Running Head**:** CUES THAT TRIGGER DISINHIBITION

Cues that trigger social transmission of disinhibition in young children

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Abstract

Previous studies have shown that observing a human model's actions, but not a robot's actions, could induce young children's perseverative behaviors, and suggested that children's socio-cognitive abilities can lead to perseverative errors ("social transmission of disinhibition"). This study investigated how the social transmission of disinhibition would occur. Specifically, the authors examined whether a robot with human appearance (an android) triggered young children's perseveration and compared the effects of the android with those of a human model. The results revealed that the android induced the social transmission of disinhibition. Also, children were more likely to be affected by the human model than by the android. The results suggested that behavioral cues (biological movement) may be important for the social transmission of disinhibition.

Keywords: executive function, social cognition, preschool children, Dimensional Change Card Sort, robot, simulative process

In the last decade, there have been growing interest in the development of executive function. A search of Psyc-INFO using the key words 'executive function' under 12 years of age yielded 48 records for the period from1985-1995, and 458 records for the period between 1996 and 2005. This expansion includes advances in brain research (e.g., Durston et al., 2002), research on the developmental relationship between executive function and other cognitive abilities (e.g., Carlson & Moses, 2001), and research on developmental disorders (e.g., Barkley, 1997).

Executive function refers to the ability to plan, execute and monitor appropriate and relevant actions and to inhibit irrelevant and inappropriate actions for the attainment of a specific goal. This ability develops rapidly during the preschool years, with adult-level performance being achieved during adolescence, which is subserved by the maturation of the prefrontal cortex (Davidson, Amsoa, Anderson, & Diamond, 2006; Moriguchi & Hiraki, 2009; Zelazo & Müller, 2002).

Recent studies have shown that developing cognitive control may involve more social processes than previously considered. For example, Moriguchi, Lee, and Itakura (2007) showed that young children’s cognitive control may be affected by observing another person’s actions. They used a social modification of the dimensional change card sort (DCCS) task, which is used for assessing children’s executive function (Zelazo, Frye, & Rapus, 1996). In the standard DCCS task, children are asked to sort cards that have two dimensions such as color and shape (e.g., yellow flowers, green houses) into trays with target cards (e.g., a yellow house, a green flower). First, the children are asked to sort cards according to one dimension (e.g., color) for six trials. Then, the children are asked to sort the cards according to the other dimension (e.g., shape) for six trials. Typically, most three-year-olds fail to switch the dimension, whereas four- and five-year-old children make the dimension switch. In the modified social DCCS task, instead of sorting the cards by themselves, preschoolers watched an adult model sorting the cards according to one dimension (e.g., shape), after which they were asked to sort according to a different dimension (e.g., color). The results showed that most three-year-olds failed to sort the cards according to the different dimension and perseverated sorting according to the observed dimension, as in the standard DCCS task (also see Moriguchi & Itakura, 2008).

Interestingly, children's cognitive control process could be affected by a human's actions, but not a robot's actions. Moriguchi, Kanda, Ishiguro, and Itakura (2010) showed that children who observed a robot sorting according to one dimension had no difficulty in sorting the cards according to a different dimension. The authors explain the results in terms of a socio-cognitive perspective that children perseverate on the human model's rule because they mentally simulate the model's actions while watching. In fact, they used the first, observed rule even when asked to choose the second rule. On the other hand, the children's actions were not affected by the robot's actions because the robot did not induce young children's simulative process. Moriguchi et al. (2010) concluded that children's socio-cognitive abilities can lead to perseverative errors in the social DCCS task, and they labeled the perseverative tendencies as the "social transmission of disinhibition."

The social understanding literature suggests that observing human actions, but not mechanical actions, may elicit young children's and adults' imitative behaviors (Itakura et al., 2008; Kilner, Paulignan, & Blakemore, 2003; Meltzoff, 1995). This is consistent with Moriguchi et al.'s (2010) explanation. However, it is still unclear why a human's actions, but not a robot's actions, may induce the social transmission of disinhibition. The cues that may trigger the social transmission of disinhibition are not known.

