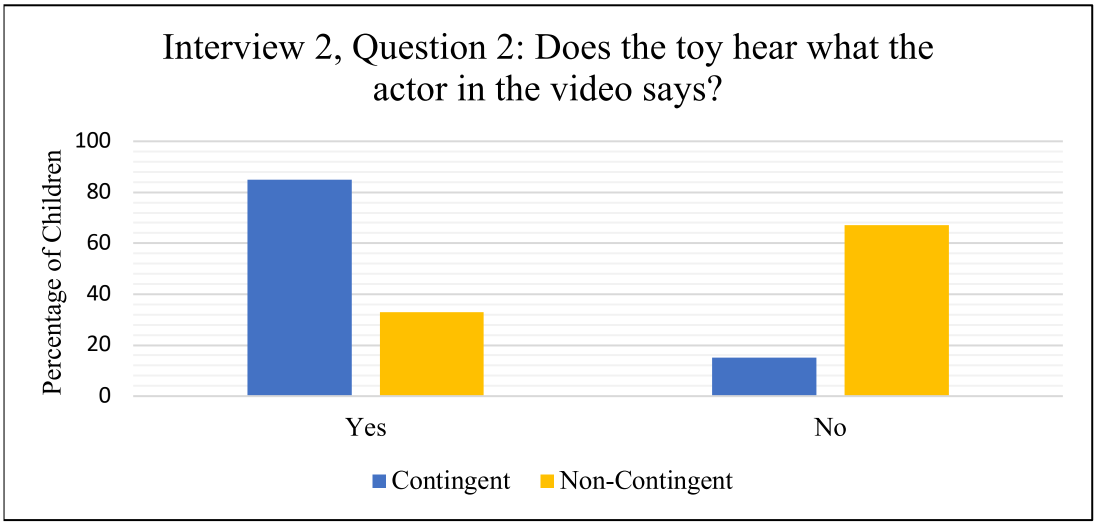
Children's Responses to Question 3 of Interview 1



Communication. During the second interview, children responded to a question about the communicative ability of the toy, (Question 2: *"Does the toy hear what the girl says?"*). Most of the children ($n = 58$, 60%) said the toy could hear (Figure 11). A chi-square test of Question 2 indicated that children's responses differed by condition, X^2 (1, $N = 96$) = 26.91, $p < .001$, 95% CI [.33, .66] and by age, X^2 (1, $N = 96$) = 5.59, $p = .018$, 95% CI [.04, .41]. When comparing children's "Yes" and "No" responses, more children in the Contingent condition thought the toy could hear. Additionally, older children were more likely to attribute hearing to the toy than younger children.

