

Are Pink Robots for Girls? Children's Gender-Related Toy Preference Toward Robotic Toys

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Research Article

Keywords: gender stereotypes, gender-related preference, toy preference

Posted Date: October 19th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11034284/v1>

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Additional Declarations: No competing interests reported.

Abstract

This study examined toy preferences among children aged 3–5 years (recruited from August to October 2025, in Japan), focusing on their choices between humanoid robotic toys and dolls. In Study 1, children ($n = 162$; 81 boys and 81 girls; age range = 36–67 months) were asked to choose between commercially available humanoid robots, typically perceived as male, alongside same-gender dolls. Boys preferred robots over boy dolls, whereas girls preferred girl dolls over robots ($\eta^2 = .488$); however, the preference for dolls among 5-year-old girls was only marginally significant (Cohen's $d = 0.464$). In Study 2, girls ($n = 183$, age range = 36–69 months) were presented with AI-generated, girl-oriented humanoid robots, designed to increase their interest. Only a weak shift was observed toward robot preference ($\eta^2 = .011$). Notably, 3-year-olds did not show a significant preference for dolls (Cohen's $d = 0.306$), suggesting that early exposure to girl-oriented robots could foster greater interest in robotics during early childhood. Overall, the findings indicate that classical gender-related toy preferences persist among 3- to 5-year-olds, even when new technological toys are introduced. Modifying robots' colors and facial features to appear more girl-oriented was insufficient to significantly enhance girls' interest.

Introduction

In the 21st century, digital devices such as computers and smartphones have become integral to daily life. Alongside these technologies, rapid advances in robotics and artificial intelligence (AI) have created new technology-oriented career pathways. Numerous studies have examined gender gaps in robotics-related performance and attitudes (Çetin & Demircan, 2020; Master et al., 2017; Sullivan & Bers, 2013, 2016a, 2018, 2019a). As a component of the STEM fields, robotics remains an area in which girls typically demonstrate lower interest, confidence, and achievement than boys (Kucuk & Sisman, 2020; Sullivan & Bers, 2013, 2016a). Studies have shown that preschoolers and children in first- and second-grade often perceive robotics as a male domain, believing that boys both enjoy and perform better in robotics than girls do (Master et al., 2017; Sullivan & Bers, 2016a). Such attitudes remain consistent from preschool through high school: boys tend to exhibit greater confidence in their robotics abilities (Nourbakhsh et al., 2004; Sullivan & Bers, 2019b) and more positive attitudes toward technology and engineering (van Wassenaeer et al., 2023) than girls do. Sullivan and Bers (2013) attributed these gender differences to boys' greater familiarity with mechanical toys, such as cars, which are traditionally considered masculine (Davis & Hines, 2020; Todd et al., 2018), as are machines in general (Varney, 2002).

Although young children often associate robots with masculinity, their gender stereotypes regarding robots appear to be weaker than those related to other toys (Sullivan & Bers, 2016a). In Sullivan and Bers (2016a), 64% of child participants stated that boys would enjoy playing with LEGO blocks, whereas only 33% believed boys would enjoy playing with a non-humanoid robot. Children's reasons for classifying robots as "for boys" were related to colors (e.g., blue is for boys) or sounds (e.g., it might annoy girls). Furthermore, some evidence suggests that young children's gender stereotypes are less pronounced than those of adults. For instance, when asked to assign a gender to humanoid and dog-like robots, both

adults and children over 4-year-old tended to identify them as male (Okanda & Taniguchi, 2021, 2026). However, only adults—unlike 6- and 7-year-olds—classified humanoid robots perceived as males into a “boy’s group,” although children did categorize human images by gender (Okanda & Taniguchi, 2026). Because robotics is a relatively new field, children may have fewer opportunities to form gender stereotypes than in more established STEM domains, such as computer science, engineering, and physics (Miller et al., 2024; Sullivan & Bers, 2016a). Consequently, promoting gender-equitable robotics education early in childhood is essential to prevent these stereotypes from becoming entrenched (Bers et al., 2013; Master et al., 2017; Sullivan & Bers, 2013, 2016a, 2019a). Indeed, participation in programming activities has been found to increase girls’ motivation toward STEM subjects from preschool through second grade (Master et al., 2017; Sullivan & Bers, 2019a).

Similar outcomes to those gained from educational robots may also arise from children’s interactions with robotic toys at home, particularly for preschoolers. Companies such as LEGO have developed robots designed to foster STEM engagement among young children. Robot kits for children and/or adults, such as Vstone’s Robovie-i ver.2 and DeAgostini’s humanoid robot Robi, both of which can be assembled by users, are also available. Robotic pets, such as Sony’s *aibo*, have also become increasingly popular. This proliferation raises the question of whether children’s interest in robotic toys differs by gender. Despite growing commercial availability of such toys, no empirical studies have directly compared boys’ and girls’ preferences for robotic toys versus non-robotic toys.

