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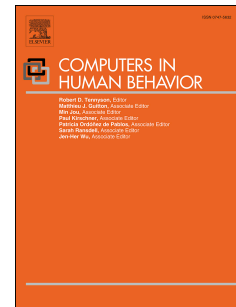
Preschoolers' and adults' animism tendencies toward a humanoid robot

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Preschoolers' and adults' animism tendencies toward a humanoid robot

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Abstract

This study examined whether three- and five-year-old children and adults changed their perceptions of a robot after a naturalistic interaction with it. We examined whether participants exhibited animism errors (i.e., attributing biological properties to a target in addition to psychological, perceptual, and name properties) or agentic animism (i.e., attributing psychological, perceptual, name, and artifact properties to a target while not attributing biological properties) before and after they interacted with the robot. Results indicated that the three-year-olds made animism errors: they were more likely than older participants to attribute biological properties to the robot, although this tendency decreased after the interaction. The five-year-olds and adults did not attribute biological properties to the robot before or after the interaction, suggesting that they did not make animism errors. Additionally, the five-year-olds attributed more perceptual properties to the robot after the interaction and the adults showed a similar, yet modest tendency. Thus, older participants tended to exhibit agentic animism. Through a discussion of the differences between young children's and older participants' animism, we found that it is necessary to further study this topic to create robots that are better suited to people's needs.

Keywords: animism; human-robot interaction; mentalizing

1. Introduction

Piaget (1929) originally noted that children demonstrate animistic thinking, which means that they are likely to think that nonliving things, such as clouds, clocks, and candle flames, are conscious and alive. Given Piaget's contention, many developmental psychologists have investigated whether children can distinguish living from nonliving, alive from not alive, animate from inanimate, and/or biological from non-biological things (Backscheider, et al., 1993; Bullock, 1985; Carey, 1985; Dolgin & Behrend, 1984; Gelman, et al., 1983; Hatano, et al., 1993; Laurendeau & Pinard, 1962; Massey & Gelman, 1988; Springer & Keil, 1991). Some results have supported Piaget's original view; however, most studies have not (see more reviews in Opfer & Gelman, 2011). Recent studies have concluded that children as young as three or four years of age have some knowledge of living-nonliving or animal-object distinctions and five-year-olds are able to differentiate between these clearly with respect to biological properties, such as eating, growing, dying, reproducing, transforming, and moving (Backscheider, et al., 1993; Bulloch & Opfer, 2009; Gelman, et al., 1983; Inagaki & Hatano, 1996; Jipson & Gelman, 2007; Jipson, et al., 2016; Massey & Gelman, 1988; Springer & Keil, 1991).

Previous studies have indicated that animism decreases with age (Bullock, 1985; Carey, 1985; Inagaki & Sugiyama, 1988; Jipson & Gelman, 2007; Jipson, et al., 2016;

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Okita & Schwartz, 2006; Opfer, 2002; Piaget, 1929; Somanader, et al., 2011). However,

it does not completely disappear in adulthood (Goldberg & Thompson-Schill, 2009;

Ikeuchi, 2010; Jipson & Gelman, 2007; Looft, 1974), even though adults have a more

consolidated knowledge of living and nonliving things at various levels than young

children (e.g., Jipson & Gelman, 2007; Jipson, et al., 2016). Both children and adults have

difficulty judging whether ambiguous things, such as plants (Backscheider, et al., 1993;

Fouquet, et al., 2017; Goldberg & Thompson-Schill, 2009; Opfer & Siegler, 2004),

elements of nature (e.g., clouds and rivers; Carey, 1985; Laurendeau & Pinard, 1962),

and some nonliving things such as clocks and candles (Klingensmith, 1953) are alive

because movement can be linked with living status by some people. A study with

Japanese adults (Ikeuchi, 2010) showed that some believed that nonliving things, such as

clocks (58/522 participants), candles with fire (115/465 participants), and clouds

(154/426 participants) were living things (Ikeuchi, 2010).

Studies on animism are now beginning to encompass robots because they serve

as an intermediate between animate and inanimate objects (see also the Introduction in

Jipson, et al., 2016). A social robot is an artificial object made by humans, but it can have

eyes, talk, move spontaneously, and display goal-directed behaviors. Previous studies

reported that adults and older children, particularly around five years of age, were likely

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to agree that various types of robots had cognitive, psychological, and/or perceptual

properties. However, some studies showed that they were not as likely to think that robots

were alive or attribute biological properties (Beran, et al., 2011; Cameron, et al., 2017;

Cameron, et al., 2015; e.gJipson & Gelman, 2007; Jipson, et al., 2016; Katayama, et al.,

2010; Melson, Kahn, Beck, & Friedman, 2009; Melson, et al., 2009; Okita & Schwartz,

2006; Saylor, et al., 2010; Somanader, et al., 2011). Interestingly, some of the same

studies along with a few others showed that younger children were likely to attribute

these properties, including biological properties, to robots (Jipson & Gelman, 2007;

Jipson, et al., 2016; Saylor, et al., 2010; Somanader, et al., 2011).

Various types of robots with a face (e.g., a doglike robot, a socially

communicative humanoid robot) and without a face (e.g., a cleaning robot, a smart

speaker) are now available in homes and some public areas. Robots may help older adults

in nursing homes or teach children in schools or other venues in the near future. Before

we develop such a society, we need to understand how people, both children and adults,

perceive robots, especially those capable of moving and talking spontaneously (see also

Itakura, 2008; Itakura, et al., 2008). Therefore, the main goal of the present study is to

clarify developmental changes in animism tendencies toward a humanoid robot that can

talk spontaneously and make autonomous movements. We hypothesize that this type of

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robot, which can talk and move in face-to-face situations, should be livelier than the robot

stimuli that was used in most previous studies, such as real doglike robots, or humanoid

or doglike robots presented in pictures or videos.