Recent research regarding infants' perception of others' goal-directed actions are relevant to understanding the influence of human or robot action: in this field, some researcher suggested that behavioral cues may be important for infants' perception of goal-directedness and others suggested featural cues may be relatively important (Biro & Leslie, 2007). The former emphasizes that infants are sensitive to behavioral cues, such as self-propelledness and contingent responses (Gergely & Csibra, 2003; Luo & Baillargeon, 2005; Premack, 1990; Johnson, Slaughter, & Carey, 1998; Shimizu & Johnson, 2004). On the other hand, the latter emphasizes that the appearance of the agents may have a significant role in infants' perception of goal-directed actions (Melzoff, 1995; Woodward, 1998). Research evidence is presently inconclusive, providing some support for each theory (Biro & Leslie, 2007; Gergely, Nadasdy, Csibra, & Biro, 1995; Woodward, 1998).

Both appearance and behavioral cues may be important for infants' social perception. The present study examined which cues may trigger young children's social transmission of disinhibition. We tested hypotheses that behavioral cues (biological movement) may affect young children's social transmission of disinhibition. We devised a new android condition and compared it with a human condition in the social DCCS task. The android had a human appearance (Figure 1); however, its movement was mechanical, similar to the robot used in the previous study (Moriguchi et al., 2010). Thus the android was different from a human in terms of its movement, but not its appearance. Using the android, we could evaluate the effect of a behavioral cue (physiological movement) of agents. Before the experiment, we conducted a pilot study for adult participants to verify the validity of stimuli in the experiment.

Pilot study

We conducted pilot studies to determine whether the android used in the experiment was not different from a human in terms of its appearance with two groups of adult participants (N = 20 for each group, M = 19.0 years of age). The first group (appearance group) judged whether the appearance varied significantly between a human, an android, and a mechanical robot. The second group (movement group) rated whether the movements varied significantly between the three agents.

To assess the differences of appearance and movement between agents, we used a scale of animacy that consists of six items evaluated on a 10-point Likert scale (Dead/Alive, Stagnant/Lively, Mechanical/Organic, Artificial/Lifelike, Inert/Interactive, Apathetic/Responsive). This scale was developed for assessing the lifelikeness of robots (Barneck, Kulic, Croft, & Zoghbi, 2009; Lee, Park, & Song, 2005). The appearance group was asked to rate the animacy of the agents when presented with static pictures of each agent. We used pictures of the stimuli used in the present experiment (an android and a human) and a stimulus used in the previous study (a robot; Moriguchi et al., 2010). The movement group was asked to rate the animacy of the agents when presented with video clips of each agent. We used video clips of card sorting from the present experiment (an android and a human) and the previous study (a robot; Moriguchi et al., 2010).

The Cronbach's Alpha for the animacy scale was 0.85. We used the composite animacy scores of the six items to assess the difference of appearance and movement between agents (0-9, inanimate-animate). For the appearance group, the mean animacy scores (SD) were 4.34 (2.24) for the human, 3.97 (1.93) for the android, and 2.51 (1.57) for the robot. For the movement group, the mean scores were 6.51 (1.84) for the human, 3.89 (1.60) for the android, and 2.65 (1.46) for the robot. We conducted a group (appearance vs. movement) × agent (human vs. android vs. robot) two-way ANOVA of the animacy scores. We found a significant main effect of agent, F (2, 76) = 32.945, p < .001, ή = .46 and a significant interaction between group and agent, F (2, 76) = 6.213, p < .003, ή = .14, but did not find a significant main effects of group, F (1, 38) = 3.493, p > .06, ή = .08. We conducted separate ANOVAs for each group to further examine the significant interaction between group and agent. We found a significant main effect of agent for the appearance group, F (2, 38) = 7.262, p < .01, ή = .28 and the movement group, F (2, 38) = 33.196, p < .001, ή = .63. Post-hoc comparisons using the Bonferroni method revealed that the participants in the appearance group rated the human and android as more animate than the robot, whereas the participants in the movement group rated the human as more animate than the android and the robot (p <.05). The results suggest that the adult participants did not consider the android significantly different from the human in appearance, but did consider the android significantly different from the human in movement.