Figure 11

Children's Responses to Question 2 of Interview 2

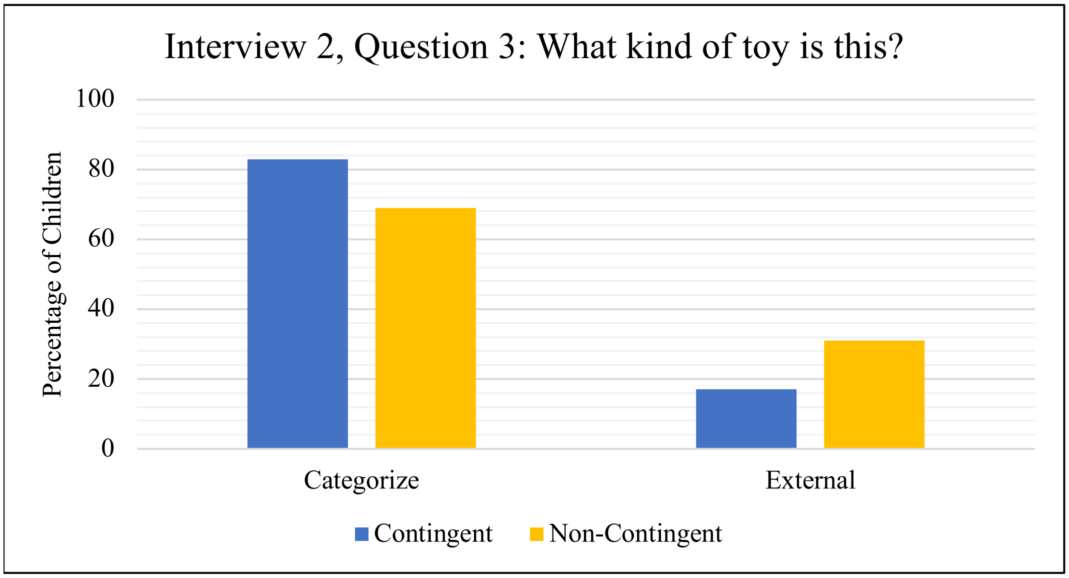


Of the 58 children who attributed hearing to the toy, 34 children (59%) (Contingent condition = 24, Non-Contingent condition = 9), justified their response by referring to the contingent behavior of the toy (e.g., "The toy did what the girl said."). A total of 18 out of the 38 children who said the toy could not hear supported their response by referring to an external feature of the toy (e.g., "The toy did not have any ears.") and 16 out of the 38 children justified the toy could not hear by pointing out the toy failed to follow the directions of the actor (*n* = 16: Contingent condition = 1, Non-Contingent condition = 15, 41%).

Categorization. Finally, children were asked to categorize the robotic toy in Interview 2, Question 3 (*"What kind of toy is this?").* A majority of children labelled the toy as a 'Robot" (*n* = 65, 68%) and the remainder of the children described the toy's external features (e.g., "It was small and white."; see Figure 12).