It should be noted that the term "animism" has been applied to the evaluation of

several different properties. Some studies have investigated whether children and adults

categorize targets as living (or animate or "alive") and nonliving (or inanimate or "not

alive") (e.g., Goldberg & Thompson-Schill, 2009; Ikeuchi, 2010; McDonald &

Stuart-Hamilton, 2000). Other studies have focused on children's and adults' attributions

of cognitive, perceptual, psychological, biological, and teleological properties to such

targets (e.g., Inagaki & Hatano, 1996; Jipson & Gelman, 2007; Opfer & Siegler, 2004;

Saylor, et al., 2010; Somanader, et al., 2011). Leddon et al. (2008) reported that four- to

ten-year-olds had difficulty affirming questions that asked whether plants were *alive*, but

they were able to do so when asked whether plants had biological properties, such as

growing or dying (see more reviews in Opfer & Gelman, 2011). This indicates that the

categorization of living and nonliving things and the attribution of biological properties

represent different aspects of animism.

To resolve the problem of multiple meanings for the term "animism," Okanda et

al. (2019) proposed that there should be at least three different definitions of animism

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(Figure 1). One is Piaget's categorical animism, or *animism error*, exhibited by young children who confuse living and nonliving things. This is a tendency to mistakenly believe that ambiguous things such as moving machines or elements of nature are alive, or a tendency to attribute biological properties to things like clouds, rivers, and robots (e.g., Carey, 1985; Jipson & Gelman, 2007; Jipson, et al., 2016; Laurendeau & Pinard, 1962). For example, Jipson and Gelman (2007) showed participants, both children and adults, various stimuli with and without faces in videos and found that three-year-olds did not distinguish between a starfish with no face and a doglike robot with a face. Thus, they were less likely to attribute biological properties to the starfish, but were more likely to do so with the doglike robots. Younger children might be confused as to whether these things are living when characteristics such as movements and faces are incongruently linked. Children in the study aged four were more likely to attribute biological properties to the starfish than to the doglike robots, and were more likely to do so to the degu than to the starfish. In addition, three-year-olds also attributed perceptual properties to the doglike robots (Jipson & Gelman, 2007).

Furthermore, Saylor et al. (2010) reported that three-year-olds were more likely than four-year-olds to attribute biological (and psychological) properties to humanoid robots. Somanader et al. (2011) reported that four-year-olds were more likely than

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five-year-olds to attribute biological properties to a non-animal-like robot, while Jipson et

al. (2016) found that three-year-olds did not clearly differentiate a doglike robot from a

toy car or a rodent when asked whether these were all artifacts that were made by a human

or could be broken. These results indicate that young children are more likely to exhibit

animism errors than older children and adults because they have unconsolidated

knowledge of the biological or artificial properties of ambiguous things such as robots. It

is thus clear that animism errors may be observed only in early life, or decrease with age,

as other studies suggest (Bullock, 1985; Carey, 1985; Inagaki & Sugiyama, 1988; Jipson

& Gelman, 2007; Jipson, et al., 2016; Piaget, 1929; Somanader, et al., 2011).

The second type of animism, *anthropomorphizing animism*, also referred to as

general animism by a previous study (Okanda, et al., 2019), derives from cultural

anthropology or theology (Ikeuchi, 2010). This represents people's tendency to believe

that a *soul* or a *spirit* dwells in every natural and/or some man-made objects. Shinto, one

of the traditional religions in Japan, holds that gods exist everywhere in nature, including

mountains, oceans, the sun, and in other locations as well as in tools. In fact, some

Japanese people hold funerals for nonliving objects (e.g., dolls, needles, and combs) that

were loved by someone for a long time (see also Ikeuchi, 2010). This term might explain

why some Japanese adults said that clocks, candles with fire, and clouds were living

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things (Ikeuchi, 2010). Unlike young children who make animism errors, older children

and adults might *respect* these things and pretend that or treat them as if they had souls or

spirits as humans do (this is why people conduct religious ceremonies such as funerals for

these things), rather than believing that these are actually living things. Therefore, this

type of animism might be observed in people who no longer make animism errors.

The third type of animism, *agentic animism*, relates to mentalizing or perceiving

both living and nonliving things as intentional agents with a mind (as if they have mental

capacities or psychological features). Robotic research has studied people's mind

perception using the terms experience and agency (Gray, et al., 2007). According to Gray

et al. (2007), experience includes biological capacities and emotions, such as hunger, fear,

pain, pleasure, rage, desire, personality, consciousness, pride, embarrassment, and joy,

while agency includes mental capacities, such as self-control, morality, memory,

cognition, recognition, planning, and communication. Gray et al. (2007) reported that a

robot was perceived as not having experience, but it was perceived as having

agency—specifically more agency than animals, but less than adult humans. The term

experience, according to Gray et al. (2007), might include what Jipson et al. (Jipson &

Gelman, 2007; Jipson, et al., 2016) used for biological properties (e.g., growing and

eating), while agency might include psychological (e.g., thinking and feeling happy) and

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perceptual (e.g., seeing and sensing tickling) properties. Agentic animism can be defined

as a person's tendency to believe that things, including robots, are psychological agents

only when they understand that things do not have biological capacities (Okanda, et al.,

2019).