There appear to be two main types of robots designed for children. The first type is mechanical robots with car-like features. Educational robots frequently fall into this category and often include wheels to enable mobility (Master et al., 2017; Sullivan & Bers, 2016a, 2016b, 2019a). However, this type of robot elicited little interest from 6-year-old girls (Master et al., 2017); although as only children in the robotic programming condition in the study directly interacted with the robot, they may have focused more on its mechanical features than its face. Robots that emphasize such mechanical aspects (Sullivan & Bers, 2013) may therefore be perceived as boy-oriented.

The second type, the humanoid robot, incorporates human-like face and eyes, blurring the boundary between mechanical and social toys. Specific design features—especially the presence of eyes—may play a crucial role in capturing children’s interest regardless of their gender. Fulcher and Hayes (2018) found that while boys were more likely to build wheeled objects from LEGO blocks, few children of either gender incorporated eyes into their creations, and no significant gender differences were observed in this respect. Stuffed toys, which almost always have eyes, tend to be categorized as gender-neutral (see Davis & Hines, 2020 for a review). Supporting this perspective, infants as young as six months showed a general preference for faces, though this interest appeared to decline in boys around 15 months of age (Liu et al., 2020). While dolls are culturally associated with girls, some masculine-themed dolls (e.g., G.I. Joe) appeal to boys’ interest (Campenni, 1999; Davis & Hines, 2020; Nelson, 2005; Rheingold & Cook, 1975; Todd et al., 2018). Similarly, girls may find humanoid robots more appealing than the mechanical, car-like robots commonly used in robotics education. Therefore, the present study aims to determine whether humanoid robots are boy-oriented or gender-neutral toys.

Robots are increasingly used as tools for STEM education (Bers et al., 2013; Master et al., 2017; Sullivan & Bers, 2016a, 2016b, 2019a), and humanoid robots are being explored as potential robotic tutors (Belpaeme et al., 2018; Rossi et al., 2024). To design age- and gender-appropriate educational robots—whether as instructional tools or learning companions—it is important to understand how gender differences influence children’s interest in robotics. If girls continue to exhibit lower interest in humanoid robots, as they do with mechanical ones (Sullivan & Bers, 2016a), targeted design modifications—such as adjustments in color, shape, or attire—may be warranted to enhance their appeal (see also Fulcher & Hayes, 2018; Sullivan & Bers, 2016a).

Accordingly, the present study examined children’s preferences for humanoid robots, comparing standard designs—typically perceived as male (Okanda & Taniguchi, 2021)—with explicitly girl-oriented versions. Study 1 investigated preschoolers’ preferences for standard humanoid robots and dolls to determine general gender differences and developmental trends. Dolls were chosen because they are conventionally girl-associated toys (Blakemore & Centers, 2005; Campenni, 1999; Davis & Hines, 2020; Martin et al., 1995; Nelson, 2005) and share visual similarities with humanoid robots. Study 2 extended this investigation by examining whether girls preferred girl-oriented robots, featuring pink coloring and feminine designs, over traditional dolls.

Participants were children aged to five years—an age range during which gendered toy preferences typically emerge (see Davis & Hines, 2020 for a review). Prior reviews have highlighted ages one, four, and five years as key periods for investigating toy preferences, with 31 of 95 age groups in the reviewed literature including children aged four and five years old. To capture developmental variation, this study also included a younger cohort of 3-year-olds.

Three hypotheses were proposed. First, boys were expected to prefer robots to dolls, while girls were expected to prefer dolls to robots. However, given the human-like faces and bodies of robots, some girls were expected to show preference for them. Second, gender-based preferences were expected to strengthen with age, with older boys increasingly favoring robots and older girls increasingly favoring dolls—a trend identified in Davis and Hines’ (2020) meta-analysis. Third, in Study 2, when presented with girl-oriented robots, girls aged three to five years were expected to show weaker preferences for dolls and a stronger inclination toward robots.

This study explored gender differences in preferences for robotic toys to inform efforts toward gender-equitable early robotics education. It also examined whether girl-oriented humanoid robots could increase girls’ interest in robotics, potentially fostering greater engagement in STEM fields in the future.

Study 1

Study 1 investigated boys’ and girls’ toy preferences for humanoid robots and dolls. Children were shown commercially available humanoid robots that were likely to be perceived as male (Okanda & Taniguchi, 2021) to examine potential gender differences and developmental changes in toy preference.

Methods

Participants

An a priori power analysis was conducted using G*Power for a multiway analysis of variance (ANOVA) (fixed effects, special effects, main effects, and interactions). The parameters were set as follows: effect size = 0.25, alpha = 0.05, power = 0.80, numerator $df = 2$ (two genders: boy, girl; three age groups: 3, 4, and 5 years; $2 - 1 \times 3 - 1$), and number of groups = 6 (2 genders $\times$ 3 age groups). The analysis indicated that a total sample size of 158 participants was required, with 26–27 participants per group. Accordingly, 27 children were recruited for each gender and age group.

The sample comprised 162 children: 54 three-year-olds ($M = 41.00$ months, $SD = 3.890$; 27 boys; age range = 36–47 months), 54 four-year-olds ($M = 54.35$ months, $SD = 3.471$, 27 boys; age range = 48–59 months), and 54 five-year-olds ($M = 62.33$ months, $SD = 1.873$; 27 boys; age range = 60–67 months). Exclusion criteria were applied to children who responded with “I don't know” or failed to answer all the questions. Three children who did not choose either option—a 3-year-old boy, a 3-year-old girl, and a 4-year-old girl—were excluded. A total of 159 participants were included in the final analysis.

