The role of social eye-gaze in children's and adults' ownership attributions to robotic agents in three cultures

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Young children often treat robots as social agents after they have witnessed interactions that can be interpreted as social. We studied in three experiments whether four-year-olds from three cultures (China, Japan, UK) and adults from two cultures (Japan, UK) will attribute ownership of objects to a robot that engages in social gaze with a human. Participants watched videos of robot-human interactions, in which objects were possessed or new objects were created. Children and adults applied the same ownership rules to humans and robots – irrespective of whether the robot engaged in social gaze or not. However, there was cultural variation in the types of ownership rules used. In Experiment 3, we removed further social cues, finding that just showing a pair of self-propelled robot-arms elicited ownership attributions. The role of social gaze in social attributions to robots and cross-cultural differences in ownership understanding are discussed.

Keywords: social gaze; ownership; robots; cross-cultural; social cognition

1. Introduction

The ability to control objects in the environment and to own property seem to be intimately linked to our understanding of human autonomy. Yet, developmental research has discovered an early emergence of attributions of autonomy, intentionality, and goal-directedness to non-human agents such as geometric shapes

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(Csibra, 2008; Kuhlmeier, Wynn, & Bloom, 2003). Robots are a paradigmatic example of non-human agents that can appear uncannily human (Gray & Wegner, 2012) and can offer a prime case to probe intuitions about what it takes to appear as a human agent (MacDorman & Ishiguro, 2006). Research has found that robots that engage in eye gaze and contingent movement with a human trigger behaviors in children that are akin to their responses towards human agents (e.g. Arita, Hiraki, Kanda, & Ishiguro, 2005; Itakura et al., 2008; Meltzoff, Brooks, Shon, & Rao, 2010). However, do children also apply more complex social constructs such as ownership to robotic agents that engage socially with humans (i.e. engage in mutual eye gaze)?

1.1 Eye gaze and social agency

Eye gaze is a powerful social tool. It plays an important role in social coordination and communication (Kendon, 1967), acts as a cue to intimacy and affiliation (Argyle & Dean, 1965), and helps to process information about people more quickly (Macrae, Hood, Milne, Rowe, & Mason, 2002). In addition, eye gaze facilitates shared attention with others (Frischen, Bayliss, & Tipper, 2007) and may be vital in understanding others as mental agents (Baron-Cohen, 1997). Developmental research shows that three-month-old babies will already follow an adult's gaze (Hood, Willen, & Driver, 1998), suggesting that sensitivity to eye gaze emerges shortly after birth. At 12 months of age infants show an understanding of eye gaze in a variety of situations such as following someone's gaze around barriers (Moll & Tomasello, 2004), expecting social partners to look at each other (Beier & Spelke, 2012) and engaging in joint attention with others by means of shared gaze (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998). By two years of age, children use eye gaze to infer what someone desires (Lee, Eskritt, Symons, & Muir, 1998) and by 6 years of age they rely on mutual eye gaze to infer relationships between people (Nurmsoo, Einav, & Hood, 2012). Children's early sensitivity to eye gaze is further supported by studies that show that 12-month-olds even follow the gaze of a non-human, amorphous agent to a target object (Johnson, Slaughter, & Carey, 1998) and that 15-month-olds imitate a non-human agent if the agent possess certain agency cues such as a face and eyes (Johnson, Booth, & O'Hearn, 2001).

Children's sensitivity to social eye gaze has been found to play an important role in children's behavior and stance towards robotic agents. Specifically, using a looking time paradigm, Arita and colleagues (2005) found that 10-month-olds expected a human to talk to a robot after the robot and a human had interacted socially (i.e. via gestures, speech and eye gaze), but did not show such an expectation in the absence of a mutual social interaction. Similarly, 18-month-olds follow a robot's gaze to an external target if the robot and the human have

talked to each other and displayed reciprocal imitation of each other's movements beforehand (Meltzoff et al., 2010). Focusing exclusively on mutual eye gaze between a robot and a human, Itakura and colleagues (2008) found that 2.5-year-olds imitated the intended outcome of a robot's action more often if the robot and the human had engaged in mutual eye gaze than if they had not done so. Importantly, in the absence of social cues children will usually cease to treat robots like human agents. For example, three-year-olds have been found to perseverate in a card sorting task after a demonstration by a human model, but not after a demonstration by a non-social robot (Moriguchi, Kanda, Ishiguro, & Itakura, 2010).

Taken together, the findings to date suggest that children will treat robotic agents similarly to human agents if the robot engages in mutual social interactions with a human agent. Yet, even though children may follow a social robot's gaze (e.g. Meltzoff et al., 2010) or imitate it (e.g. Itakura et al., 2008), there may be limitations in what children are willing to attribute to robotic agents. In a recent study, Kahn Jr. and colleagues (2012) interviewed 9- to 15-year-old children after they had interacted with Robovie (a social robot) and found that children viewed the robot as a social agent with mental states, but did not grant it full liberal and civil rights. In this study, however, children always interacted with a robot that behaved in a contingent and social manner and the role of social agency cues in eliciting social attributions to a robot was not directly investigated. Our study addressed this question and – in line with previous research on social agency in robots (e.g. Itakura et al., 2008) – manipulated whether the robot engaged in mutual social gaze with a human or not. Moreover, we wanted to study a social construct that is understood early on in human life, allowing us to test younger children. Ownership of objects is such a social construct. It plays an important role in young children's lives and is possibly one of the first social institutions that children begin to grasp (Kalish & Anderson, 2011).

1.2 The development of ownership understanding

Ownership of objects is a unique relation between people and objects. Children's understanding of ownership emerges during the second year of life when they first show the ability to recognize ownership relations and indicate who owns what (Blake & Harris, 2011; Fasig, 2000; Tomasello, 1998). During this time, children also become increasingly involved in conflicts over possession (Dunn & Herrera, 1997), in which first possessors or original owners are often at an advantage (Ross, Conant, & Vickar, 2011). Similarly, when being asked to infer ownership in third party scenarios (i.e. stories of children playing with toys), children from 2 years of age will usually side with the character who possessed an object first (first

possession rule; Friedman & Neary, 2008). By 3 years of age children will begin to use object history (Gelman, Manczak, & Noles, 2012) and object category (natural kinds vs. artifacts; Neary, van Vondervoort, & Friedman, 2012) to determine ownership. In addition, they will assign ownership to the person who invested labor into creating a new object (Kanngiesser, Gjersoe, & Hood, 2010) and show a first appreciation of ownership rights in their personal property or newly made things (Kanngiesser & Hood, 2014; Rossano, Rakoczy, & Tomasello, 2011). During the following years, children's understanding of ownership becomes more sophisticated, including insight into different ownership rights and transfers at four years of age (Blake & Harris, 2009; Kim & Kalish, 2009) and into ownership of ideas at age six (Olson & Shaw, 2011; Shaw, Li, & Olson, 2012).