Therefore, we suggest that adults and older children can demonstrate both

anthropomorphizing animism and agentic animism and sometimes demonstrate both

simultaneously. For example, some people might believe in souls or spirits but also

believe in the mental capacities or agency of things (e.g., one might believe that an

earthquake is the result of a mountain god getting angry and trying to punish people: the

mountain, in this case, has an intention to punish people). Furthermore, infants and young

children can also demonstrate a sort of agentic animism with one key difference: they

lack the consolidated biological knowledge that adults and older children have. This can

lead to animism *errors* at the beginning of our lives. However, after we acquire

consolidated biological knowledge of living and nonliving things (or a concept of

aliveness), we develop the *ability* to feel that a nonliving thing is a living thing (i.e.,

agentic and anthropomorphizing animisms).

We now discuss the key factors that influence people's likelihood of

demonstrating agentic animism toward robots. Jipson and Gelman (2007) found that

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automatic movements and faces are likely factors in both children's and adults'

judgments of whether living and nonliving things have psychological or perceptual

properties. Somanader et al. (2011) found that four-year-old children were more likely to

think that a robot was alive when it moved autonomously. As Premack and Premack

(1997) indicated, spontaneous movements and goal-directed behaviors can also make

nonliving things appear to be intentional agents (see also Heider & Simmel, 1944). In fact,

five- to ten-year-olds and adults were likely to attribute biological and psychological

properties to blobs or unfamiliar shapeless entities, only when these showed goal-directed

behaviors (Opfer, 2002).

Robots may need to exhibit certain social skills for infants and young children to

believe that they are intentional agents. For example, ten-month-old infants needed to

witness evidence that a humanoid robot could interact with a human to conclude that it

might be an intentional agent (Arita, et al., 2005) and toddlers attempted to complete a

humanoid robot's incomplete acts by observing and imitating the humanoid robot's failed

attempts when it made eye contact with a human (Itakura, et al., 2008). Thus, an infant or

a toddler who encounters living-like characteristics or social abilities in a robot may

perceive it as an intentional agent.

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However, Okanda et al., (2013) proposed that preschoolers may already have developed expectancies that humanoid robots can behave like humans since their verbal responses toward robots and humans did not differ. Three-year-olds exhibited a yes bias toward both robots and humans in videos, while four-year-olds exhibited a nay-saying bias toward both kinds of interviewers. Furthermore, Okanda, et al., (2018) showed preschoolers videos in which a humanoid robot did or did not demonstrate the ability to interact with humans; four- and five-year-olds answered similarly (i.e., exhibited a nay-saying bias) to the robot's questions in both situations. Because these studies used experiments with between-subjects designs, it remains unclear whether the experience of interacting with a humanoid robot that verbally communicates could change a person's attitudes toward it. We propose that this experience is also an important factor for people to perceive robots as agent-like beings.

In the present study, we showed three- and five-year-olds and adults a real humanoid robot. Before they interacted with it, we asked if they would attribute living-like properties such as biological, artifact, psychological, perceptual, and name (i.e., give a proper name) to it. Biological and artifact properties were used to test whether participants made an animism error, while other properties tested whether they exhibited agentic animism. Then, we allowed the participants to have a brief natural interaction

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with the robot and asked the same questions again. We focused on animism errors and

agentic animism since we included preschoolers who might find it difficult to answer the

questions about anthropomorphizing animism used in previous studies (Ikeuchi, 2010;

Okanda, et al., 2019). We hypothesized that younger participants would make animism

errors (attributing biological properties), while older participants would demonstrate

agentic animism (attributing other properties except for biological properties).

Several previous studies have shown pictures or videos of robots to children

(Jipson & Gelman, 2007; Katayama, et al., 2010; Okanda, et al., 2013; Okanda, et al.,

2018), while others employed real and interactive but non-humanoid robots (Beran, et al.,

2011; Jipson, et al., 2016; Melson, et al., 2009; Melson, et al., April, 2005; Somanader,

et al., 2011). However, previous studies on humanoid robots did not investigate

participants' perceptions before and after interacting with the robot (Cameron, et al.,

2017; Cameron, et al., 2015). To the best of our knowledge, the present study is the first to

investigate how verbal interaction affects children's and adults' perception of a humanoid

robot with respect to biological, artifact, psychological, perceptual, and name properties

using a within-subjects design.

2. Methods

2.1 Participants

A priori power analyses in g*power (ANOVA repeated measures, within-between interaction) were conducted to determine the sample size. The parameters were set as follows: 0.25 (medium) for effect size, .05 for alpha, 0.95 for power, 3 for number of groups (age groups), 9 for number of measurements (number of trials at before and after interaction phase), .05 for correlation, and 1 for ε. The results indicated that a sample size of 30 participants would be required.

Three- and five-year-old Japanese children and adults participated as an experimental group: 20 three-year-olds (M = 42.35 months, SD = 3.36, range = 36–47 months, 9 boys), 31 five-year-olds (M = 63.42 months, SD = 2.84, range = 60–69 months, 14 boys), and 28 adults (M = 25.36 years, SD = 8.32, range = 18–62 years, 15 males). Eight children were excluded from further analysis: four children (one boy and one girl among the five-year-olds and two three-year-old girls) did not want to look at the robot, three children (two five-year-old boys and one three-year-old girl) provided incomplete data because of experimental errors (i.e., the robot did not work properly), and one five-year-old boy refused to complete the experiment. The final number of children who participated was 43.

Additionally, we tested 12 three-year-old (M = 42.83 months, SD = 3.41, range =

38–47 months, 6 boys) and 12 five-year-old (M = 65.33 months, SD = 2.74, range = 60–

69 months, 8 boys) children as a control group.

The children were recruited from a waiting list of participants for developmental

experiments at [blinded] University. The adults were undergraduate and graduate

students and faculty members in one of the universities in Osaka prefecture. The study

design and purpose were explained to the adult participants or the children's parents prior

to the experiment and their permission was obtained through signed informed consent

documents. The children were also asked if they were willing to participate in the

experiment. Ethical approval was granted by [blinded] University for the child

experiment ("How children answer questions," approval no. 16092) and by [blinded]

University for both the child and adult experiments ("Adults' and children's perception of

robots," approval no. 2017–15).