Materials

Three pairs of stimuli were used, each consisting of a robot and a doll (Fig. 1). All stimuli were presented as pictures. The three humanoid robots—Nao (from SoftBank), Sota (Vstone), and KIROBO mini (Toyota)—were identical across participants. These robots were likely unfamiliar to the children, as the first two were primarily developed for research purposes and the third was discontinued several years ago.

Note

A: Children were presented with robots appearing in the center. Boys were presented with a male doll on the left, whereas, girls were presented with a female doll on the right. The pairings were fixed. B: The dolls were the same as in Study 1, and the robots were AI-generated using Google Gemini.

The dolls resembled preschool- and school-aged children (the Chelsea and Skipper lines from Mattel). As these dolls are from a foreign manufacturer and not part of the main Barbie and Ken line, they were also likely unfamiliar to participants. Children were presented with dolls of their own gender, as previous studies have shown that boys generally avoid female dolls (see Davis & Hines, 2020 for a review). For instance, studies have reported that boys tend to have dolls depicting stereotypically masculine figures (e.g., soldiers and cowboys) in their rooms (Nelson, 2005; Rheingold & Cook, 1975), and parents perceived such dolls as “for boys” (Campenni, 1999). Consequently, some boys might prefer male dolls over robots.

The present study aimed to examine children's interest in both robots and dolls, ensuring that neither stimulus type was a toy that children were reluctant to play with. This was important because if boys

consistently chose robots over dolls, the result could reflect avoidance of “girly” toys rather than a genuine preference for robotic ones. To reduce such confounding effects, doll images were selected to align with children’s preferences (Okanda & Taniguchi, 2026): boys were shown dolls with black hair and eyes, and girls were shown dolls with blonde hair and blue eyes. These design differences were intended to encourage engagement and minimize “neither” responses.

Procedure

The experiment was conducted online using a mixed-participants design. Each child was shown one of three pairs of stimuli, presented on either smartphone or computer screens (including tablets), and asked, “Which one would you like to play with?” The child selected one toy from each pair, and the same question was repeated for all three pairs. The procedure followed a design similar to that used in a previous study investigating gender stereotypes, in which children selected an appropriate character (male or female) to match a story using repeated measures (Bian et al., 2017).

The order of stimulus presentation was pseudo-randomized, as was the placement of the stimulus (right versus left). Therefore, each participant answered three questions in total. Parents were instructed to read the questions verbatim and refrain from giving their children any hints. If a child failed to respond after three prompts or provided inconsistent answers, parents were asked to report this separately.

Ethical Considerations

Prior to the experiments, parents were provided with information about the study’s design, purpose, and procedures, presented on the first page of the online survey. They were informed that they could discontinue the survey at any time if their children declined to answer questions or view the images. Parents who agreed to their children’s participation completed and submitted the survey. Submission of the completed survey was considered to indicate parental consent. The study was conducted in accordance with the principles of the Declaration of Helsinki and received ethical approval from the Institutional Review Board of the author’s university.

Results and Discussion

To the best of my knowledge, there is no previous evidence demonstrating that robots are perceived as toys for boys. In this study, boys were presented with male dolls and girls with female dolls, alongside standard commercially available humanoid robots. Consequently, it was difficult to code the children’s responses based on gender-type versus non-gender-type toy choices (e.g., 1 for gender-typed and – 1 for non-gender-typed choices), because the gender associations between robots and dolls differed for boys and girls. Male dolls and humanoid robots perceived as male could both be categorized as boy-related toys, whereas female dolls and these robots were less comparable. Therefore, children’s responses were coded as 1 for choosing a robot and – 1 for choosing a doll. Mean preference scores were obtained by

averaging results across the three trials for each age and gender group (Fig. 2). Positive scores indicated a tendency to choose robots, negative scores indicated a tendency to choose dolls, and a score of zero indicated no preference.

A 3 (pair: 1, 2, 3) $\times$ 2 (gender: girls vs. boys) $\times$ 3 (age: 3, 4, 5 years) mixed-design ANOVA with pair as the within-participant factor, using SPSS (IBM, Armonk, NY, USA), showed no significant main effect of pair [$F(2, 306) = .049, p = .952, \eta^2 = .000$] and no interaction between pair and gender [$F(2, 306) = .762, p = .468, \eta^2 = .005$].

A 2 (gender: girls vs. boys) $\times$ 3 (age: 3, 4, 5 years) between-participants ANOVA on mean preference scores (Fig. 2) revealed a significant main effect of gender [$F(1, 153) = 145.840, p < .001, \eta^2 = .488$]. Boys ($M = .749$) showed significantly higher preference scores than girls ($M = -.512$). Neither the main effect of age [$F(2, 153) = 1.035, p = .358, \eta^2 = .013$] nor the interaction between gender and age [$F(2, 153) = .372, p = .690, \eta^2 = .005$] was significant. Overall, boys were more likely than girls to choose robots, whereas girls tended to prefer dolls, across age groups.