Even though it has been suggested that every society knows some form of ownership (Brown, 1991), the majority of the research on the development of ownership understanding has been carried out in industrialized, Western populations (Canada, USA, Germany, UK). In a cross-cultural study, Furby (1978, 1980) interviewed five- and ten-year-olds and adults from the US, Israeli kibbutz groups and Israeli cities and found that in all three populations possession and ownership were associated with a sense of self, control, and efficacy. A more recent study found similarities in Japanese and British children's ownership transfers following the investment of labor – though developmental trajectories varied in the two populations across two different tasks (Kanngiesser, Itakura, & Hood, 2014). Although these results suggest similarities in ownership understanding in different industrialized cultures, the extent to which they would generalize to other tasks and cultures remains understudied.

We focused our investigation on two ownership rules – namely, the first possession rule (i.e. assigning ownership to the agent that possessed an object first; Friedman & Neary, 2008) and the labor rule (i.e. assigning ownership to the agent that made an object; Kanngiesser et al., 2010). These two rules were chosen because they emerge early in development (between two to three years of age), continue to be used into adulthood (Friedman, 2008; Kanngiesser & Hood, 2013), and have been found in a Western and an Eastern culture (labor rule only; Kanngiesser et al., in press). By studying these two rules in the context of robot-human interaction, we wanted to find out whether children would apply these ownership rules exclusively to human agents or whether they would use them indiscriminately for any type of agent – even non-social ones. In addition, we wanted to test whether these ownership attributions would generalize across three different, industrialized cultures.

1.3 Cross-cultural difference in attitudes towards robots

Studies on cultural differences in attitudes towards robots have primarily been carried out with adults from industrialized, Eastern and Western cultures such as

Japan, China and the US. Many studies have included participants from Japan as robots are more prevalent in Japanese pop-culture and everyday life than in many other cultures. In addition, Japanese culture is strongly influenced by Shintoism, according to which all things (natural and artificial) are imbued with living spirits. Consequently, there is a less pronounced dichotomy between the artificial and the natural than in Western cultures (Kaplan, 2004). Even though this suggests that Japanese may have more positive attitudes towards robots, cross-cultural studies so far have produced mixed results.

Using the negative attitude towards robots scale (NARS; Nomura, Suzuki, Kanda, & Kato, 2006), a survey with participants from seven different cultures such as Japan, China, the UK, and the US found an influence of culture on attitudes towards robots – contrary to predictions, however, Japanese participants had fewer positive stereotypes regarding robots than US participants (Bartneck, Suzuki, Kanda, & Nomura, 2007). Yet, a study comparing attitudes in China and Korea with attitudes in the US revealed that participants from the two Eastern cultures viewed robots as more anthropomorphic, likeable, and trustworthy than US participants (Li, Rau, & Li, 2010). In contrast, MacDorman and colleagues (2009) found that attitudes towards robots and reaction times on an implicit association task (IAT) were similar among members of university faculties in the US and in Japan. The impact of culture on attitudes towards robots thus remains an open question. It is also unclear whether different Eastern cultures (China, Korea, Japan) have similar views on robots or whether Japanese culture with its positive image of robots differs from other Eastern as well as Western cultures.

1.4 Present studies

The present study was designed to address the following two questions: (1) Do children attribute ownership to robots and does this attribution depend on agency cues such as social eye gaze? (2) Does culture shape the attribution of ownership to robotic agents in children and adults?

In line with previous studies on cross-cultural differences in attitudes towards robots we focused our investigation on different industrialized cultures (e.g. Nomura et al., 2006) and recruited 4-year-old children from Japan, China and the UK as well as adults from Japan and the UK. We studied whether children and adults would assign ownership of objects to a robotic agent based on rules that have been established for human agents (first possession rule: Friedman, & Neary, 2008; labor rule: Kanngiesser et al., 2010). Based on previous findings (Arita et al., 2005; Itakura et al., 2008), we predicted that children and adults would only assign ownership to a robot after the robot had engaged in mutual eye gaze with a human. We expected little cultural variation in the influence of

mutual gaze on children's ownership attributions given that sensitivity to eye gaze and to agency emerges early in development (Csibra, 2008; Kuhlmeier, Wynn, & Bloom, 2003), but we remained agnostic on how different cultural conceptions of non-human agents (e.g. animism in Japanese culture) influence adult ownership attributions to robots.

2. Experiment 1

In this experiment, 4-year-old children from China, Japan, and the UK were presented with videos of a human interacting with a humanoid robot (Robovie). Robovie has been used in previous studies on the role of social gaze in children's understanding of social agency in robots (e.g. Arita et al., 2005; Itakura et al., 2008). We manipulated whether children saw the robot and the human engage in mutual eye gaze at the beginning of each video (social-gaze group) or whether they did not see them engage in mutual eye gaze (non-social group). In the videos, one agent possessed an object (a piece of paper) first and the other agent either briefly held on to it (possession condition) or transformed it by drawing a picture (labor condition). At the end of each video, children were asked to decide who owns the object. Previous research has found that children assign ownership to the first possessor of an object, if the second agent has only briefly possessed it (Friedman, & Neary, 2008). However, they override first possession and assign ownership to the creator of an object, if the second agent has created something new (Kanngiesser et al., 2010).

2.1 Methods

2.1.1 *Participants*

In the British sample, forty-one 4-year-olds took part in the experiment. Twenty-one children were assigned to the social-gaze group (Mean Age = 53 months, SD = 4 months, Range = 47–60 months, 8 female) and twenty children were assigned to the non-social group (Mean Age = 55 months, SD = 4 months, Range = 48–61 months, 10 female). Eight additional children were excluded from the analysis either because they failed the control questions (seven children) or due to experimenter error (one child). The children were tested in Bristol, a city with a population of 400,000 in South West England. Testing took place at a developmental lab at Bristol University and at a local science museum, with equal numbers of children per group being tested in each location.

In the Chinese sample, thirty-seven 4-year-olds took part in the experiment. Eighteen children were assigned to the social-gaze group (Mean Age = 54 months,

SD = 3 months, Range = 48–59 months, 9 female) and nineteen children were assigned to the non-social group (Mean Age = 55 months, SD = 3 months, Range = 48–60 months, 10 female). One additional child was excluded because the child did not complete the experiment. The children were tested in Shengze, a town with a population of 180,000 situated in the Wujiang District of Jiangsu Province in Eastern China. All testing took place at a nursery.