Experiment

Participants

The participants were 75 three and four year-old children (M = 46.0 months, SD = 5.2, range = 36 months to 56 months; 45 boys and 30 girls). They were recruited from nursery schools in Kyoto and Fukuoka, and were not reported to have developmental abnormalities. All children were from Japanese middle-class families. Informed consent was obtained from the parents of all the children prior to their involvement in the study. The children were randomly assigned to one of the following three conditions: human condition, android condition, or control condition. Mean ages (ranges) were 46.2 months (37 to 54 months) in the human condition, 45.9 months (39 to 54 months) in the android condition and 45.8 months (36 to 56 months) in the baseline condition. There were no significant age differences between the conditions.

Materials

Laminated cards (9.0 × 7.5 cm) were used in the trials. Two trays (4.5 × 10.5 × 15 cm) were provided, one containing a target card depicting a red star and the other containing a card depicting a blue cup. There were six sorting cards, each of which depicted either a red cup or a blue star.

An android named Repliee Q2 was used as a model. Repliee Q2 was developed by Osaka University and Kokoro Co., Ltd (Minato, Shimada, Itakura, Lee, & Ishiguro, 2005). As shown in Figure 1, the face of Repliee Q2 was quite similar to that of a Japanese lady and it wore female clothing. However, the android's movements appeared awkward compared to a real human; its movements were very mechanical (for details, see the stimuli at http://www.youtube.com/watch?v=JomR4cmy1-8). The android and a human female were videotaped performing the sorting task in similar ways. In the human and android conditions, the stimuli (video clips) were presented using a notebook personal computer with a 15-inch display (Dell Latitude D610) .

Procedure

There were three phases in the human and android conditions: a warm-up phase, an observation phase, and a sorting phase. The control condition included only a warm-up phase and a sorting phase. In each condition, the children were tested individually for about 5 min and were seated on a chair next to an experimenter.

Human condition

In the warm-up phase, the experimenter introduced the two trays with target cards and sorting cards. The child was asked to name the shape and the color on each card. Following this, the experimenter announced the general rule of the task (“There are two ways to sort the cards, color and shape. I will tell you whether you should sort the cards according to their color or shape.”).

In the observation phase, the child was asked to watch a video on the computer. In the video, there was an adult female model and the two trays and cards identical to those used with the children. The child was told that the model would sort the cards into the trays (“Now she [the model] is going to sort the cards first. Please watch carefully.”). The model sorted the cards according to one dimension. Half of the children saw the model sorting the cards according to the shape dimension, and the other half saw the model sorting the cards according to the color dimension. During the observation, the children were not given any explicit rules. Instead, they were encouraged to watch the video. The model performed four trials (two blue star and two red cup cards).

In the sorting phase, the experimenter introduced the trays and sorting cards to the child again. The child was instructed to play a game ("Now, it is your turn. We are going to play a game"). In this game, the child was to sort the cards according to the other dimension. For example, when the model sorted the cards according to the shape dimension, the child was asked to sort the cards according to the color dimension ("Your game is a color game. In the color game, all the red ones go here and all the blue ones go there."). The child was given six trials. In each trial, the experimenter told the child the rules of the game and randomly selected a sorting card for sorting ("Where does this card go in the color game?"). The child was required to sort the cards into the two trays, and was not given any feedback about the correctness of the sort.

Android condition

The android condition was identical to the human condition, except that an android sorted the cards instead of a human model. All other aspects of the android's actions were matched to the human model including the speed with which the actions were performed.

In the observation phase, the instruction given in the android condition was the same as in the human condition. The child was instructed: “Now she [the android] is going to sort the cards first. Please watch carefully.” The experimenter did not state that Repliee Q2 was a robot/android, and therefore, the child did not know that Repliee Q2 was a robot in advance.