2.2 Materials and procedures

We used Kirobo, a small social humanoid robot (height, 10cm; weight, 183g)

from TOYOTA that has a humanlike head with eyes and a mouth, in addition to a body

with arms and legs. Kirobo can follow a human face, perceive facial emotions, and

roughly detect utterances. It cannot walk, but can talk in a more animated humanlike way

(mostly with arm and head movements). When connected to the Internet, the robot also

has the ability to learn conversations, remember past conversations, and advance to

higher levels like in certain video game; however, we used the "friend mode" setting to

avoid these behaviors. In this mode, the robot's level of conversation ability was always

the lowest, which allowed for more consistency in verbal output when it interacted with

humans. We used this robot because it showed highly contingent responses (including

utterances and body movements such as nodding) to humans' utterances. Based on our

available options, this robot provided the most suitable stimulus for investigating whether

natural human-robot interactions could affect children's and adults' perception of the

robot.

The experimental group included two phases: before- and after-interaction. In

the before-interaction phase, an experimenter presented the robot to a participant without

describing it. The experimenter avoided giving any clues about the robot's living status.

They also did not use pronouns, so the experimenter always called it "the robot" or

"Kirobo" throughout the whole experiment. The experimenter then asked nine questions

that were used in previous studies to examine children's and adults' distinction between

living and nonliving things, including a doglike robot (Jipson & Gelman, 2007; Jipson, et

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al., 2016). These questions were also used in Okanda et al. (2019) to examine Japanese

adults' perception of various types of robots. The questions covered five properties:

biological ("Does this one eat?" and "Does this one grow?"), artifact ("Did a person make

this one?" and "Can this one break?"), psychological ("Does this one think?" and "Does

this one feel happy?"), perceptual ("Does this one see things?" and "If I tickled it, would

this one feel it?"), and name ("Can you give this a name?") properties. The adults marked

"yes" or "no" responses on a paper questionnaire, while the children were asked these

questions orally and their responses were recorded online by the experimenter. The order

of questions in the questionnaire was fixed for the adults, but none of the questions from

the same category were placed next to each other. For children, the experimenter asked

the questions in random order.

Following the before-interaction phase, the participants were allowed to talk to

the robot for approximately two minutes. To avoid experimenter effects, adult

participants were left alone in a room with the robot without video recording (some of the

participants may have been embarrassed and may have behaved unnaturally when talking

to the robot in front of the experimenter and on video). The experimenter asked the

participants about their impressions of their experience with the robot and the contents of

their conversations to make sure that they interacted with it and to confirm that all

participants had some conversation with the robot.

The experimenter encouraged the children to talk to the robot and joined them in

the conversation because the robot had difficulty in recognizing child voices due to their

unstable pitch or the Kansai dialect. The parents oversaw the experiments; some of them

even decided to join the conversation themselves since they too were interested in the

robot. Additionally, one needed to talk to the robot when it entered the "hearing" mode:

the children needed to wait a few seconds before talking. Since it was difficult for the

children to wait, the experimenter sat next to the children and urged them to be patient.

The experimenter also asked the children to exchange social greetings with the robot (e.g.,

"hello" or "how are you?"). Some children asked the robot about its preference for food

or colors; however, the robot often failed to appropriately answer the children's questions

(probably because the robot really did not have such preferences) and just responded or

nodded contingently (e.g., saying "yeah, yeah, I see, so what next?" while nodding). In

addition, Japanese people rarely use the verb "think"; therefore, the children were unable

to get clues about whether the robot had biological or living-like properties during the

interaction. In the after-interaction phase, the participants were asked the same questions

again.

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Children in the control group only interacted with the robot, then participated in the after-interaction phases (in which they were asked questions about biological, artifact, psychological, perceptual, and name properties). This condition examined whether looking at a "still robot" (i.e., a robot that did not move or talk) could affect their belief that it was more likely to be an artifact. This group also allowed us to control for the possibility that repeated exposure to the questionnaire before and after interacting with the robot could affect how they perceived the robot.

3. Results

We used two scoring methods in this study. First, we replicated the scoring methods used by Jipson and Gelman (2007). Participants received a score of 1 for a "yes" response and a score of zero for "no", "I don't know," and "no answer" responses to the questions. Table 1 shows the adults' and children's mean scores for each property in the before- and after-interaction phases. Aside from the name property (which included just one question), all other properties included two questions. Therefore, scores for each property, other than the name property, ranged from zero (did not attribute any characteristics to the robot) to two (attributed both characteristics to the robot), and scores for the name property ranged from zero to one. We used this method for comparisons to

chance levels. Second, to compare the question properties fairly, we manipulated the

score that ranged from 0 to 1 by averaging each question's score in this analysis. We used

this method for ANOVAs.

We partly followed analyses that were used by Jipson and Gelman (2007). First,

we compared children's scores in the experimental and control groups to evaluate

whether their perceptions of the robot would change when they saw/did not see the

"sitting still robot." Second, we conducted ANOVAs with the Greenhouse–Geisser

correction to adjust the degrees of freedom and used Shaffer's modified sequentially

rejective Bonferroni procedure for multiple comparisons if there were developmental

changes and differences in the response patterns in the before- and after-interaction

phases. Finally, we compared each group's mean scores to chance levels using

one-sample t-tests.