In the Japanese sample, thirty-eight 4-year-olds took part in the experiment. Nineteen children were assigned to the social-gaze group (Mean Age = 54 months, SD = 2 months, Range = 50–56 months, 9 female) and nineteen children were assigned to the non-social group (Mean Age = 54 months, SD = 2 months, Range = 51–57 months, 9 female). Two additional children were excluded from the analysis because they failed the control questions (one child) or did not complete the experiment (one child). The children were tested in Kyoto, a city with a population of 1.5 million in the central part of the island Honshu in Japan. All testing took place at a child developmental lab at Kyoto University.

2.1.2 *Video stimuli*

The robot (Robovie) that featured in the videos was developed by Advanced Telecommunications Research Institute International (ATR), Kyoto. Robovie is a mobile robot of 1.2 meters height and equipped with movable eyes, arms and hands (see Figure 1), that has been used in previous studies to investigate children's understanding of social robots (e.g. Arita et al., 2005; Itakura et al., 2008).

In the videos, a human and the robot were placed at a table opposite each other, with the human always being seated at the left side of the table and the robot always being seated at the right side of the table (see Figure 1). At the beginning of each video one of the agents (the human or the robot) picked up a blank piece of paper, put it in front of herself/itself and then placed it in the middle of the table. The other agent then took the paper and manipulated it in one of two ways. In the *first possession condition*, the second agent was shown holding the paper and moving it around for 10 seconds. In the *labor condition*, the second agent was shown drawing a picture for 10 seconds. At the end of each condition the agent returned the final object to the middle of the table where it was displayed in a propped-up manner for 5 seconds at equidistance between the two agents. Each video was about 40 seconds long. In each condition, there was one video in which the human retrieved the paper first and one video in which the robot retrieved the paper first. Thus, each child watched four videos in total (two videos in each of the two conditions), which were presented in random order.

Half of the participants saw the robot and the human engaged in mutual eye gaze at the beginning of each video (social group) and half of the participants did not see them engage in mutual gaze (non-social group). In the *social-gaze group*,

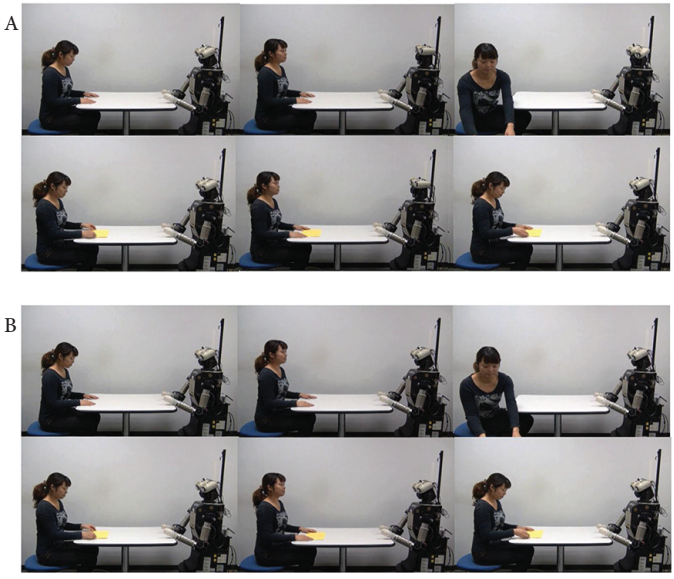

Figure 1. Sequence of movements in (A) the social gaze and (B) the non-social group at the beginning of the videos in Experiments 1 and 2. In the social group (A), the robot engages in mutual eye gaze while the human retrieves the paper. In the non-social group (B), the robot's gaze remains fixed on the middle of the table

mutual gaze was presented in the following way: Both agents initially held their gaze focused on the middle of the table, they then briefly looked at each other and started following the other agent's movement with their gaze (see Figure 1). That is, when the human retrieved the paper first, the robot's eyes and head followed the human's movement, and when the robot retrieved the paper first, the human followed the robot's movements. Once the paper had been placed on the table, both agents briefly looked at each other and then turned their gaze towards the middle of the table where it remained fixed until the end of the video. In the *non-social group*, all movements (i.e. picking up the paper and placing it on the table) – including the human's gaze behavior – remained the same except that the robot did not engage in mutual eye gaze and instead kept its gaze focused on the middle of the table throughout the entire video (see Figure 1).

2.1.3 *Procedure*

Children in all three populations were tested by a native speaker, who showed children the videos on a laptop. The experimenter stopped each video at the end of the interaction sequence, so that it showed the human (on the left hand side), the robot (on the right hand side) and the object (either a blank piece of paper

or a picture) in the middle of the table between the two agents. Next, she asked the child who the object belonged to (first possession condition: "Whose paper is it?"; labor condition: "Whose picture is it?"). The questions were translated into Japanese and Chinese and we consulted with native speakers to ensure that translations were accurate. Children were also asked to indicate who had the object first and who had it second to ensure that children correctly remembered the sequence of events in the videos. Data from children who failed to correctly answer the control questions to more than one video were excluded. Note that Chinese and Japanese children were asked the two control questions before they were asked the ownership question.

2.1.4 *Data coding and analyses*

We treated verbal responses and pointing to one of the agents on screen as equivalent responses. In each condition, we coded whether children assigned ownership to the first possessor or the second possessor (i.e. the laborer in the labor condition), respectively. If children said they did not know the answer or indicated both agents, their response was coded as "other".

We analyzed whether social gaze and culture had an influence on children's ownership assignments in the two conditions, using generalized linear mixed-effect models (GLMM) in R (R Development Core Team, 2005; lme4 package: Bates & Maechler, 2009). Responses for the two ownership conditions were analyzed separately and we entered as response variable whether children assigned ownership to the first possessor or the laborer (yes/no), respectively. Variables of interest such as gaze (social/non-social), agent (i.e. whether the human or the robot possessed the object first or labored on it) and culture (China/Japan/UK) were entered as fixed effects, and participant ID as a random effect due to the repeated measures design of the experiment. In addition, we controlled for effects of gender. As we were interested in the interaction between the three variables "culture", "agent" and "gaze" all three-way-interactions were included in the model. Initially, we always compared a model including all fixed effects and their interactions (full model) to a model including only the control variable "gender" and the random effect (null model) to test whether the fixed effects had any influence at all on children's ownership judgments in the two conditions. We only proceeded with the analysis if the full model differed significantly from the null model, and – when applicable – excluded non-significant interaction terms using likelihood ratio tests (i.e. comparing the more complex model to a simpler one).