Figure 12

Children's Responses to Question 3 of Interview 2



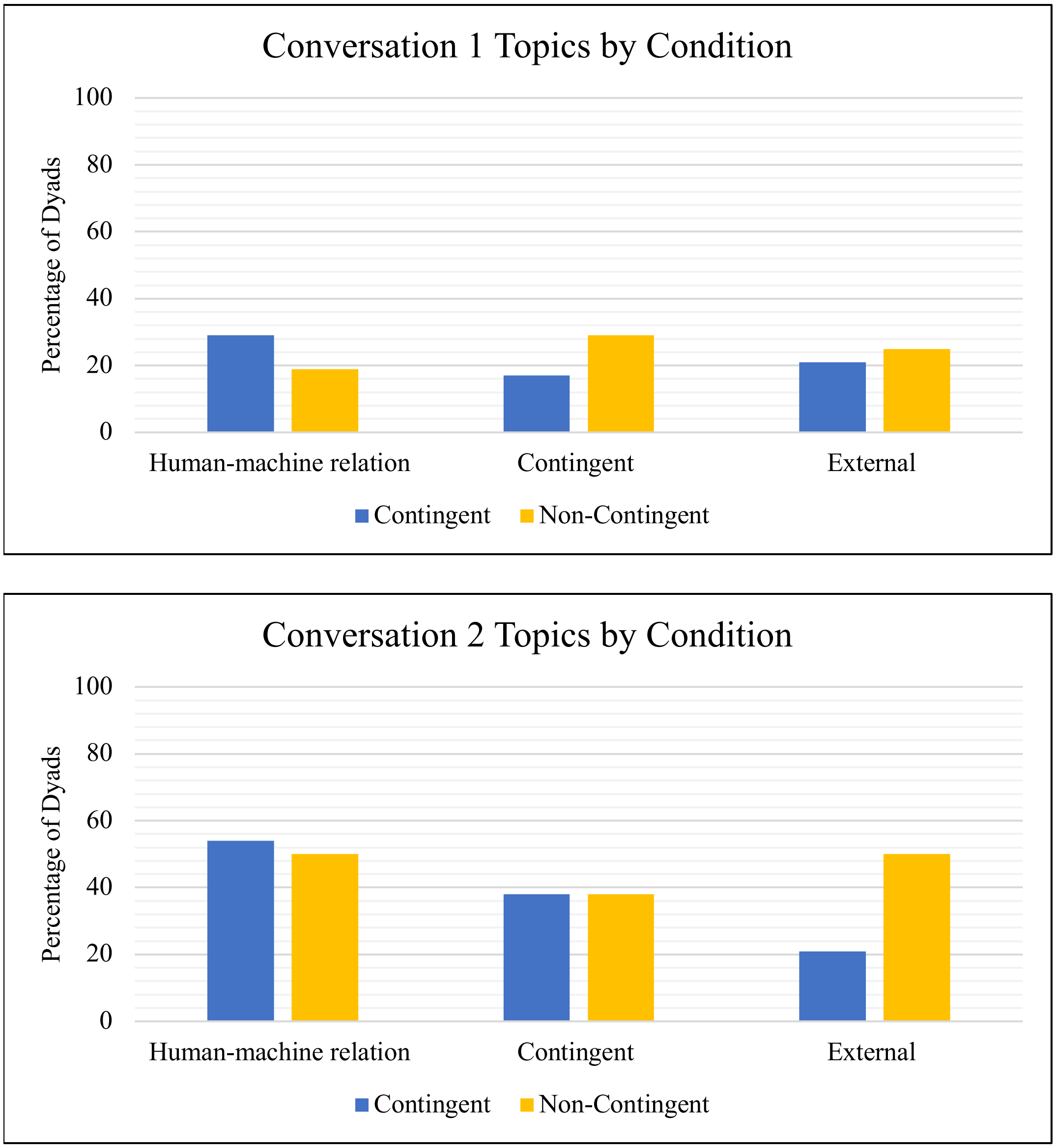
Parent-child conversation

To better understand how parents help their young children make meaning out of the robotic toy, we examined what dyads discussed during the conversation which lasted between three to four minutes. All dyads talked about at least two topics and no dyads discussed more than six conversation topics. In the section below, we examined the first two topics the dyads brought up. We first looked at who (the parent or the child) initiated the conversation topic and found that parents initiated most of the conversation topics: 90% of the time for the first topic and 89% for the second topic. Next, we compared conversation topics by condition (Contingent or Non-Contingent), age (Younger or Older), child gender (male or female), and parent occupation (STEM or Non-STEM). Chi-square tests of independence yielded no significant effects, all $X^{2 <}$ 9.09, all *p*s > .26.

Regardless of the assigned condition, the dyads tended to discuss similar topics. For Topic 1, they discussed three topics equally: human-machine relation (24%: *n* = 23 dyads; Contingent = 14, Non-Contingent = 9), contingent (23%: *n* = 22 dyads; Contingent = 8, Non-Contingent = 14), and external (23%: *n* = 22 dyads; Contingent = 10, Non-Contingent = 12). For Topic 2, the dyads tended to discuss human-machine Relation (26%: *n* = 25 dyads; Contingent = 13, Non-Contingent = 12) more often than external (19%: *n* = 18 dyads; Contingent = 9, Non-Contingent = 9) and contingent (18%: *n* = 17 dyads; Contingent = 5, Non-Contingent = 12), although these three topics remained the most discussed. Figure 13 shows the percentage of dyads who discussed these three most frequent conversation topics.

Figure 13

The Most Frequent Topics Dyads Discussed Coded by Assigned Condition



We next looked for any connections between the parent-child conversation and children's responses in the second interview. One possibility is that parents provided scaffolding during the parent-child conversation to help children conceptualize and make meaning out of the robotic toy. As a reminder, temporally the parent-child conversation happened prior to Interview 2. As we did not ask the same questions in Interview 1 and Interview 2, we cannot infer that children's responses to Interview 2 were caused by the parent-child conversation.

Recall that during Interview 1, children were asked whether the toy moves on its own (Question 1). During the conversation, 55 dyads (58%) discussed what made the toy move during the parent-child conversation. Regardless of the assigned condition, children overwhelmingly responded "Yes" when asked whether the toy could move on its own (*n* =90, 94%). Of the children who responded "Yes" to Question 1 *("Does the toy move on its own?"),* 14 (16%) justified their response by saying batteries allowed the toy to move on its own. During the conversation, 21 dyads (22%) brought up the idea that the toy had batteries. See an excerpt below from a 5-year-old girl.