3.1 Comparison between the experimental and control groups

We conducted a $2 \times 2 \times 6$ mixed ANOVA (age: 3 years, 5 years group:

experiment, control; property: biological, psychological, perceptual, artifact, and name)

with property as a within-participants factor. The main effect of the group was not

statistically significant [$F(1, 63) = 1.14$, n.s., $\eta^2_p = .02$]. However, the main effect of

property [$F(4, 252) = 14.03$, $p < .01$, $\eta^2_p = .18$] and the interaction between property and

age [$F(4, 252) = 6.79$, $p < .01$, $\eta^2_p = .10$] were statistically significant. The results indicated

that the before-interaction phase did not affect children's perceptions of the robot.

Therefore, all further analyses focused on data from the experimental group.

3.2 Developmental changes

We conducted a $3 \times 2 \times 6$ mixed ANOVA (age: 3 years, 5 years, adult; phase:

before, after; property: biological, psychological, perceptual, artifact, and name), with

phase and property being within-participants factors (Figure 2). The main effects of age

[$F(2, 68) = 8.86$, $p < .01$, $\eta^2_p = .20$], property [$F(4, 272) = 45.48$, $p < .01$, $\eta^2_p = .40$, $\varepsilon = .94$],

interaction between age and phase [$F(2, 68) = 3.22$, $p < .05$, $\eta^2_p = .09$], and interaction

between age and property [$F(8, 272) = 24.16$, $p < .01$, $\eta^2_p = .42$, $\varepsilon = .94$] were statistically

significant.

Simple main effect analyses for age and phase revealed that age differences were

significantly different only in the before-interaction phase [$F(2, 68) = 12.92$, $p < .01$,

$\eta^2_p = .28$]. The three-year-olds' scores were higher than those of the five-year-olds and

adults, and the adults' scores were higher than those of the five-year-olds [all $ts(68) >$

2.27, ps $< .05$]. Moreover, the five-year-olds' scores in the after-interaction phase were

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significantly higher than those in the before-interaction phase [$F(1, 25) = 6.63$, $p < .05$,

$\eta^2_{\text{p}}=.20$].

Simple main effect analyses for age and property revealed that scores for each

property showed age group differences [all $Fs(2, 68) > 8.33$, $p <.01$, $\eta^2_{\text{p}} > .19$]. For the

artifact property, the adults had the highest scores, followed by the three-year-olds, with

the five-year-olds having the lowest scores [$ts(68) > 4.99$, $ps < .05$]. For the biological

and psychological properties, the three-year-olds' scores were higher than those of the

five-year-olds and adults [$ts(68) > 3.76$, $ps < .05$]. For the perceptual property, the three-

and five-year-olds' scores were higher than those of the adults [$ts(68) > 3.29$, $ps < .05$].

For the name property, the adults' scores were higher than those of the five-year-olds

[$t(68) = 4.08$, $p < .05$], whereas the three-year-olds' scores were not significantly different

from those of the five-year-olds or adults. The three-year-olds did not show significant

differences in scores for each property; however, the five-year-olds' and adults' scores

for properties were significantly different [$F(4, 100) = 11.15$, $p <.01$, $\eta^2_{\text{p} =} .31$ for

five-year-olds; $F(4, 108) = 102.09$, $p < .01$, $\eta^2_{\text{p}} = .79$ for adults]. The five-year-olds'

scores for the biological property were significantly lower than their scores for other

properties and their scores for the perceptual property were significantly higher than

those for the psychological property [all $ts(25) > 3.62$, $ps < .05$]. The adults' scores were

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highest for the name and artifact properties, followed by the perceptual and psychological

properties, and their scores for the biological property were the lowest [all $ts(27) > 2.90$,

$ps < .05$].

3.3 Comparison to the chance level

We conducted one-sample t-tests to clarify whether participants were likely to

attribute any properties to the robot. We compared participants' mean scores for each

property with the chance level (i.e., a score of 1 for the biological, psychological,

perceptual, and artifact properties in which the maximum scores were 2, and a score of

0.5 for the name property in which the maximum score was 1) in the before- and

after-interaction phases separately (Table 1). The three-year-olds' scores for the

psychological and perceptual properties were significantly higher than the chance level in

the before-interaction phase; however, these differences were not observed in the

after-interaction phase, where scores for the artifact property were significantly higher

than the chance level. This means that three-year-olds might believe that the robot could

have psychological and perceptual properties only when they saw it sitting still, but they

immediately claimed that it was actually an object after they interacted with it. In addition,

their scores for the name property were significantly higher than the chance level for both

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phases. Even though the three-year-olds recognized that the robot was a man-made object, they nevertheless continued to think that giving it a name was appropriate.

The five-year-olds' scores for the biological and psychological properties were significantly lower than the chance level in the before-interaction phase. In the after-interaction phase, the biological property remained significantly lower than the chance level, but their perceptual property score was significantly higher than the chance level. A similar tendency was observed in adults. In the before-interaction phase, their psychological property scores were significantly lower than the chance level; however, this tendency did not persist in the after-interaction phase. In both phases, the adults' scores were significantly higher than the chance level for biological property and a ceiling effect was observed for the artifact property. These results suggest that the five-year-olds and adults understood that the robot was a nonliving thing, but after the interaction, they started to believe that the robot could have psychological features.

In both phases, the adults, like the three-year-olds, were likely to believe that it was acceptable to give the robot a name. However, the five-year-olds did not believe that in any of the phases.

4. Discussion

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The present study investigated children's and adults' perceptions of a humanoid robot that could move autonomously and have natural conversations with humans. We first introduced the robot sitting still to the participants and asked them whether they could attribute biological, artifact, perceptual, psychological, and name properties to it, and then we allowed them to have a brief interaction with the robot. After the interaction, we asked the participants the same questions. We examined two issues in the present study: 1) whether younger participants made animism errors; and 2) whether older participants demonstrated agentic animism toward the robot and whether this tendency would be stronger after a brief verbal interaction with the robot. We hypothesized that younger participants would make animism errors (i.e., attributing biological properties), while older participants would demonstrate agentic animism (i.e., attributing other properties except for biological properties). In addition, we tested whether repeating the same questions before- and after-interaction while looking at the unmoving robot would affect the children's perception of the robot, and determined that there was no effect.