2.2 Results and discussion

Children's ownership assignments in the first possession and in the labor condition, respectively, are depicted in Figure 2. In order to investigate whether social gaze

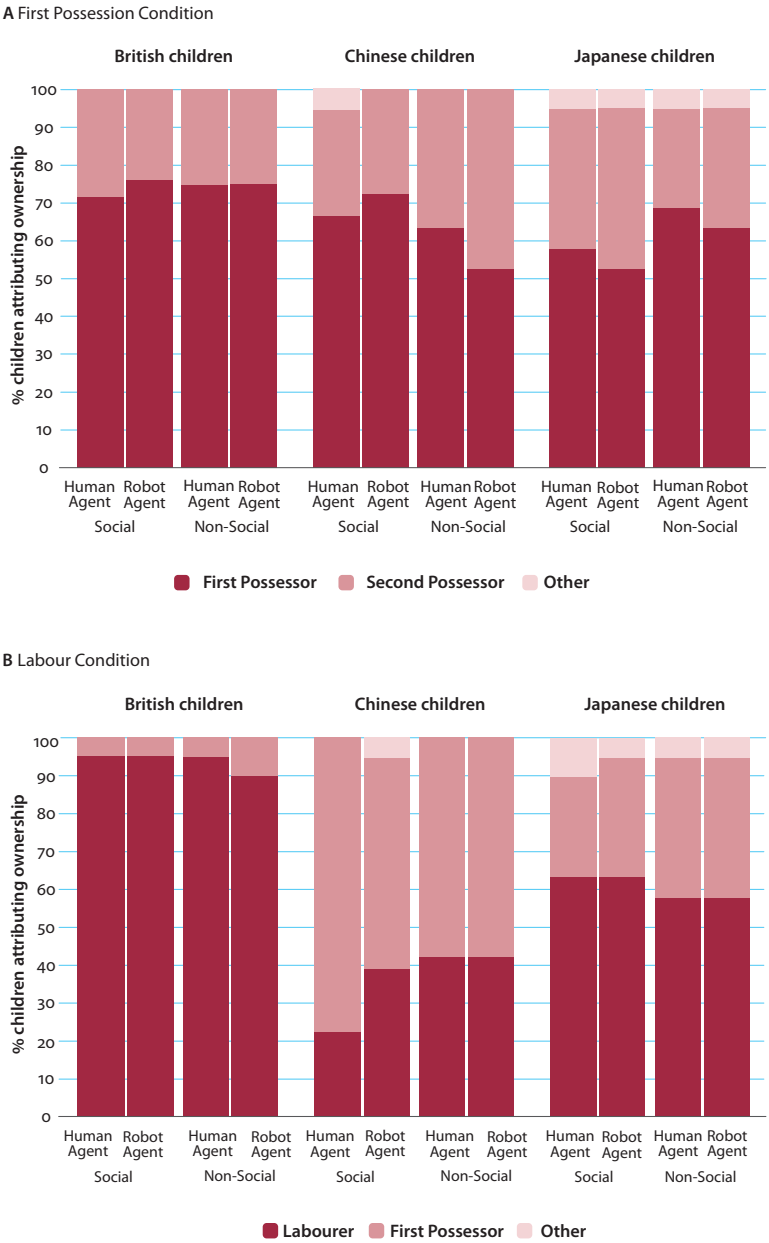

Figure 2. Ownership responses of British, Chinese and Japanese four-year-olds in Experiment 1 in (A) the first possession condition and (B) the labour condition. Data is shown separately for the social gaze and the non-social group, and for human and robotic agents.

and culture had an effect on children's ownership attributions, we used generalized linear mixed effects models (GLMMs). In the first possession condition, we found that a full model including culture (China/Japan/UK), agent (robot/human), and gaze (social/non-social) and all three- and two-way interactions between these variables did not differ significantly from a null model, i.e. a model excluding all variables of interest (likelihood ratio test: $\chi^2 = 6.43$, df = 11, p = .843). This suggests that none of the variables had an effect on children's ownership judgments in the first possession condition. In fact, children from all three cultures attributed ownership equally to the human and the robot irrespective of whether the two agents had engaged in social gaze or not. In the labor condition, tests revealed that the full model differed significantly from the null model (likelihood ratio test: $\chi^2 = 55.18$, df = 11, p < .001), but further analysis showed that none of the three or two-way-interactions were significant (see Table 1). The final model thus only included the main effects, revealing a significant effect of culture (see Table 1). Specifically, British and Japanese children were significantly more likely to assign ownership based on the investment of labor than Chinese children, and British children were significantly more likely to do so than Japanese children. Social gaze and agency, however, had no significant influence on children's ownership responses.

Given that neither social gaze nor agency had a significant effect on children's ownership attributions, we collapsed the data across the two dimensions to further investigate children's responses in the first possession and the labor condition. Specifically, we calculated an ownership score based on children's responses to the two videos in each of the two conditions (range of score = 0–2), scoring 1 every time they assigned ownership to the first possessor (first possession condition) or the laborer (labor condition; see Figure 3). We then compared these scores to chance (i.e. a score of 1) using Wilcoxon tests (exact, two-tailed). Since we found no effect of culture in the first possession condition, we combined the data from the three cultures, finding that children assigned ownership to the first possessor significantly more often than expected by chance ($Z = 4.05$, $p < .001$). In the labor condition, British children assigned ownership to the laborer significantly above chance ($Z = 5.69$, $p < .001$). In contrast, Japanese children's responses did not differ significantly from chance, $Z = 1.51$, $p = .185$, and Chinese children showed a marginally significant trend for assigning ownership to the laborer below chance (that is, to assign ownership to the first possessor), $Z = 2.13$, $p = .052$. Finally, we compared how often children assigned ownership to the first possessor in the two conditions to directly measure the effect of the investment of labor on ownership assignments. We found that British and Japanese children, but not Chinese children, assigned ownership significantly more often to the first possessor in the first possession condition than in the labor condition (British:

Table 1. Summary of fixed effects in GLMMs predicting children's use of the labour rule in Experiment 1