Baseline condition

The baseline condition was identical to the human condition, with the exception that there was no observation phase. After the warm-up phase, the child was instructed to sort the cards according to one dimension (e.g., “We are going to play a game. The game is a color game. In the color game, all the red ones go here and all the blue ones go there.”).

Results and Discussion

Children in the human condition and the android condition watched the video clip during the observation phases, and never looked away from it. This suggested that children in both conditions equally attended to the stimuli. The children’s sort was scored as “correct” if they sorted a card correctly according to the dimension instructed by the experimenter in the sorting phase. As shown in previous studies (e.g., Moriguchi et al., 2010), most children (63 out of 75; 84.0%) were either correct or incorrect on all six trials. Therefore, the children were classified as passing or failing the task according to whether or not they sorted at least five of the six cards correctly. Preliminary analyses using Fisher’s exact tests showed no significant differences in children’s performance in the shape and color games, or related to the children’s sex, $p > .10$.

Therefore the data for these variables were combined for the subsequent analyses.

More than half of the children in the human condition failed to use the second (instructed) rule, which is consistent with previous studies (e.g., Moriguchi et al., 2007). They sorted the cards according to the first rule presented by the human model. Only eight children (32%) passed the task (Figure 2). On the other hand, the children in the android condition were more likely to sort the cards according to the second, instructed rule. Sixteen children (64%) in the android condition were classified as passing. In addition, as expected, almost all the children (24 out of 25 children) in the baseline condition sorted the cards according to the instructed rules (Figure 2).

To examine the performance differences between the human, android, and baseline conditions, we conducted chi-square tests and found a significant difference between conditions, $\chi2$ (2, N = 75) = 22.222, $p < .0001$. Post hoc analyses using Fisher's exact test (two-tailed) showed significant differences between the human and android conditions, $p < .05$, between the human and baseline conditions, $p < .0001$, and between the android and baseline conditions, $p < .02$. The results showed that the human's and android's actions had different influences on the young children's cognitive control process.

Finally, we conducted an additional analysis to compare the effect of the android to the effect of a mechanical robot in the previous study (Moriguchi et al., 2010). The participants in the previous robot condition (robot condition) included 3-year-old children. Thus, we added six 4-year-old children to the previous data (N = 26, *M* = 45.8 months range = 38 months to 56 months). In the robot condition, about 85 % of the children were classified as passing. We conducted chi-square tests and found a marginally significant difference between conditions, $\chi 2$ (1, N = 51) = 2.851, $p < .10$.

The results are important in two aspects. First, the non-human agent with a human appearance may trigger young children's social transmission of disinhibition. Compared to the baseline condition, children in the android condition were more likely to sort the cards according to the first (modeled) dimension even though they were instructed to sort the cards according to the second dimension. These results contrast with those in the previous study using a mechanical robot (Moriguchi et al., 2010). In that study, the mechanical robot did not affect young children's actions; the results were as though the children had not observed any demonstrations and were not significantly different from the baseline condition. Although the differences between the android condition and the robot condition were marginally significant, the results suggested android could trigger children's social transmission of disinhibition. Second, the results of the present study reveal that the performance in the android condition was significantly different from those in the human condition. This was found despite the fact that the participants in the android condition were instructed, "She is going to sort the cards first." The children were not explicitly told that the android was a robot. Adult participants did not consider the human and android to be significantly different in appearance in our pilot study. The children may have detected that the android was a robot from its movements. This is interesting because Moriguchi, Sanefuji, and Itakura (2007) showed that a televised model triggered the social transmission of disinhibition in young children as well as a live model did. Children may identify the televised model with the live model, but discriminate the televised model from the android. The results suggest that an agent's physiological movement might play an important role in the social transmission of disinhibition.

Conclusion

The present study investigated whether behavioral cues may affect young children's perseverative behaviors. The results showed that the android's movements did trigger, to some extent, young children's perseverative tendencies. Moreover, their performance in the android condition was significantly different from those in the human condition. The results suggest that an agent's movement (i.e., human-like movement) might play an important role in the social transmission of disinhibition.

The present study contributes to our understanding of why young children engage in perseverative behaviors after observing another person's actions. A previous study proposed that children perseverate on a human model's actions because they mentally simulate the model's actions and thus they executed these (mentally rehearsed) actions even when asked to choose other actions (Moriguchi et al., 2010). Consistent with this, we interpret the android's effect on young children's actions in terms of the simulative processes. The children expected to observe a "lady" who would demonstrate the card-sorting game, and thus initially observe the android as if she were a lady. This may have triggered mental simulation. However, while watching the android's actions, they may have detected that its movements were mechanical, and their simulative process may have been hampered. Nevertheless, the simulative process may have, to some extent, affected young children's performance in the second phase.

Our results are consistent with social understanding research. There is evidence that infants begin to detect goal-directedness in human or non-human agents during the first years of life (Biro & Leslie, 2007). Although the nature and emergence of infants' ability to understand others' goal-directed actions are now controversial, both appearance and behavioral cues may be critical for detecting goal-directedness (Gergely et al., 1995). In the present study, we were unable to address directly the controversy because our research paradigm was too different from the infant goal-detection studies. Nevertheless, we suggest that behavioral cues might be crucial in young children's social cognition. Further research is needed to examine whether the appearance may have a significant role in the social transmission of disinhibition and how these other cues interact with the behavioral cues observed in the present study.

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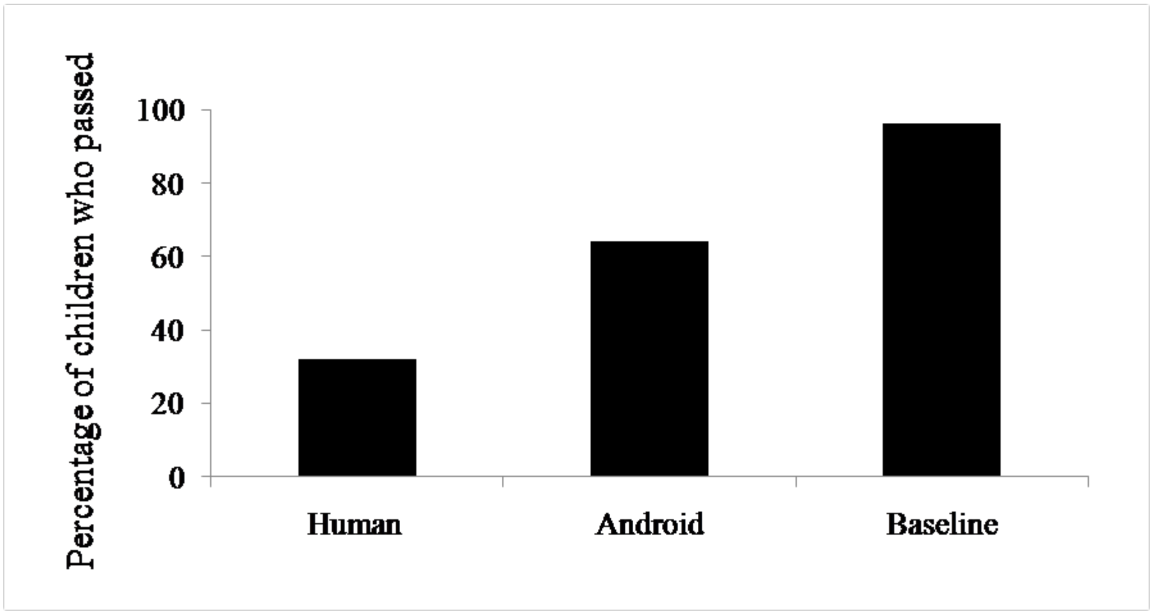
Figure Captions

Figure 1. The android's actions in the android condition. Android Repliee Q2 was developed by Osaka University and Kokoro Co., Ltd.

Figure 2. Percentage of children who correctly sorted cards according to the second dimension.

Figure 1

Figure 2


Percentage of children who passed
100
80
60
40
20
0
Human
Android
Baseline