Furthermore, one-sample t -tests were conducted for each age and gender group to confirm whether children demonstrated gender-related preferences (Table 1). Each group's mean preference score was compared to zero (no gender-related preference). Bonferroni corrections were applied to adjust for multiple comparisons (multiple of six). With the exception of 5-year-old girls, all groups exhibited significant gender-related preferences.

Table 1
Results of One-sample T-Tests Conducted for Each Age and Gender Group in Study 1

3 years	Boy		Cohen's d	Girl		Cohen's d
	$t(25) = 5.640$	**	1.106	$t(25) = -4.961$	**	0.973
4 years	$t(26) = 9.053$	**	1.742	$t(25) = -3.313$	*	0.650
5 years	$t(26) = 7.416$	**	1.427	$t(26) = -2.412$		0.464
Note. ** < .01, * < .05.						

Overall, Study 1 showed that boys preferred robots, whereas girls preferred dolls. To the best of my knowledge, no prior empirical research has examined whether children exhibit gender-related preferences for robots relative to other toys. Although one might expect different results given that humanoid robots share some doll-like characteristics, the current findings align with prior research showing that children often associate robots with masculinity (Bers et al., 2013; Master et al., 2017; Sullivan & Bers, 2016a) and that girls typically prefer dolls (Davis & Hines, 2020; Todd et al., 2018). This may be explained by prior research, which indicates that boys are better at assembling robotic parts, likely due to their familiarity with mechanical toys such as cars (Sullivan & Bers, 2013), which are

traditionally considered boy-related toys (Davis & Hines, 2020; Todd et al., 2018). The present findings provide direct evidence of gender-related preferences for robotic toys among preschool-aged children. Further, this pattern aligns with social learning or social cognitive theory, which suggests that children internalize gendered norms through observation and reinforcement (Bussey & Bandura, 1999). Boys' preference for robots may reflect early exposure to male-typed mechanical play, whereas girls' interest in dolls reflects socialized nurturing play schemas.

No developmental differences in children's toy preferences emerged in the ANOVA results. Although meta-analytic evidence shows that gender-type toy interests typically strengthen with age (Davis & Hines, 2020), the current findings did not show such a trend. However, only 5-year-old girls' scores were not significantly different from zero. The effect size of the one-sample *t*-test for 5-year-old girls (Cohen's *d*: 0.464) was the smallest among girls (3-year-olds; 0.973; 4-year-olds; 0.650). Although not statistically significant with the ANOVA results, the trend among 5-year-old girls toward increased robot preference suggests early flexibility in gendered toy interest, warranting further investigation.

Unlike mechanical robots typically used for programming in educational settings (Master et al., 2017; Sullivan & Bers, 2013, 2016a), the humanoid robots in this study exhibited doll-like features, which might have appealed to some girls. Future research may explore whether introducing humanoid robots with features aligned to girls' aesthetic preferences could increase engagement. Such findings could inform inclusive STEM education strategies.

To further test whether modifying robot features could shift girls' preferences, Study 2 examined girls' responses to girl-oriented humanoid robots using the same set of dolls.

Study 2

Study 2 focused on 3- to 5-year-old girls and examined whether modifying humanoid robots to appear more girl-oriented would influence their toy preferences. The robots presented in this study were redesigned using AI-generated imagery to include doll-like facial features with pink and/or lavender hues, which girls generally prefer (Jonauskaite et al., 2019; LoBue & DeLoache, 2011). The goal was to determine whether such visual adjustments could positively affect young girls' interest in robots.

Methods

Participants

An a priori power analysis using G*Power for a one-way ANOVA (fixed effects, omnibus, one-way) was conducted. Parameters were set as follows: effect size = 0.25, alpha = 0.05, power = 0.80, and number of groups = 3 (ages 3, 4, and 5 years; 3 – 1). The analysis indicated that a total sample size of 159 participants (approximately 53 participants per group) was required. Because few children selected

neither option in Study 1 and the stimuli in Study 2 were more uniform, approximately 60 children were recruited per age group.

The final sample comprised 183 girls: 60 three-year-olds ($M = 40.30$ months, $SD = 3.290$, age range = 36–47 months), 63 four-year-olds ($M = 55.27$ months, $SD = 3.308$, age range = 48–59 month), and 60 five-year-olds ($M = 63.08$ months, $SD = 2.479$, age range = 60–69 month). One 3-year-old child who did not choose either option was excluded from the analyses.

Materials

Each participant viewed three fixed pairs of images, each consisting of a girl-oriented robot and a doll (Fig. 1). The dolls were identical to those used in Study 1. Because no commercially available humanoid robots resembled girl dolls, new robot images were generated using Google Gemini. The prompts were designed to produce robots with feminine characteristics—bright pink hues, decorative elements, slender body—while maintaining a humanoid structure similar to existing robots.