The results of the present study indicate that the experience of interacting with a robot had different effects on three- and five-year-olds and adults. Before the interaction, the biological and psychological scores of the three-year-olds were higher than those of the five-year-olds and adults. Their perceptual scores were also higher than those of the

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five-year-olds. Further, the three-year-olds were more likely than older participants to

attribute biological, psychological, and perceptual properties to the robot, but less likely

to attribute the artifact property. Their scores for the psychological and perceptual

properties were above the chance level. These results are consistent with previous

findings (Jipson & Gelman, 2007; Saylor, et al., 2010; Somanader, et al., 2011). The

three-year-olds may not have understood that the robot was a nonliving or an inanimate

object, therefore they made animism errors.

However, the three-year-olds' judgment unexpectedly changed after they had

interacted with the robot. They no longer attributed biological, psychological, and

perceptual properties to the robot, but they were likely to consider it an artifact object.

Younger children may have some knowledge that a robot is an inanimate object; however,

because the robot had eyes and human-like features (head, torso, and arms), they may be

more likely to misinterpret this ambiguous thing as a living thing (see also Jipson &

Gelman, 2007). During the interaction; however, the three-year-olds in our study may

have discovered that the robot was an object because its movements were not yet close to

those of a real human (in fact, Kirobo's utterances were not perfectly contingent due to

voice recognition errors, and, of course, its movements were far inferior to that of a

human). The children may have easily concluded that it was more like a toy, such that the

robot was no longer ambiguous for them. Therefore, we conclude that the youngest

children, who have unconsolidated biological knowledge, make animism errors only

when dealing with robots with no obvious evidence of their nonliving status.

This result is partly similar to earlier findings that ten-month-old infants and

toddlers did not interpret humanoid robots as social agents if they did not display any

social abilities (Arita, et al., 2005; Itakura, et al., 2008). In other words, infants and

toddlers may require certain criteria to be met before concluding that a robot is a social

agent. However, unlike the present study, participants in these studies were more likely to

consider the robot as an intentional agent after presenting them with evidence of

conversation and eye gaze abilities. Age differences or presentation methods might be

more likely to explain these differences. For example, previous studies showed

participants a robot in videos (Arita, et al., 2005; Itakura, et al., 2008), while the present

study showed children a real one.

Further studies involving younger participants are needed to clarify these

inconsistent results between infants/toddlers in previous studies (Arita, et al., 2005;

Itakura, et al., 2008) and the three-year-olds in the present study. These studies might

need to examine whether their interpretation would change when they saw more lively

robots. The results of the present study also suggest that animism error toward nonliving

or inanimate things—as noted by Piaget (1929)—can be easily corrected by showing children evidence that the thing is "not alive."

Similar to previous studies (Jipson & Gelman, 2007; Jipson, et al., 2016; Saylor, et al., 2010; Somanader, et al., 2011), the five-year-olds and adults in the present study were less likely to attribute any living-like properties to the robot. Most importantly, they did not attribute biological properties to the robot, while the adults attributed an artifact property to it; they clearly knew that the robot was a nonliving thing. However, the five-year-olds' scores, especially their scores in terms of perceptual properties, increased in the after-interaction phase compared to the before-interaction phase. This pattern was very different from that of three-year-olds. Older children knew that the robot was an object (i.e., fewer attributions of biological properties) and this belief did not change through the interaction experience; however, they may have been more "open-minded" and become likely to attribute some of the living-like properties (i.e., a perceptual one) after they interacted with the robot verbally.

It is worth noting that five-year-olds were most likely to attribute perceptual properties to the robot. This is similar to a study that suggested that the ability to see might be an important social capacity for infants to perceive a robot as a social agent (Meltzoff, et al., 2010). Moreover, Cameron et al. (2017) reported that children younger

than six years of age judged that a humanoid robot could be a living thing when they saw

it moving autonomously, but not when they saw the same robot being operated by

someone or when it was standing still. In this context, our results provide new evidence

that interaction positively affects five-year-olds' agentic animism toward robots.

Simultaneously, five-year-olds did not accept giving a name to the robot both

before and after the interaction. Dolgin and Behrend (1984) reported that five-year-olds

correctly decided whether nonhuman, inanimate stimuli possessed biological,

psychological, perceptual, and cognitive properties (although they did not categorize

their questions according to these properties). However, among three- and nine-year-olds

and adults, five-year-olds made the greatest number of errors about a dead animal, a doll,

and a car. Similarly, the five-year-olds in the present study showed the most drastic

changes in their perception of robots after interacting with it. In addition, Klingensmith

(1953) reported that third-, fifth-, and seventh-grade children said a clock and a candle are

alive, while kindergartners and first-grade children did not. Thus, children aged five years

or older may have an intermediate interpretation of an ambiguous object, such as a

moving, nonliving thing when they need to judge whether it is a living thing (see also the

Discussion in Jipson, et al., 2016). In addition, Klingensmith (1953) explained that a

clock and a candle were more "lively" for older children. The robot in the present study

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may also have been "lively" for five-year-olds. However, they seemed to struggle to determine whether it was a living or nonliving thing; therefore, they sometimes judged that it had some living characteristics while simultaneously judging that they should not give it a name. Further studies are needed to investigate whether older children would change their minds after they interact with the robot and when this transition occurs.