> *Parent (02:00): Hey, do you think when it ran out of energy, is there another way? Is there another thing that happens with toys? Maybe toys that don't plug in? What makes them…*
>
> *Child (02:20): Charge?*
>
> *Parent (02:21): Toys that don't charge though toys that we can't plug in? Sometimes we have to change the... batteries! That happens all the time. Do you think that toy had batteries, or do you think it was alive?*
>
> *Child (02:27): Batteries! I think it had batteries.*

Recall that during Interview 2, 41 children (43%) responded batteries when asked what makes the toy go. Batteries were discussed during the parent-child conversation by 21 dyads (22%). Of these 21 dyads who brought up batteries, 14 children answered batteries when asked what makes the toy go (Child Interview 2).

After the parent-child conversation, the number of children who said batteries were responsible for the toy's movement increased from 14 to 41.

During the second interview, when asked whether the toy could hear what the actor in the video was saying (Question 2), 58 children (60%) responded "Yes," and 38 children (40%) responded "No." See an excerpt below from a conversation between a 5-year-old boy and their parent where the dyad discussed the toy's ability to hear.

> *Child (00:31): Maybe it needs something to make it hear, so it knows where to go.*
>
> *Parent (00:38): You think they need to make it something to hear, so it knows where to go?*
>
> *Child (00:42): Yeah.*
>
> *Parent (00:45): Yeah, I think so, makes sense to me.*
>
> *Child (00:47): The reason why it wasn't going to where it wants it to is probably because it didn't hear what the girl said.*

Since we asked about whether the toy could hear only in Interview 2, we do not know how children would have judged the toy's ability to hear in Interview 1 prior to the parent-child conversation. We speculate that since the robot in the present study did not speak or make sounds, children may have relied on the toy's contingent behavior (e.g., following or not following the verbal directions of the actor) to determine whether the toy could hear. During Interview 2 a third of the children (34%: *n* = 33; Contingent = 24, Non-Contingent = 9) justified whether the toy could or could not hear by referencing the contingent behavior of the toy.

It is worth noting that dyads spontaneously brought up the topic of the toy's contingency during conversation even though the initial prompt ("*Talk about the toy* *together."*) did not specifically ask them to do so. More dyads in the Non-Contingent condition (n =22) discussed the contingency of the toy's behavior without being prompted to do so than dyads in the Contingent condition (n =10), X^2 (1, N = 96) = 6.75, p = .009. Even though more Non-Contingent dyads brought up contingency during the parent-child conversation, children in the Contingent condition were more likely to support their answer to Question 2 (*"Does the toy hear?"*) with contingency, X^2 (1, N = 96) = 4.43, p = .019.

Discussion

Previous research has shown that children's understanding of living and non-living things develops gradually over time (Carey, 1985, Richards, 1989; Venville, 2004). As shown, children can differentiate between living and non-living things, especially when the objects in question are more clearly classifiable (e.g., a dog is living, and a ball is non-living) (Carey, 1985; Jipson & Gelman, 2007; Richards, 1989; Venville, 2004). Importantly, children may know something is non-living yet still attribute other animate qualities (e.g., feeling, thinking) to it. The present study examined children's conceptualization of a novel robotic toy and explored the role of parent-child conversation in the process.

Children's Conceptualization

To achieve the first objective—to examine how children conceptualize a novel and ambiguous robotic toy, the present study used interview questions to assess children's conceptualizations of the toy and its animate qualities (e.g., autonomous movement, having feelings, thinking, hearing). We examined if the robotic toy's contingent behavior impacted how children responded to the interview questions and justified their responses. Overall, children in the Contingent and the Non-Contingent conditions appeared to conceptualize the robotic toy in a similar way, apart from one question during Child Interview 2 ("*Does the toy hear?*"). Examining the interview questions, a majority of the children in the present study thought the toy could move autonomously. Children were evenly split regarding whether the robotic toy had feelings or could think on its own. Additionally, children overwhelmingly labelled the toy as a robot. However, children in the Contingent condition and older children were more likely to say the toy could hear what the actor was saying.

Children's conceptualization of the toy in the present study aligns with the findings of Kahn et al. (2012), as children appeared to treat the toy as a unique entity. Children went beyond classifying the robot as something that is merely living or non-living. Instead, they seemed to attribute some animate qualities (e.g., autonomous movement, the ability to hear) but not others (e.g., feeling, thinking) to the toy.

In Interview 1, children, regardless of condition, overwhelmingly thought the toy could move on its own. This is consistent with the prior findings that even very young children including infants can attribute goals and goal-directed actions to non-human agents (e.g., a self-propelled box; see Luo & Baillargeon, 2005; Luo, 2011; Setoh et al., 2013). Additionally, previous research has shown that autonomous movement is often associated with animacy (Fouquet et al., 2017; Hatano et al., 1993; Tao, 2016; Venville, 2004) and children can readily differentiate between a robot that moves autonomously and a robot that does not (Arita et al., 2005; Chernyak & Gary, 2016; Sommander et al., 2011). Since children in both conditions saw the robotic toy move without assistance (e.g., without a person pushing or moving it; without a remote control), it is not surprising that children overwhelmingly thought the toy moved autonomously.

The absence of differences across the Contingent and Non-contingent conditions could stem from several factors. One possibility is children in both conditions interpreted the toy's behavior as being contingent. Perhaps children associated programming with the robot and assumed the robotic toy was programmed to behave a certain way. Thus, regardless of how the toy behaved children could have presumed that the robot was not showing agency and was merely behaving as it had been programmed to do.

Another possibility is that the non-contingent behavior the toy displayed still resembled contingent behavior in some ways. For example, the robotic toy in the present study exhibited non-contingent behavior by failing to follow the verbal directions of the actor. Children assigned to the Non-Contingent condition saw the toy move after a delay. Even though there was a time delay from when the actor issued the direction and when the toy began moving, there was still some level of contingency present. For example, the robot still moved after the actor gave verbal instructions.

A prior study demonstrated contingent behavior in a robot by having the robot follow commands (Martinez-Miranda et al., 2018). In this study, children interacted with an agreeable robot (e.g., the robot congratulated the child and followed the child's commands) or a disagreeable robot (e.g., the robot blamed the child and ignored the child’s commands). Although the present study and the Martinez-Miranda et al. (2018) study both used some form of direction following to convey contingency there were some differences. For example, the robot in the Martinez-Miranda et al. (2018) study spoke directly to the child, whereas the robot in the present study did not speak or make any sounds. It could be that direction-following alone does not suffice to convey the level of contingency in a robot and would need to be manipulated in conjunction with other animate qualities. Future work could explore this possibility by manipulating both the contingent behavior of the robot along with other animate qualities (e.g., eye contact, turn-taking, talking, sounds).

Although research on children’s thinking about robotic toys is emerging, more research is needed to understand what motivates children’s conceptualizations of robots. A variety of information (e.g., facial features, autonomous movement, contingent behavior) can guide children’s reasoning (Jipson & Gelman, 2007; Saylor et al., 2010). For example, as the robotic toy in the present study had eyes that moved. We anticipated children might attribute feelings to the toy because the toy had eyes. However, prior work has shown mixed results when examining whether young children attribute feelings to things that have other animate qualities (Beran et al., 2011; Chernyak & Gary, 2016; Hatano et al., 1993; Kahn, et al., 2012; Melson et al., 2005 Ochiai, 1989). Children in the present study, regardless of condition, were evenly split regarding whether the toy had feelings or not. Children who attributed feelings to the toy tended to justify their response by citing the external features of the toy (e.g., “The toy had a face.”). Whereas children who said the toy did not have feelings often provided categorical reasoning (e.g., “Toys do not have feelings.”). As children used different reasoning to justify their responses, it remains unclear why children did not come to a consensus on whether the toy had feelings. One possibility is that children were unsure, made a guess, and simply needed more information to make such a determination. Future research could manipulate whether the robot has a face. For example, researchers could have a no-face condition to see whether the lack of facial features impacts whether children attribute feelings to the robot. Additionally, the number of facial features (e.g., eyes, mouth, nose) the robotic toy displays could be varied.

Parent-Child Conversation

The parent-child conversation provided some insight into how parents can help their young children make meaning out of ambiguous things. Although the conversation topics did not differ by condition, children's age, children’s gender, or parent occupation, parents tended to follow up on the questions asked in the interviews. For example, after the child was asked if the toy moved on its own (Child Interview 1, Question 1), most parents discussed what made the toy move during the conversation. This discussion of the toy’s movement during the conversation may have influenced how children subsequently responded to the question, “*What makes the toy go*” (Child Interview 2, Question 1). Additionally, many of the most frequent justifications for children’s responses to the Child Interview 2 questions were discussed during the parent-child conversation. For example, batteries were the most common response children provided when asked what made the toy go during Child Interview 2, and batteries were discussed by almost a quarter of dyads during the parent-child conversation. Specifically, of the dyads who discussed batteries during the conversation, two-thirds of those children said the toy could move because it had batteries.

The parent-child conversation fortuitously touched on topics related to the questions that children would be asked in Interview 2. For example, most dyads discussed whether the robotic toy could hear, without knowing the child would be asked about the toy's ability to hear in the second interview . Similarly, when asked "*What kind of toy is this?"* (Interview 2, Question 3), most children said the toy was a "Robot," which aligned with what most dyads called the toy during their conversation. There were connections between what the dyads discussed during the parent-child conversation and the responses children gave during Interview 2, suggesting the conversation could have impacted how children responded to the second set of interview questions.

Without any specific prompting from the researcher (*"Talk about what the toy did."*), more dyads in the Non-Contingent condition discussed the contingency of the toy's behavior during the parent-child conversation than dyads in the Contingent condition. Parents assigned to the Non-Contingent condition likely noted the toy failed to follow directions and wanted to speculate with their child on why that might have been the case. In contrast, parents in the Contingent condition observed the toy follow directions and may have refrained from bringing this up during the conversation because the toy was doing what it was instructed to do. In our own lived experiences, we are more likely to talk about when a device fails to work rather than when a technological device is working as expected.

Additionally, children in the Contingent condition tended to support their answer to Question 2 (*"Does the toy hear?"*) by referencing the contingent behavior of the toy. Whereas children in the Non-Contingent condition were less likely to refer to the toy's contingency despite having discussed it with their parent during the conversation. Therefore, the conversation could have influenced children differently, at least in regard to the question about whether the toy could hear (Question 2).

Future Directions

An interesting design for future research would be to ask children the same set of questions in Interviews 1 and 2. This would make comparing children's responses before and after the parent-child conversation easier. There are several reasons why we elected not to adopt this procedure in the present study. First, as the study was done on Zoom, the length of the study was a concern. Much of the prior research (Ahmad et al., 2017; Beran et al., 2011; Chernyak & Gary, 2016; Kanda et al. 2004; Kennedy et al. 2017; Somanader et al. 2011) focused on older children who arguably have a longer attention span. Our study was designed to be short to keep children engaged throughout the duration of the study, while still collecting the data we needed to address our research questions. As a compromise, the present study used two similar questions that assessed the same overall topic, movement (Interview 1, Question 1: *"Does the toy move on its own?"* and Interview 2, Question 1: *"What* *makes the toy go?"*). Asking one question about movement in Interview 1 and the other in Interview 2 allowed us to compare children's responses to determine if they had changed their answers. Furthermore, we were able to examine the parent-child conversation to see if what dyads discussed could have influenced how children responded when asked about the toy's movement in Interview 2.

Second, we felt it was important to include questions that assessed different animate qualities (e.g., autonomously moving, feelings, thinking, hearing) as this was reflective of what prior research had done (Ahmad et al., 2017; Beck et al., 2012; Beran et al., 2011; Kahn et al., 2012; Kim et al., 2019). Additionally, using a different set of questions in Interview 1 and 2 allowed us to ask children about a broader range of topics, which provided children's overall impression of the robotic toy's animacy. Finally, as we were working with young children, a concern we had was that if we asked the same interview questions during Interviews 1 and 2, children would give the same responses without thinking about the question or reflecting on the parent-child conversation. As the parent-child conversation occurred after Interview 1 but prior to Interview 2 we elected to us a design that would give children the opportunity to consider what they had discussed with their parent. Future research could test this assumption by using the same questions in Interviews 1 and 2.

Examining what pronoun dyads use to refer to the robotic toy has been done in previous research. In prior work researchers referred to the robot in their studies as "It," called the robot "This one," or gave the robot a name (e.g., Sam) (Jipson & Gelman., 2007;Khan et al., 2012; Kim et al., 2019). For example, Jipson and Gelman

(2007) found that younger children were more likely to use gendered pronouns to refer to a robot than their older peers. In the present study, we elected to call the robot a “Toy.” Calling the robot a “Toy” inevitably constrained the way parents and children talked about the robotic toy together. Specifically, it likely influenced how dyads chose to refer to the toy. Unsurprisingly, a majority of dyads labelled the robot as “Toy” after hearing the researcher call it a “Toy.” For example, the researcher called it a “Toy” during the study when they asked the child to categorize the toy during the second interview (e.g., Interview 2, Question 3: “*What kind of toy is this?”)*. Future work could consider following prior research and using a gender-neutral name to refer to the toy. A gender-neutral name might allow parents and children to come to their own consensus without being influenced by what pronoun or label the research team used. Perhaps a gender-neutral name might encourage dyads to use a pronoun (e.g., He, She, It) to refer to the robotic toy.

Most previous research with younger children involved presenting events in which a robot interacts with someone else, usually an adult (Johnson et al., 1998; Meltzoff et al.,2010; Peca et al., 2016). In this design, the child is a mere observer to the interaction. The present research intended to examine the triadic interaction between the parent, child, and robot. Initially, the study was designed to be run in the research lab where dyads would observe an interaction between the robotic toy and the actor. After observing the interaction, dyads would have been able to interact with the robotic toy together. To ensure the safety of our participants and research team during COVID-19, the study was conducted on Zoom. Running the study on Zoom prevented the dyads from interacting directly with the robotic toy. However, in the present study, parent-child dyads were able to observe and discuss the toy together. In the future, in-person research should examine how children and their parents interact and engage directly with robots together. More research is needed to fully unpack how parents' guide their children through interactions with ambiguous agents, like robots.

Unsurprisingly, conducting the present study on Zoom presented many challenges. Using Zoom allowed dyads to participate from their own home. As a result, the research team had little control over the environment of our participants. Prior to the study parents were instructed to find a quiet place in their home where they and their child could participate. Additionally, parents were encouraged to put toys away to prevent distractions. Since children participated from their own homes they tended to know where the toys were kept, and some dyads were distracted by their environment. It was also challenging to gather non-verbal (e.g., pointing, body language, gestures) information on Zoom. Parents were asked and reminded to verbally describe what their child pointed at, but some non-verbal information and cues may not have been adequately captured on Zoom.

In conclusion, the present study builds upon existing work and attempts to further understand how children conceptualize novel and ambiguous things. Additionally, this exploratory work looks at the role parents can play in their child's conceptualization of an ambiguous robotic toy. Prior work along with the present study suggests that children may view technological devices, like robots, that have both animate and inanimate qualities as a unique entity from living or non-living things (Jipson et al., 2016; Kahn et al., 2012; Kim et al., 2019). Future work should explore what information children rely on when making judgements on ambiguous things and further examine how parents can play a role in their child's conceptualizations of something ambiguous.

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