All AI-generated images were produced using Google Gemini’s public model, and no real child likenesses were used. Images were generated solely for research purposes. To ensure novelty and ethical integrity, image searches were conducted using Google, Microsoft Bing, TinEye, SmallSE, SauceNAO, and Yandex to confirm that comparable robots did not exist. Additionally, the images were reviewed by Softbank Robotics Japan to verify that they did not violate the company’s intellectual property (e.g., Nao and Pepper designs).

Procedures

The procedures were identical to those used in Study 1, except that only girls participated and were presented with girl-oriented robots and dolls.

Ethical Considerations

Prior to the experiments, parents read the first page of the online survey that described the study design, purpose, and procedures. It explained that they could stop answering the survey if their children refused to answer questions or see the pictures. Parents who agreed to their children’s participation sent their answers after completing the survey. Submission of their answers was considered to indicate informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki, and was approved by the Institutional Review Board of the author’s university.

Results and Discussion

Mean preference scores were obtained using the same procedure as in Study 1 (Fig. 3). A 3 (pair: 1, 2, 3) $\times 3$ (age: 3, 4, 5 years) mixed ANOVA with pair as a within-participant factor, using SPSS (IBM, Armonk, NY, USA), revealed no significant main effect of pair [$F(2, 514) = .927, p = .396, \eta^2 = .004$] and no interaction between pair and age [$F(4, 514) = .124, p = .974, \eta^2 = .001$].

A one-way ANOVA with a between-participants design (age: 3, 4, 5 years) was conducted for the mean preference scores. The main effect of age was not significant [$F(2, 179) = 1.238, p = .292, \eta^2 = .014$].

As in Study 1, one-sample t -tests were conducted for each age group to confirm whether girls exhibited gender-related preferences (Table 2). These tests compared each age group’s mean preference score against zero (no gender-related preference). Bonferroni corrections were applied (multiple of three). With the exception of 3-year-old girls—whose results were marginally significant—girls across all ages significantly preferred dolls.

Table 2

Results of One-Sample T-Tests Conducted for Each Age Group in Study 2

Girls' ages		Cohen's d	
3 years	$t(58) = -2.349$	†	0.306
4 years	$t(62) = -2.809$	**	0.354
5 years	$t(59) = -4.890$	**	0.618
Note. ** < .01, * < .05, † < .10.			

To determine whether the girl-oriented design increased robot preference relative to Study 1, a 2 (study: 1 vs. 2) × 3 (age: 3, 4, and 5 years) between-participants ANOVA was conducted on the mean preference scores (Fig. 3). The main effect of the study was marginally significant [$F(1, 255) = 2.768, p = .097, \eta^2 = .011$]. Girls in Study 2 ($M = -0.336$) showed slightly higher preference scores than girls in Study 1 ($M = -0.512$), indicating a small shift toward robot selection. The main effect of age [$F(2, 255) = .069, p = .934, \eta^2 = .011$] and the interaction between age and study [$F(2, 255) = 1.698, p = .185, \eta^2 = .013$] were not significant.

Overall, Study 2 demonstrated that 3- to 5-year-old girls continued to prefer dolls, though 3-year-olds exhibited a milder tendency, with scores marginally lower than zero in the one-sample t -tests. Further, the one-sample t -tests revealed that the effect sizes for 3- and 4-year-olds (Cohen’s $d = 0.31$ and 0.35 , respectively) were small to medium, suggesting that younger children showed a weaker preference. When comparing Studies 1 and 2, girls exposed to girl-oriented robots were marginally more likely to choose robots than those in Study 1, suggesting that the modifications had a small positive influence on their interest. However, the limited magnitude of this effect indicates that superficial changes (e.g., color and facial design) are insufficient to substantially alter girls’ interest in robots.

General Discussion

The present study investigated whether 3- to 5-year-old children show gender-related preferences when choosing between robots (typically considered boy-related toys) and dolls (girl-related toys). Study 1

used standard, commercially available humanoid robots, whereas Study 2 introduced girl-oriented robots designed to be more appealing to girls. Three hypotheses were proposed: (1) children would prefer gender-consistent toys (boys choosing robots, girls choosing dolls), with a weaker tendency among girls owing to the human-like features of robots; (2) gender-related preferences would strengthen with age (Davis & Hines, 2020; Todd et al., 2018); and (3) girl-oriented robots would reduce girls' preference for dolls. Overall, the results partially supported these hypotheses, though no developmental changes were observed.

As predicted, 3- to 5-year-old children demonstrated clear gender-related toy preferences. Boys preferred robots and girls preferred dolls, consistent with previous studies (Campenni, 1999; Davis & Hines, 2020; Nelson, 2005; Rheingold & Cook, 1975; Sullivan & Bers, 2013). In Study 1, 84–88% of boys selected robots and 72–74% of girls selected dolls. Similarly, in Study 2, girls' preference for dolls remained high, with 61–69% of them selecting dolls. These results indicate that gender-related preferences for robots emerge as early as age three. Previous research indicates that fewer preschoolers and younger elementary school children believed robots were for boys than LEGO was (Sullivan & Bers, 2016a). Moreover, at later developmental stages, boys from elementary to high school showed positive attitudes toward robotics, such as confidence (Nourbakhsh et al., 2004; van Wassenaeer et al., 2023). The present results suggest that this attitude is rooted in early childhood.