Finally, the adults' scores for each property were significantly different from each other. They did not attribute biological properties, but they attributed artifact properties to the robot. They clearly understood that the robot was a nonliving thing; however, their scores for perceptual, psychological, and name properties were significantly greater than the score for the biological property. This pattern was also very different in comparison to the three- and five-year-olds. The adults may not be able to ignore the mind (or mental capacities or psychological features) of an intentional agent, especially if it can talk and behave like a human or animal (see also about doglike robots in Friedman, et al., 2003 for more about doglike robots). In fact, Kim et al. (2013) reported that adults preferred a robot that called them by name over the same robot that did not behave this way, and Waytz et al. (2014) reported that adults attributed humanlike mental capacities to a vehicle that had a humanlike name, voice, and gender. Adults who have consolidated knowledge of robots might be likely to expect robots to have social or

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mental capacities. Thus, adults can exhibit agentic animism toward robots regardless of

interacting with them; however, lifelike interaction with them could make this animism

stronger.

Today's technological advances may also help adults (and older children)

believe that robots could act as an intermediate between living and nonliving things or

make people exhibit agentic animism toward robots. As noted above, people can have

doglike robots at home as pets, and not only children but also adults treat these as if they

are alive (Friedman, et al., 2003; Kahn, et al., 2006). When technology is able to build

more realistic robots, people's animism tendencies (e.g., agentic and anthropomorphizing

animism) could be stronger than ever. Thus, further studies are needed to investigate

whether people can exhibit agentic and anthropomorphizing animisms simultaneously.

The results of the present study revealed that interaction effects varied among

different age groups. The differences by age may be explained by the possibility that

young children's animism is different from older children's and adults' animism. More

specifically, whereas simple animism errors made by three-year-olds were immediately

corrected after they saw evidence that the robot could not perfectly behave like a living

thing, such evidence led older children to feel that it had a mind or mental capacities.

Thus, older children have agentic animism, which might lead them to overlook the

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robot's imperfect behaviors. Children may acquire biological knowledge before the age of five, but their knowledge is not as consolidated as adults; therefore, their belief in robots can be changed easily with these experiences. It is important to note that adults, who should have the most consolidated biological knowledge and a concept of aliveness, had higher scores for the perceptual, psychological, and name properties than the biological property throughout the experiment. This implies that adults might expect the robot to be an intentional agent that can possess mental capacities.

Some limitations of the present study should be noted. We did not control Kirobo's behaviors and utterances since we kept participants' interaction with it natural. Thus, we could not investigate which actions or attitudes of the robot (e.g., whether the robot was friendly or not friendly, whether it called the participant by name or not, etc.) could be perceived as more lifelike. These factors need to be investigated in future studies. The robot we used here was also very small; however, most of the previous studies that employed humanoid robots used bigger ones (Cameron, et al., 2015; Okanda, et al., 2013; Okanda, et al., 2018). It is not clear whether the size of the robot is an important factor in people's sensing that the robot has a mind. A small robot could be more like a small pet than a human.

We also did not ask participants whether they would like to behave in a morally

acceptable way toward the robot (e.g., asking whether it is good or not good to hit it, or

to leave it alone during a family chat; see Kahn, et al., 2004; Kahn, et al., 2012; Melson,

Kahn, Beck, & Friedman, 2009; Melson, et al., 2009). This issue might also be important

in the investigation of people's animism tendencies toward robots. We expect that older

participants would attribute more morality to robots, especially after they have seen that it

can talk or interact with them (see also Kahn, et al., 2012). We also need to investigate

how this morality relates to people's behavior in treating robots or other tools as if they

are alive, for example, holding funerals (see more in Ikeuchi, 2010). Holding funerals for

tools may reflect anthropomorphiz*ing* animism, but this may not necessarily be the case

when people do so for robots. Holding funerals for robots may be more closely aligned

with attitudes toward companion animals and morality could be an index of this

distinction. In fact, Melson et al. (2009) reported that children over seven years of age

treated a doglike robot as a moral being, just as they did with a real dog.

4.1 Conclusions

In sum, the present study added a new perspective on children's and adults'

animism tendencies toward robots by indicating that we might need to be a certain age

(i.e., five years of age) to perceive a mind in robots that can talk spontaneously. Humans

make animism errors at the beginning of life and the ability to sense a mind or some

mental capacities without believing targets have biological capacities remain (or develop)

in adulthood, resulting in a tendency for agentic animism. Animism errors and agentic

animism differ in terms of quality. The former is expressed in errors due to

underdeveloped living-nonliving distinctions, while the latter evinces the capacities

required to process mentalizing in complex ways. Thus, future studies are needed to

investigate the sizes, behaviors, and utterances of robots, which are important for us to

sense their minds.

The present investigation is important because we need to study how people

interact with robots before they become commonplace. Exploring the effects of

interaction or different contingency levels is thus important to identify further

implications for building robots that better meet people's demands.

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Table 1. Children's and adults' scores before and after they interacted with the robot

Property	3 years				5 years				Adults			
	Mean	*SD*	*t* scores		*Mean*	*SD*	*t* scores		*Mean*	*SD*	*t* scores	
			Before interaction									
Biology	1.35	0.86	*t* (16) = 1.69		0.19	0.49	*t* (25) = -8.38	**	0.43	0.50	*t* (27) = -6.00	**
Psychology	1.65	0.70	*t* (16) = 3.80	**	0.62	0.64	*t* (25) = -3.08	**	0.61	0.69	*t* (27) = -3.03	**
Perceptual	1.59	0.71	*t* (16) = 3.41	**	1.23	0.77	*t* (25) = 1.54		0.86	0.45	*t* (27) = -1.67	
Artifact	1.18	0.64	*t* (16) = 1.14		0.96	0.77	*t* (25) = -0.25		2.00	0.00		
Name	0.71	0.47	*t* (16) = 1.81	+	0.50	0.51	*t* (25) = 0.00		0.93	0.26	*t* (27) = 8.65	**
			After interaction									
Biology	1.18	0.88	*t* (16) = 0.82		0.46	0.71	*t* (25) = -3.89	**	0.39	0.57	*t* (27) = -5.67	**
Psychology	1.29	0.92	*t* (16) = 1.32		0.88	0.82	*t* (25) = -0.72		0.93	0.72	*t* (27) = -0.53	
Perceptual	1.29	0.85	*t* (16) = 1.43		1.42	0.58	*t* (25) = 3.73	**	0.89	0.63	*t* (27) = -0.90	
Artifact	1.29	0.69	*t* (16) = 1.77	+	1.00	0.63	*t* (25) = 0.00		2.00	0.00		
Name	0.76	0.44	*t* (16) = 2.50	*	0.62	0.50	*t* (25) = 1.19		0.93	0.26	*t* (27) = 8.65	**