Parameter	**Model 1**	**Model 2**	**Model 3**
	Estimate (*SE*)	*Estimate* (*SE*)	*Estimate* (*SE*)
Constant	–0.41 (0.75)	–0.28 (0.72)	–0.67 (0.59)
Culture (China = 0, Japan = 1)	1.11 (0. 99)	0.83 (0.91)	1.64 (0.58)**
Culture (China = 0, UK = 1)	3.96 (1.39)**	3.87 (1.32)**	4.97 (0.91)***
[Culture (Japan = 0, UK = 1)][1]	–	–	–[3.34 (0.91)***][1]
Eye Gaze (Non-Social = 0, Social = 1)	-0.16 (0.98)	–0.42 (0.91)	–0.01 (0.55)
Agent (Human = 0, Robot = 1)	< 0.001 (0.78)	–0.26 (0.67)	–0.16 (0.37)
Gender (Female = 0, Male = 1)	–0.32 (0.56)	–0.31 (0.56)	–0.32 (0.55)
Culture (China = 0, Japan = 1) x Eye Gaze (Non-Social = 0, Social = 1)	0.54 (1.40)	1.10 (1.18)	–
Culture (China = 0, UK = 1) x Eye Gaze (Non-Social = 0, Social = 1)	1.19 (2.26)	1.29 (1.86)	–
Culture (China = 0, Japan = 1) x Agent (Human = 0, Robot = 1)	< –0.001 (1.09)	0.56 (0.79)	–
Culture (China = 0, UK = 1) x Agent (Human = 0, Robot = 1)	1.00 (1.92)	1.09 (1.43)	–
Eye Gaze (Non-Social = 0, Social = 1) x Agent (Human = 0, Robot = 1)	–1.16 (1.14)	–0.62 (0.75)	–
Culture (China = 0, Japan = 1) x Eye Gaze (Non-Social = 0, Social = 1) x Agent (Human = 0, Robot = 1)	1.16 (1.58)	–	–
Culture (China = 0, UK = 1) x Eye Gaze (Non-Social = 0, Social = 1) x Agent (Human = 0, Robot = 1)	0.16 (2.93)	–	–
Observations	232	232	232
Subjects	116	116	116
ΔLog likelihood	–	10.41	24.61
χ^2	–	0.48	2.63
Df	–	2	5
P	–	.786	.757

*p < .05, **p < .01, ***p < .001.
[1]obtained by changing the reference category to "China".

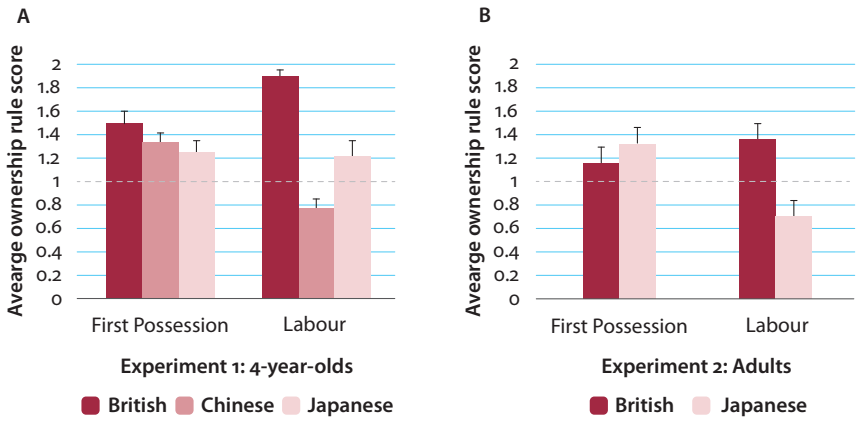

Figure 3. Average ownership sum scores (+SEM) for the two videos (human agent and robot agent) in the first possession and the labour condition. Data of the social gaze and of the non-social group were collapsed. (A) depicts children data from Experiment 1 and (B) depicts adult data from Experiment 2

$Z = 5.25$, $p < .001$; Japanese: $Z = 3.14$, $p = .001$; Chinese: $Z = 0.23$, $p = .758$). This indicates that the investment of labor had an effect on ownership assignments in British and Japanese children, but not in Chinese children. We thus found cultural variation in children's ownership attributions in the two conditions, with children from all three cultures using the first possession rule; yet, only British and (less so) Japanese children also used the labor rule.

Taken together, our results suggest that neither social gaze nor culture had an influence on whether children attributed ownership to a robot; that is, children from all three cultures treated the robot as a social agent. It is conceivable that children's ownership attributions to the robot are due to an early bias to over-attribute social agency to non-human agents that are equipped with eyes and move in a contingent way. The question remains, however, whether this childhood bias is overcome during development or whether it continues to influence ownership attributions in adults. In a second experiment, we thus presented adults with the same videos that children had watched to investigate whether adults would differentiate between human and robotic agents in their ownership responses. In addition, we wanted to maintain the cross-cultural angle of our work and thus conducted Experiment 2 with adults from the UK and Japan.

3. Experiment 2

In this experiment, adults from Japan and the UK watched the same videos that children had been presented with in Experiment 1.

3.1 Methods

3.1.1 *Participants*

In the British sample, thirty-nine adults from Bristol took part in the study. Nineteen adults were assigned to the social-gaze group (Mean age = 35 years, SD = 15 years, Range = 19–75 years, 9 female) and twenty adults were assigned to the non-social group (Mean age = 42 years, SD = 13 years, Range = 19–67 years, 12 female). Data from one additional adult was excluded due to failure to complete the survey. All participants were tested at a science museum in Bristol.

In the Japanese sample, forty adults from Kyoto took part in the study. Twenty adults were assigned to the social-gaze group (Mean age = 20 years, SD = 1 year, Range = 18–23 years, 10 female) and twenty adults were assigned to the non-social group (Mean age = 21 years, SD = 3 years, Range = 18–29 years, 10 female). All participants were tested in a testing room at Kyoto University.

3.1.2 *Video stimuli and procedure*

The video stimuli and the procedure were identical to the one used in Experiment 1 with the exception that adults were not asked any control questions. In addition, British adults watched the videos and answered the questions as part of a survey on a laptop. They were instructed to carefully watch each video and to indicate after each video who owned the final object. Japanese adults were shown the videos on a desktop computer and were asked to write down their answers on an answer sheet. Like in Experiment 1, we presented adults with an open ended response format instead of a binary choice (i.e. a choice between "robot" or "human") to avoid possible priming effects by using words such as "robot" or "human".

3.1.3 *Data coding and analyses*

Data coding and analyses were identical to Experiment 1.

3.2 Results and discussion

Adults' ownership attributions in the first possession and the labor condition, respectively, are depicted in Figure 4. Using generalized linear mixed effects models (GLMMs) we found that none of the variables of interest had a significant influence on adults' ownership responses in the first possession condition – that is, a full model including culture (Japan/UK), agent (robot/human), and gaze (social/non-

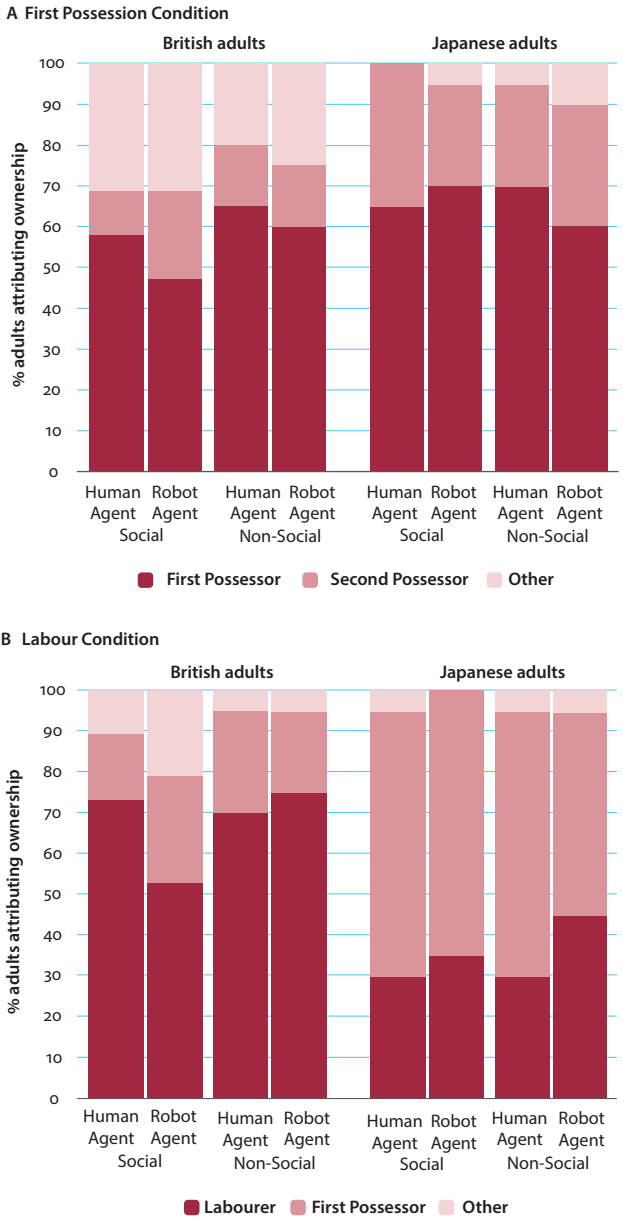

Figure 4. Ownership responses of British and Japanese adults in Experiment 2 in (A) the first possession condition and (B) the labour condition. Data is shown separately for the social gaze and the non-social group, and for human and robotic agents.

social) and all interactions did not differ significantly from a null model excluding all variables of interest (likelihood ratio test: $\chi^2 = 4.00$, df = 7, p = .780). In the labor condition, however, we found a significant difference between the full model and the null model (likelihood ratio test: $\chi^2 = 23.88$, df = 7, p = .001), but further analysis revealed that none of the three- or two-way-interactions had a significant effect (see Table 2 for details). The final model thus only included the main effects, revealing that British adults were significantly more likely to assign ownership after the investment of labor than Japanese adults (see Table 2 for details). Social gaze or agency, however, had no significant effect on ownership responses in the labor condition.

Table 2. Summary of fixed effects in GLMMs predicting adults' use of the labour rule in Experiment 2

Parameter	Model 1	Model 2	Model 3
	Estimate (*SE*)	*Estimate* (*SE*)	*Estimate* (*SE*)
Constant	−2.55 (1.54)	−2.05 (1.40)	−2.05 (0.95)*
Culture (Japan = 0, UK = 1)	5.54 (2.14)**	4.54 (1.88)*	3.82 (0.95)***
Eye Gaze (Non-Social = 0, Social = 1)	−1.15 (1.91)	−1.56 (1.71)	−0.96 (0.94)
Agent (Human = 0, Robot = 1)	−1.74 (1.11)	−2.19 (1.00)	−0.13 (0.49)
Gender (Female = 0, Male = 1)	2.40 (1.36)	2.25 (1.25)	1.74 (0.95)
Culture (Japan = 0, UK = 1) x Eye Gaze (Non-Social = 0, Social = 1)	−2.33 (2.87)	−1.17 (2.42)	–
Culture (Japan = 0, UK = 1) x Agent (Human = 0, Robot = 1)	1.04 (1.68)	2.07 (1.17)	–
Eye Gaze (Non-Social = 0, Social = 1) x Agent (Human = 0, Robot = 1)	1.13 (1.62)	2.08 (1.17)	–
Culture (Japan = 0, UK = 1) x Eye Gaze (Non-Social = 0, Social = 1) x Agent (Human = 0, Robot = 1)	2.35 (2.48)	–	–
Observations	158	158	158
Subjects	79	79	79
ΔLog likelihood	–	4.15	3.35
χ^2	–	0.91	6.69
Df	–	1	3
P	–	.340	.082

*p < .05, **p < .01, ***p < .001.

Similarly to our analysis in Experiment 1, we combined the data from the social-gaze and the non-social group, and calculated an ownership rule score

(range = 0–2) based on the ownership responses in each of the two conditions (see Figure 3B). When comparing the ownership scores to chance scores, we found that adults from both cultures used the first possession rule significantly above chance ($Z = 2.39$, $p = .023$). In case of the labor rule, however, only British adults used the rule significantly above chance ($Z = 4.05$, $p < .001$), while Japanese adults used the rule significantly below chance, that is, sided with the first possessor, $Z = 2.12$, $p = .050$. This result was further confirmed when comparing ownership assignments to the first possessor in the two conditions: we found a significant difference between conditions for British adults ($Z = 3.44$, $p < .001$), but not for Japanese adults ($Z = 0.61$, $p = .610$). Our data indicate cultural differences in adults' use of the two ownership rules; namely, that adults from both cultures used the first possession rule, but that only British adults also used the labor rule.

Overall, these findings suggest that social gaze and agency did not have an effect on adults' ownership attributions to robotic agents. Ownership attributions to robotic agents are thus not just an early bias that is overcome during development, but rather remain present into adulthood in the two cultures in this study (Japan and UK). Yet, it is possible that children and adults in the non-social group attributed ownership to the robot because we did not succeed in removing all social agency cues. For example, children have been found to attribute agency to simple amorphous shapes if they have a face and eyes or move in a contingent manner (Johnson et al., 1998; Johnson et al., 2001). In a final experiment, we thus further removed possible sources for social cues and studied whether this would have an impact on children's and adults' ownership attributions. Given that the previous experiments had not revealed any cross-cultural differences in how participants treated the human and the robotic agent, we only conducted this final experiment with British children and adults.

4. Experiment 3

In this experiment, British 4-year-olds and adults were tested with two sets of video stimuli, in which we further reduced social agency cues (1) by removing the robot's pair of camera-eyes (no-eyes group), and (2) by only showing the robot's arms (robotic-arms group).

4.1 Methods

4.1.1 *Participants*

Forty-one British 4-year-olds took part in the experiment. Twenty children were assigned to the no-eyes group (Mean Age = 55 months, SD = 4 months, Range = 47–60 months, 10 female) and twenty-one children were assigned to

the robotic-arms group (Mean Age = 55 months, SD = 4 months, Range = 48–59 months, 16 female). In addition, thirty-nine British adults took part in the experiment, twenty adults were assigned to the no-eyes group (Mean age = 37 years, SD = 13 years, Range = 22–67 years, 14 female) and nineteen adults were assigned to the robotic-arms group (Mean age = 38 years, SD = 17 years, Range = 18–70 years, 12 female). Children and adults were tested at a science museum in Bristol.

4.1.2 *Video stimuli*

Video stimuli were similar to the ones used in Experiment 1 and 2, with the following exceptions. In the *no-eyes group*, the robot's camera eyes were removed and in the *robotic-arm group*, only the robot's two arms were visible (see Figure 5). In both groups, the human in the video performed the same gaze movements as in the videos used in Experiments 1 and 2.

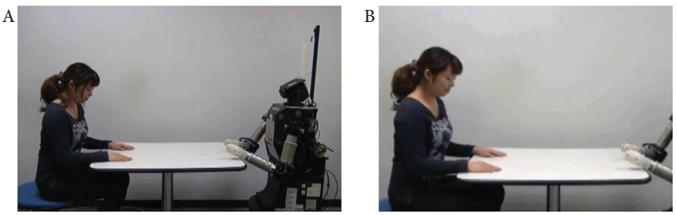

Figure 5. Images from the videos used (A) in the no-eyes group and (B) in the robotic-arms group, respectively

4.1.3 *Procedure*

The procedures for children and adults were identical to the ones used in Experiment 1 and 2, respectively.

4.1.4 *Data coding and analyses*

Data coding and analyses were identical to Experiments 1 and 2 with the exception that we included the data from the social-gaze group from Experiments 1 and 2 (British data only) into the generalized linear mixed models. This allowed us to directly assess the effect of removing further social cues on participants' ownership attributions.

4.2 Results and discussion

Children's and adults' ownership assignments in the first possession and labor condition, respectively, are depicted in Figure 6. None of the variables of interest (i.e. social cues and agent) had a significant effect on children's ownership

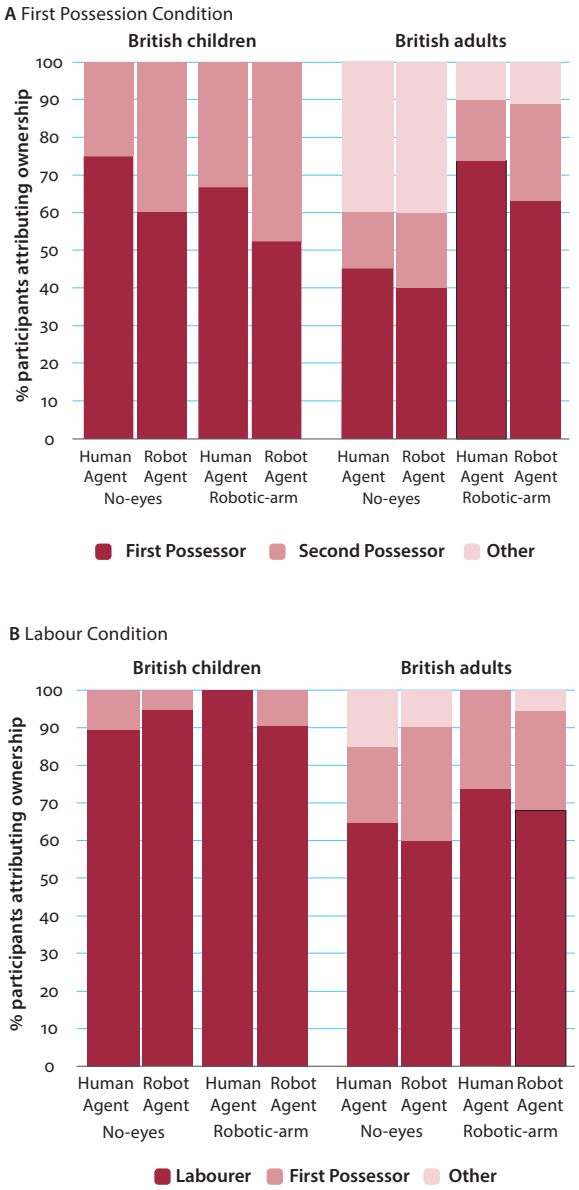

Figure 6. Ownership responses of British four-year-olds and adults in Experiment 3 (A) in the first possession condition and (B) the labour condition. Data is shown separately for the social gaze and the non-social group, and for human and robotic agents.

responses in the first possession condition (likelihood ratio test between null model and full model: $\chi^2 = 5.97$, $df = 5$, $p = .309$). In the labor condition, the full model differed significantly from the null model (likelihood ratio test: $\chi^2 = 17.49$, $df = 5$, $p = .004$); yet, none of the variables in the full model (nor their interactions) had a significant effect.[1] Similarly, adults' ownership responses in the two conditions were not significantly affected by any of the variables that were entered into the models (likelihood ration test, first possession condition: $\chi^2 = 5.05$, $df = 5$, $p = .410$; likelihood ratio test, labor condition: $\chi^2 = 6.87$, $df = 5$, $p = .230$). Thus, even when we showed children and adults a robot without eyes or only a pair of robotic arms, they continued to assign ownership to the robot. This indicates that cues such as the self-propelled movement of the robot-arms, their anthropomorphic shape, or the contingent gaze behavior of the human (or possibly all three of these cues) may have been sufficient to elicit ownership attributions. Our findings are in contrast to earlier studies with the same robot (Robovie) that had found that children only attributed social agency to the robot if the robot and a human engaged in a mutual social interaction, but not if only one of the agents (i.e. the robot or the human) behaved socially (Arita et al., 2005; Itakura et al., 2008). Interestingly, we found a bias to attribute ownership even to robotic arms in children as well as in adults, suggesting that this is an early emerging intuition that persists into adulthood.

5. General discussion

In a series of experiments, we investigated whether social gaze in a robot-human interaction will influence 4-year-olds' and adults' ownership attributions to robotic agents and whether these attributions may differ across three cultures (China, Japan, and the UK). In Experiments 1 and 2, we found that British, Chinese and Japanese children as well as British and Japanese adults did not distinguish between human and robotic agents in their ownership judgments – irrespective of whether the robot was presented as a social agent (i.e. engaged in mutual eye-gaze) or not. However, we observed cultural variation in children's and adults' ownership assignments in the first possession and in the labor condition. A third experiment revealed that only seeing self-propelled robot-arms was sufficient to elicit

1. Model estimations produced false convergence warnings, indicating problems with the parameter estimation. They were most likely due to the fact that most children used the labor rule (117 out of 124 responses). Model parameters and likelihood ratio tests thus need to be interpreted with caution.

ownership attributions to robots in young children and adults. We will first discuss the implications of these findings for research on the role of eye gaze in children's and adults' psychological stance towards robots and will then elaborate on the cross-cultural development of ownership attributions.

5.1 The role of eye gaze on ownership attributions to robotic agents

We found that children from three cultures (China, Japan, UK) and adults from two cultures (Japan, UK) attributed ownership to a robot, irrespective of whether the robot engaged in social gaze with a human or not. Moreover, presenting a robot without eyes or only showing a pair of robotic arms did not have an influence on British children's and adults' ownership attributions. Children and adults thus made social attributions to a robot in the absence of strong social cues such as mutual social gaze or even a pair of eyes. These findings are in contrast to previous studies that found that infants and young children will only expect a human to talk to a robot, imitate the robot or follow its gaze after they had observed a mutual social interaction between the robot and a human (Arita et al., 2005; Itakura et al., 2008; Meltzoff et al., 2010).

In fact, the findings from Experiment 3 indicate that children and adults continued to treat the robot as a social agent even when presented with a pair of self-propelled, anthropomorphic robot-arms and contingent human gaze. Developmental research has revealed that infants often attribute intentionality and goal-directed behavior to geometric shapes (Csibra, 2008; Kuhlmeier et al., 2003) and follow the movements of an amorphous shape with their gaze (Johnson et al., 1998). Importantly, these objects usually do not have eyes or faces, but only move in a purposeful and contingent manner. Self-propelled motion – irrespective of anthropomorphic shape or contingent human gaze behavior – may thus be sufficient to elicit attributions of ownership to non-human agents. However, self-propelled motion may not suffice when children are asked to acquire social information from a robot (e.g. Itakura et al., 2008). In fact, in the latter situation, eye gaze may serve as a pedagogical cue that an agent wants to transmit important cultural information (Csibra & Gergely, 2009).

Interestingly, children and adults assigned ownership to a robotic agent even when they were only shown a pair of robot arms. In contrast, a recent study found that six-, eight- and ten-year-old children and adults attributed ownership less often to animals and artifacts than to humans – in fact; adults never attributed ownership to artifacts (Noles, Keil, Bloom, & Gelman, 2012). However, in their study Noles and colleagues (2012) asked participants whether it would be in principle conceivable for an artifact to own something (e.g. "Can a book own a shelf?"), thus highlighting the possibility to deny ownership to non-human entities. In our

study we asked participants to simply indicate the owner of an object ("Whose picture/paper is it?"), which may have made participants more inclined to over-extend ownership status to the robot.

Alternatively, even in its most stripped down version the robot may have resembled more an agent than an artifact. Future studies could investigate whether removing the robot's self-propulsion by, e.g. showing someone operate the robot, would give the robot a less agent-like appearance. Although participants in our study attributed ownership to a robotic agent, they may not grant it full ownership rights such as the right to sell or trade its property. Previous research has found that children usually view a robot they have interacted with as a social and moral agent, but do not grant it any civil rights (i.e. robots can be sold or bought) or liberal rights (Kahn Jr. et al., 2012). Future studies could investigate whether similar nuances exist in children's and adults' ownership attributions to robotic agents and whether these attributions vary depending on how human-like a robot looks or behaves. In addition, questions about ownership (or ownership rights) attributions could be combined with more general measures of how anthropomorphic, likeable and animated the robot appears (e.g. by adapting the Godspeed scale for children Bartneck, Kulić, Croft, & Zoghbi, 2009).

Finally, research to date has revealed mixed results regarding cross-cultural differences in attitudes towards robots (e.g. Bartneck et al., 2007; MacDorman et al., 2009). In our study, we found no cultural differences in ownership attributions to a robot in children and adults from three (China, Japan, UK) and two different cultures (Japan, UK), respectively. This suggests that the bias to attribute ownership to social and non-social robots is an early emerging predisposition that is shared across industrialized cultures. While we found no differences between children and adults, a recent survey study found changes in Japanese children's and adults' images of robots (Nomura et al., 2009) – yet, this study did not directly investigate whether participant's believed that robots could own things. Overall, most previous studies have primarily used surveys to investigate people's stance towards robots (Nomura et al., 2006), whereas our study used video stimuli to test whether people would apply a social attribute such as ownership to a robotic agent. Future studies could map in more detail cross-cultural and developmental similarities and differences in people's attitudes towards robots.

5.2 Cross-cultural development of ownership understanding

While we found no cross-cultural differences in how participants treated robots and humans, cultural differences in the use of the different ownership rules (i.e. the first possession rule and the labor rule) emerged. Specifically, we found that children and adults from all cultures assigned ownership to the first possessor if the second agent

had only briefly possessed an object and not made any modifications to it. These findings are in line with previous studies that found that adults and young children from North America assigned ownership based on first possession (Friedman, 2008; Friedman & Neary, 2008) – unless explicit verbal ownership cues are given that override first possession (Blake, Ganea, & Harris, 2012). Our results thus present the first evidence that the first possession rule is not only used by participants from Western cultures but by children and adults from Eastern cultures, too.

Our study, however, also revealed cross-cultural differences in ownership judgments. Only British children and adults, as well as Japanese children were influenced in their ownership assignments when the second agent had invested labor into creating a new object (labor rule). Previous studies have shown that children and adults from a Western (UK) and an Eastern culture (Japan) used the labor rule, but that its use was affected by task demands in the Japanese (Kanngiesser et al., 2010; Kanngiesser et al., 2014). Specifically, Kanngiesser and colleagues (2014) found that Japanese adults, but not children, used the labor rule when presented with videos of ownership conflicts between two parties. While characters in the previous study described their actions and intentions neither the robot nor the human in our current study spoke, which may have resulted in more ambiguous and difficult to interpret stimuli. Interestingly, Chinese children did not use the labor rule and it is an open question whether this was due to task demands or due to different cultural values – China being the only communist country in our study. Future studies could investigate in more details which factors underlie differences in use of the labor rule across cultures.

6. Conclusion

We found in three experiments that social gaze did not have an influence on ownership attributions in children and adults from China, Japan and the UK, and that, in fact, showing anthropomorphic, self-propelled robot-arms and contingent human gaze behavior were sufficient to elicit these attributions. Cross-cultural differences were found in the kinds of ownership rules that participants used, particularly regarding use of the labor rule (i.e. the assignment of ownership following the investment of labor). Our findings as well as other research on children's social attribution of agency to robots (e.g. Arita et al., 2005; Itakura et al., 2008; Meltzoff et al., 2010) highlights that these attributions have their origins in early childhood biases to attribute agency and goal directed behavior to moving shapes (e.g. Csibra, 2008). Importantly, we show that these biases are shared across Eastern and Western cultures and arise even in the absence of strong social cues such as mutual gaze. Findings from developmental psychology can inform the design

and developmental of social robots, in showing that a number of very basic cues such as contingent behavior and/or gaze may suffice to elicit attributions of social agency to robots.

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