Contrary to the second hypothesis, age did not influence children's gender-related toy preferences in either study. This stability may reflect the distinctive status of robots as toys that consistently evoke gender associations across the preschool years. Alternatively, it may reflect cultural influences—Japanese children's gender-related toy preferences remain stable throughout the preschool period, unlike those in Western countries (Davis & Hines, 2020). Japan's gender gap ranking (118th of 146 countries; Pal et al., 2024) suggests that gender roles remain highly salient. Japanese children are more likely to choose toys based on traditional gender roles from an early age. However, cross-cultural comparisons have reported mixed results. For example, in Italy, which had a gender gap ranking of 87, children demonstrated gender-typed preferences in toy selection (Zammuner, 1987), whereas Swedish children, with a much smaller gender gap (ranked 5th), showed gender-related toy preferences similar to those of children in other Western countries (Nelson, 2005). To explore cultural factors more closely, future research should examine parental attitudes and the socialization of gender roles in relation to children's toy choices.

Interestingly, 5-year-old girls in Study 1 and 3-year-olds in Study 2 displayed marginally weaker gender-type preferences, though in opposite directions. Younger girls in Study 2 may have perceived the pink, doll-like robots as gender-appropriate, whereas older girls in Study 1 may have had a more consolidated understanding of what a robot is. Alternatively, 4- and 5-year-old girls may have preferred familiar toys, such as dolls with blonde hair, over unfamiliar robotic toys (or AI-generated girl-oriented robots not available on the market) that appeared mechanical. However, this cannot explain why 5-year-olds in Study 1 were less likely to choose dolls. It is possible that older girls were more interested in humanoid or boy-like toys. These results must be interpreted carefully because they were observed only in one-

sample *t*-tests comparing mean preference scores with zero (no preference). However, the implication thereof is that presenting girl-oriented robotic toys may be more effective for younger children. This aligns with previous findings suggesting that early robotics education positively shapes girls' STEM motivation (Bers et al., 2013; Master et al., 2017; Sullivan & Bers, 2019a, 2019b). Thus, familiarizing girls with diverse robot designs early in life could help mitigate emerging gender disparities in robotics-related interest.

Another key finding was that boys rarely chose dolls, even when boy dolls were presented, similar to those typically found in boys' bedrooms (Rheingold & Cook, 1975). This aligns with previous findings that boys favor mechanical or action-based toys over nurturing or comfort-oriented ones (Campenni, 1999; Nelson, 2005; Rheingold & Cook, 1975; Varney, 2002). Moreover, boys were found to be more likely to build objects with wheels when playing with LEGO (Fulcher & Hayes, 2018). Boys' consistent attraction to mechanical objects—also evident in non-human primate studies (Alexander & Hines, 2002; Hassett et al., 2008)—suggests a possible biological basis for some toy preferences. Liu et al. (2020) suggested that gender-related toy preferences may emerge as early as 15 months. Boys' preference for machines (e.g., toys with wheels or mechanical toys) may develop after 15 months of age and persist throughout the preschool period, and across species. The present study extended these patterns cross-culturally.

Study 2 further explored whether humanoid robots with girl-oriented features could enhance girls' interest in robotic toys. Although girls were slightly more likely to choose these robots compared to standard ones, the difference was marginal. According to prior findings, girls are generally less confident and interested in STEM fields (Kucuk & Sisman, 2020; Sullivan & Bers, 2013, 2016a), and early robotics education exposure can increase their motivation toward these fields (Bers et al., 2013; Master et al., 2017; Sullivan & Bers, 2013, 2016a, 2019a). Therefore, it was proposed that creating girl-oriented, doll-like humanoid robots could positively influence girls' attitudes toward robotics. However, the marginal difference suggests that modifying superficial visual features—such as color and shape—alone may not be sufficient to alter gender-related preferences. Instead, functional and play-related features (e.g., whether they are mechanical, have parts that can be assembled, provide comfort, or are suitable for pretend play) may better influence interest. Nevertheless, the wide variability in girls' scores indicates individual differences that can be leveraged. Incorporating girl-oriented design features into early robotics education might still serve as a useful strategy for reducing the gender gap in STEM participation.

This study has several limitations. First, because no girl-oriented humanoid robots are commercially available in Japan, AI-generated images were used as proxies. However, given that many children today select toys online, this limitation may have minimal ecological impact. Second, the experiments were conducted online; while prior work suggests that online methods can yield comparable results to in-person settings (Meng et al., 2024; Okanda et al., 2022; Sullivan & Bers, 2019a), in-person replication would further validate these findings. Finally, although parental bias was minimized by including both mothers and fathers (86 fathers and 76 mothers in Study 1; 75 fathers, 107 mothers, and one undisclosed in Study 2), qualitative data on parents' gender attitudes could strengthen future analyses.

Conclusion

This study examined young children's preferences for gender-related toys such as humanoid robots. Across both studies, boys preferred robots and girls preferred dolls, with no significant age-related changes. However, it is possible that some 5-year-old girls in Study 1 were interested in commercially available robots. Although the girl-oriented robots in Study 2 did not fully spark girls' interest, 3-year-olds did not necessarily prefer dolls. This suggests that young girls, without a concrete understanding of robots, may have chosen robots because of their girl-oriented features. Therefore, girls need to become familiar with girl-oriented humanoid robots at an early age and use them in play (e.g., programming a robot to take on a desired role in pretend play, or using it as a communication partner). This may, in turn, foster girls' interest in robotics and future participation and confidence in STEM fields (Bers et al., 2013). Moreover, this study is the first to reveal children's preferences for humanoid robots using AI-generated stimuli. Future research should investigate how free play or programming experiences with standard—and, where possible, girl-oriented—humanoid robots influence children's interest in robotics and related fields, particularly among girls.

Declarations

Author Contribution

MO conceptualized the paper, conducted formal data analysis, acquired funding, conducted investigation, developed the methodology, managed project administration, provided resources, and wrote, reviewed, and edited the original draft.

Acknowledgement

I thank the parents and children who participated in this study. We would like to thank Editage (www.editage.jp) for their assistance in language editing and creating the graphical abstract for this paper.

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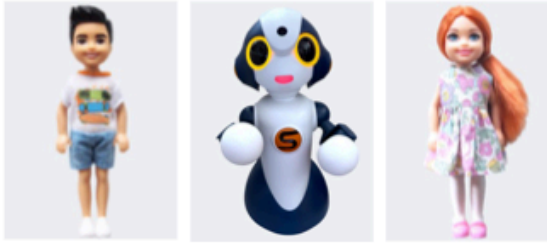
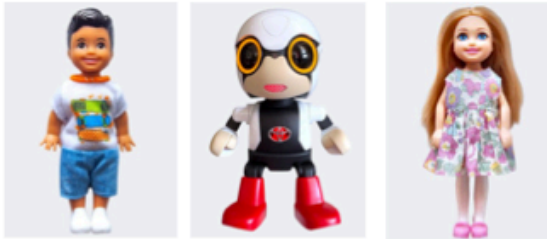
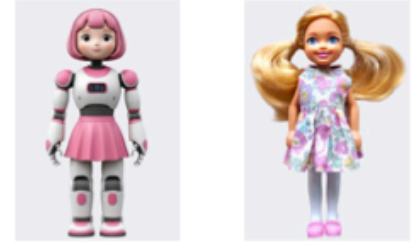
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Figures

A**Boy****Girl****Pair 1****Pair 2****Pair 3****B****Girl****Pair 1****Pair 2****Pair 3****Figure 1**

Robots and Dolls Used in Study 1 (A) and Study 2 (B)

Note. A: Children were presented with robots appearing in the center. Boys were presented with a male doll on the left, whereas, girls were presented with a female doll on the right. The pairings were fixed. B: The dolls were the same as in Study 1, and the robots were AI-generated using Google Gemini.

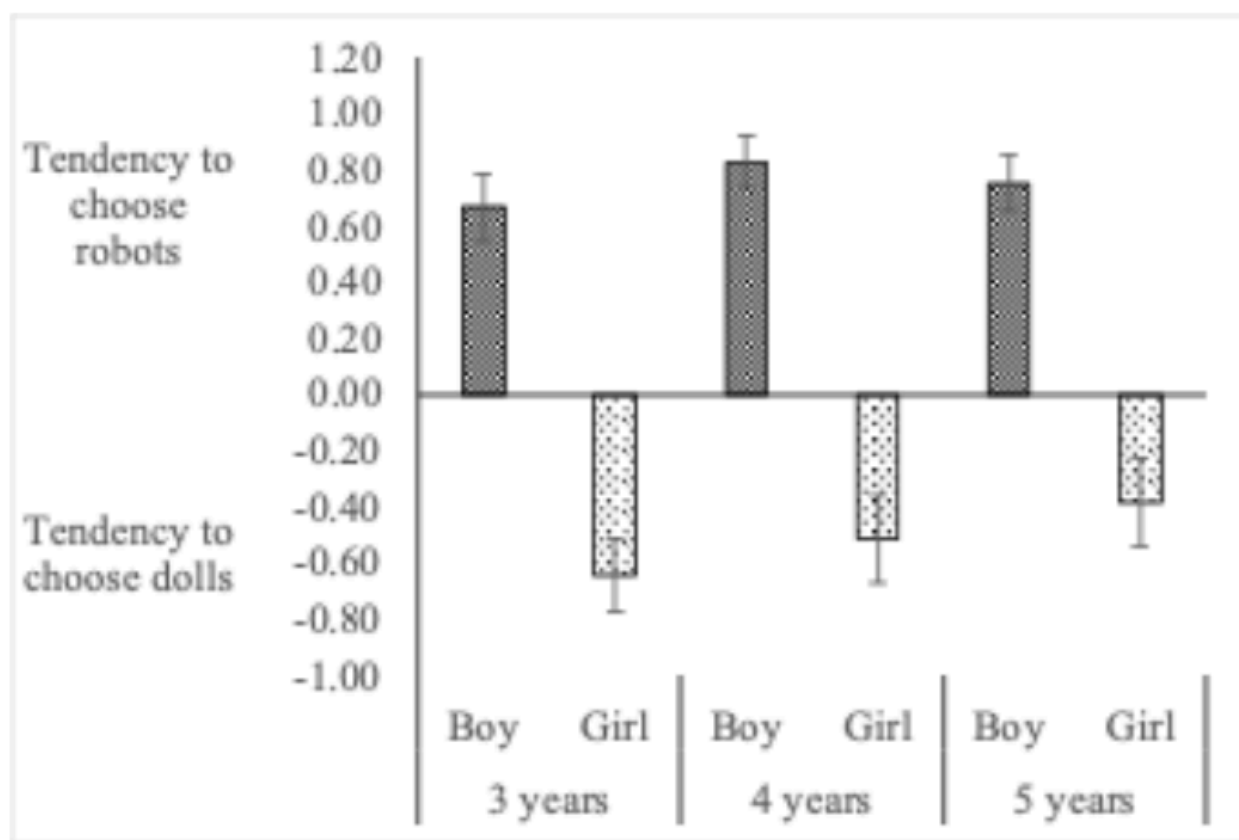


Figure 2

Children's Mean Preference Scores in Study 1

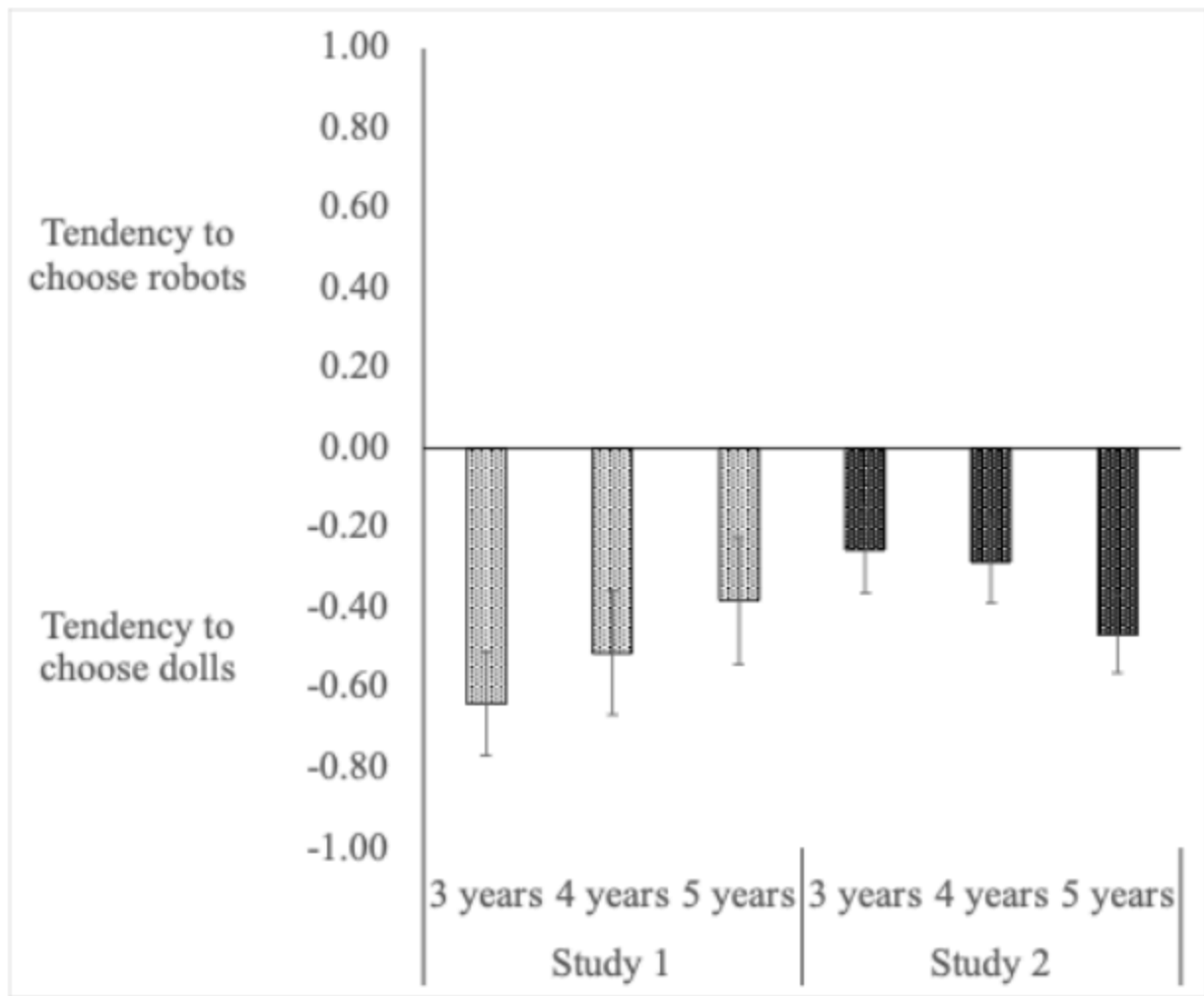


Figure 3

Mean Preference Scores for Girl-Oriented Robots and Dolls in Study 2