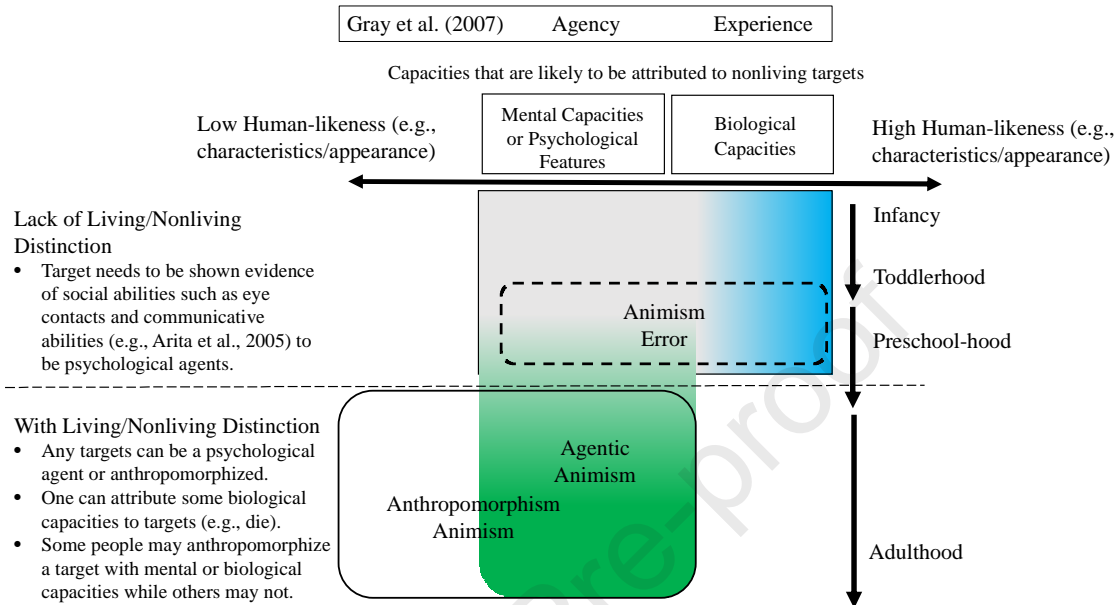Note. $^+ p < .10$, $^* p < .05$, $^{**} p < .01$

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Figure 1. A chart explaining the three animism tendencies proposed in this study (see also

Okanda et al., 2019).

*footnote

Gray et al. (2007) proposed two dimensions in mind perception: agency and experience.

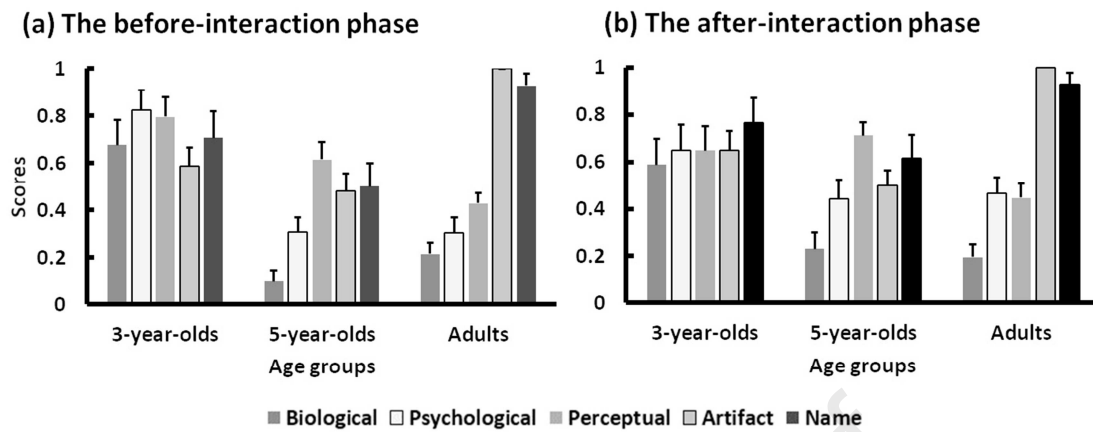Figure 1 incorporates Gray et al.'s ideas of agency and experience.

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(a) The before-interaction phase

(b) The after-interaction phase

■ Biological □ Psychological ■ Perceptual □ Artifact ■ Name

Figure 2. Each age group's mean scores for properties in the before-interaction phase (a)

and the after-interaction phase (b). Error bars indicate standard errors.

Highlights

- Japanese three-year-old children made animism errors with regards to a humanoid robot that can talk and move.

- This tendency was no longer held after the children had a brief interaction with it.

- Japanese 5-year-old children and adults exhibited agentic animism toward the robot.

- Although 5-year-olds and adults understood that the robot was a nonliving thing, but attributed living properties to it after a brief interaction.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest