Developmental Science 10:4 (2007), pp 481–491 DOI: 10.1111/j.1467-7687.2007.00601.x

# PAPER

# Social transmission of disinhibition in young children

**Yusuke Moriguchi,[1] Kang Lee[2] and Shoji Itakura[1]**

1. *Department of Psychology, Graduate School of Letters, Kyoto University, Japan*
2. *Department of Psychology, University of Toronto, Canada*

## Abstract

*The present study examined whether young children's behaviors in the Dimensional Change Card Sorting task can be influenced by their observation of another person performing the task. Experiment 1 showed that after children watched an adult sorting cards according to one rule, although the children were instructed to sort the cards according to a new rule, most 3-year-olds made perseverative errors and used the observed, old rule to sort the cards instead of the new rule. However, only some 4-year-olds and few 5-year-olds made the same mistake. Experiments 2, 3 and 4 showed that the younger children took into consideration social pragmatic information displayed by the adult model when deciding to use the old rule or the new rule. When the model appeared to know that she sorted the cards incorrectly (Experiments 2 and 3), or was uncertain whether she sorted cards correctly (Experiment 4), most 3-year-olds no longer committed perseverative errors. When the adult model was confident about her sorting or oblivious to her sorting errors, most 3-year-olds made perseverative errors. These results taken together suggest that social observation can lead to disinhibitions. In other words, disinhibition can be transmitted socially from one person to another.*

## Introduction

Inhibitory control is one of the most rapidly developing cognitive abilities in preschool years. This ability plays an important role in multiple areas of child development such as attention, thinking, communication, and social interaction (e.g. Blair, 2002; Carlson & Moses, 2001; Dempster, 1992; Diamond, Kirkham & Amso, 2002; Harnishfeger & Bjorklund, 1993; Kochanska, Murray, Jacques, Koenig & Vandegeest, 1996; Zelazo & Müller, 2002). Its importance is further underscored by the fact that its impairments are associated with severe behavioral, cognitive, and social developmental disorders such as autism, PKU, and ADHD (Barkley, 1997; Diamond, Prevor, Callender & Druin, 1997; Denckla, 1996; Dennis, Barnes, Donnelly, Wilkinson & Humphreys, 1996; Fletcher, Brookshire, Landry, Bohan, Davidson, Francis, Levin, Brandt, Kramer & Morris, 1996; Levin, Fletcher, Kufera, Harward, Lilly, Mendelsohn, Bruce & Eisenberg, 1996; Ozonoff, Pennington & Rogers, 1991; Zelazo, Jacques, Burack & Frye, 2002). Extensive research to date suggests that between 3 and 5 years of age, children's inhibitory control ability undergoes rapid development (Carlson, 2005), coupled by a similarly rapid maturation of frontal cortex (Diamond, 1991; Thatcher, 1992).

One of the tasks that has been used to index children's inhibitory control ability is the dimensional change card sorting task (DCCS; Zelazo, Frye & Rapus, 1996). In this task, children are asked to sort cards that have two dimensions (e.g. color and shape: red boats, red rabbits, blue boats, blue rabbits). There are two phases to the task. In the first phase, children are asked to sort cards according to one dimension (e.g. color) for several trials. In the second phase, the experimenter tells children that the sorting rule is to be changed. Children are now asked to sort the cards according to the other dimension (e.g. shape).

Extensive research has shown that older preschoolers can switch easily from one dimension to the other in their sorting behavior. They have no difficulty describing the rule change verbally. In contrast, younger preschoolers, after correctly sorting the cards according to the first rule in the first phase, have tremendous difficulty in switching their sorting according to the second dimension in the second phase. Instead, they perseverate and continue to sort the cards according to the first dimension. However, when younger preschoolers are probed about the rule of the game, they can indicate verbally what they are supposed to do in the second phase. This finding is very robust because the same pattern of results has been found with various procedural modifications

Address for correspondence: Yusuke Moriguchi, Department of Psychology, Graduate School of Letters, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501 Japan; e-mail: m.yusuke@bun.kyoto-u.ac.jp

(for a recent review, see Kloo & Perner, 2005; but see also Munakata & Yerys, 2001). Also, Jacques, Zelazo, Kirkham and Semcesen (1999) found that 3-year-old children not only failed to switch to sort according to a second rule but also had difficulty in determining whether another individual (a puppet) had made perseverative errors. However, it should be noted that some procedural modifications may alleviate young children's difficulty. For example, Towse, Redbond, Houston-Price and Cook (2000) found that an experimenter's demonstration of sorting according to the second rule in the second phase reduced children's tendency to perseverate.

It is highly controversial as to why younger preschoolers display perseverative errors in tasks such as DCCS. Different theories have been proposed. Zelazo and his colleagues (e.g. Zelazo *et al.*, 1996; Zelazo, Müller, Frye & Marcovitch, 2003) suggest that younger preschoolers' failure in the DCCS is due to their inability to represent a higher-order rule that integrates two incompatible pairs of rules. Kloo and Perner (2005) use a redescription hypothesis to explain children's difficulty. They argue that this difficulty stems from children's failure to understand that objects can be described in different ways. Thus, perseverative errors are conceptual deficits, rather than deficits in necessary inhibitory control abilities.

Munakata and Yerys (2001) posit that the conflict between a strong representation of a previously used rule and a relatively weak representation of a yet-to-be-used rule could account for the perseveration to the first rule. Carlson and Moses (2001) hypothesize that younger preschoolers' perseveration errors stem from their failure to exert executive inhibition of an interfering response tendency at the level of action schemas. Finally, it has been suggested that the failure to inhibit attention to the dimension focused on in the first phase may be responsible for younger children's difficulty to switch to a new dimension in the second phase (e.g. Kirkham, Cruess & Diamond, 2003; Towse *et al.*, 2000). Notwithstanding the controversy, most researchers agree that it is endogenous cognitive factors that lead to 3-year-olds' failure to inhibit an existing action pattern according to an old rule and execute a new action according to a new rule.

However, the impact of social factors on 3-year-olds' perseverative errors has largely been neglected. This is in spite of the fact that many recent studies have shown significant correlations between children's inhibitory control abilities and their social cognition in various domains such as emotional knowledge, moral conscience, and theory of mind understanding (e.g. Carlson, Moses & Breton, 2002; Eisenberg, Fabes, Murphy, Maszk, Smith & Karbon, 1995; Hughes, 1998; Hughes, Dunn & White, 1998; Kochanska *et al.*, 1996; Kochanska, Murray & Harlan, 2000; Perner, Lang & Kloo, 2002). Although the existing evidence regarding the linkage is mainly correlational, many researchers have speculated that inhibitory control abilities could provide a crucial foundation for the development of social cognition (e.g. Sabbagh, Xu, Carlson, Moses & Lee, 2006). However, it is equally possible that social cognition may contribute to improvement in children's inhibitory control abilities (Perner, 1998). Indeed, Kloo and Perner (2003) showed that training children on theory of mind tasks leads to improvement in their performance on the DCCS task (although DCCS training also improves children's performance on theory of mind tasks).

Given the existing findings, we hypothesized that social factors should have a significant impact on children's tendency to commit perseverative errors. The present study directly tested this hypothesis. More specifically, we examined whether children would continue to show perseverative errors or overcome them when asked to sort cards in a social context. We used a modified DCCS task. In the first phase, instead of sorting the cards themselves, preschoolers watched an adult model sorting the cards according to one rule (e.g. the shape rule), after which they were asked to sort according to a different rule (e.g. the color rule). We examined whether preschoolers would show perseveration and fail to sort the cards according to the second rule after merely watching the adult model sorting the cards according to the first rule. Experiments 2, 3 and 4 further investigated whether social pragmatic information displayed by the adult model would have any impact on children's perseverative errors.

## Experiment 1

### *Method*

#### Participants

Twenty 3-year-old children ($M$ = 42.3 months; range = 36 months to 47 months; 10 boys), 20 4-year-old children ($M$ = 53.1 months; range: 48 months to 58 months; 9 boys), and 20 5-year-old children ($M$ = 66.9 months; range: 60 months to 71 months; 12 boys) participated.

#### Materials

Laminated cards (9.0 cm × 7.5 cm) were used as stimuli. There were two trays (10.5 cm × 15 cm). One tray contained a target card depicting a red house, and the other tray contained target card depicting a blue car. There were 10 sorting cards depicting either a red car or a blue house (five for each).

### Procedure

Each child was tested individually for about 5 minutes. The child was seated at a table. The experimenter sat at the table across from the child, and a model sat next to the child. The experimenter and the model spoke briefly with the child to establish rapport. Once the child appeared relaxed, the experiment began. This task had three phases: pretest, observation, and sorting.

In the pretest phase, the children were presented with the trays and the sorting cards. They were asked to name all the shapes (house, car) and their colors (red, blue). This pretest was to ascertain whether the children could discriminate the cards according to either their color or shape. After labeling, the experimenter announced the general rule of the task: 'There are two ways to sort the cards, color and shape. In this game, I will tell you whether you should sort the cards according to its color or its shape.'

In the observation phase, the child was told that the model would sort cards first: 'Now she [the model] is going to sort the cards first. Please watch carefully.' The model was instructed to sort 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 according to the color dimension. For example, in the shape game, the experimenter told the model: 'This is a shape game. All the cars go here (pointing to the tray where a blue car was) and all the houses go there (pointing to the tray where a red house was).' Then the model was given a sorting card. The model performed four trials. At the beginning of each trial the experimenter told the model the rule of the game, randomly selected a sorting card, and asked her to sort the card: 'Where does this card go in the shape/color game?' The model sorted correctly according to the prescribed rule and was given feedback on every trial ('Well done!'). During the sorting, the target cards were always visible to ensure that children could determine which rule the model was following.

After the observation phase, the model made an excuse and left the room. Children were instructed: 'Now, it is your turn. We are going to play a new game. This game is different from the game she [the model] played.' If the model sorted the cards according to the shape dimension, children were asked to sort cards according to the color dimension: 'Your game is a color game. The color game is different from the shape game. In the color game, all the red ones go here and all the blue ones go there.' Likewise, if the model sorted according to the color dimension, children were asked to sort according to the shape dimension. Children were given five sorting trials. On each trial, the experimenter told the child the rule of the game, randomly selected a sorting card for them to sort: 'Where does this card go in the color game?' The child was required to place the card in one of the two trays. They were not given any feedback about whether they sorted the cards correctly. Again, the target cards were visible during the sorting.

### *Results and discussion*

One 3-year-old child was excluded from the analysis because he did not answer all the questions correctly in the pretest. The rest of the children answered the pretest questions perfectly. Children were scored as 'correct' if they sorted a card correctly according to the dimension instructed by the experimenter. Preliminary analyses showed no significant differences in children's scores in the shape and color games, and therefore the data for the two types of games were combined for the subsequent analyses.

We examined whether data at each age group were different from what would be expected by chance. Expected frequencies are based on a chance distribution of 1/32, 5/32, 10/32, 10/32, 5/32, 1/32 for participants who made 0, 1, 2, 3, 4, 5 correct responses, respectively. For this experiment, we classified children according to whether children made 0–1 correct responses, 2–3 correct responses, and 4–5 correct responses (see Figure 1). As a result, the expected frequencies are 6/32, 20/32 and 6/32, respectively. Chi-square tests revealed that distributions of scores of 3-, 4- and 5-year-old children were all significantly different from chance: $\chi^2$ (2, $N$ = 38) = 14.94, $p < .001$, $\chi^2$ (2, $N$ = 40) = 18.59, $p < .001$, and $\chi^2$ (1, $N$ = 40) = 18.79, $p < .001$, respectively.

As shown in Figure 1, whereas 5-year-olds performed at ceiling (i.e. sorting cards according to the second rule), 68% of the 3-year-old children failed to follow the new rule on at least four trials. Instead, they continued to follow the rule that the demonstrator used to sort cards. In contrast, only 35% of the 4-year-olds and 10% of the 5-year-olds displayed perseverative errors. Most of the older children scored correctly on at least four trials.

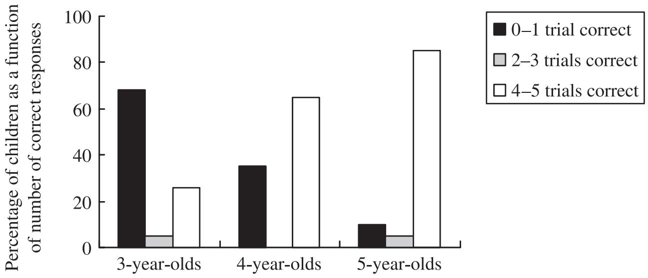


**Figure 1** *Correct response distributions of children in each age group in Experiment 1.*

The chi-square test revealed that younger children were more likely to show perseverative errors than older children, $\chi^2$ (2, $N$ = 59) = 14.288, $p < .001$. Further chi-square tests showed significant differences between 3- and 4-year-olds $\chi^2$ (1, $N$ = 39) = 4.356, $p < .05$, and 3- and 5-year-olds, $\chi^2$ (1, $N$ = 39) = 11.493, $p < .002$, but not significant differences between 4- and 5-year-olds, $\chi^2$ (1, $N$ = 40) = 2.133, $p > .05$.

The present results are consistent with the findings of previous studies using the DCCS task. What made the present experiment different from the previous ones was that younger children continued to commit perseverative errors when they sorted cards despite the fact that they themselves did not perform the sorting task according to the first dimension. Thus, observation of another person performing the card sorting task seemed to have a 'contagion effect' on younger children. Such observation appeared to cause younger preschoolers to have difficulty in inhibiting the use of an 'old' rule and switching to use a 'new' rule to sort the cards. This difficulty is highly similar to that experienced by young preschoolers in the typical DCCS task in which the children themselves have to sort cards according to both the first and second rules. Thus, without having to personally sort cards twice using different rules, young preschoolers still exhibit perseverative errors as they typically do in the classic DCCS task. In other words, it is not necessary for perseverative tendencies to occur within the same person. They can also occur through social transmission from one person to another.

## Experiment 2

Why did the younger preschoolers in Experiment 1 fail to sort the cards according to a new rule even though they themselves did not perform card sorting according to an old rule? One possibility is that the children might have simply preferred to imitate another person's motor behaviors rather than to follow the experimenter's verbal instructions, particularly when motor behaviors and verbal instructions had different goals. The present experiment tested this possibility.

In this experiment, 3- and 4-year-old children first watched a model sorting cards incorrectly (e.g. sorting the cards according to the color rule after being instructed to sort the cards according to the shape rule). In one condition, the model appeared to be aware that she was not following the experimenter's instructions but continued to sort the cards incorrectly anyway (the Aware condition). In a second condition, the model appeared not to be aware that she was sorting the cards incorrectly and thus continued to sort the cards according to an incorrect rule (the Unaware condition). After watching this model's sorting, the children were instructed to sort the cards according to the *same* rule as the one that the model was instructed to follow.

If perseverative errors observed in Experiment 1 were due to younger preschoolers' preference for imitating the model's motor behavior over following the experimenter's verbal instruction, perseverative errors should be observed in both conditions. In other words, younger preschoolers in both conditions should sort the cards according to the same rule that the model used to sort the cards rather than the rule that the experimenter asked them to use.

Alternatively, the children might show differential behaviors in the two conditions. More specifically, the children in the Unaware condition might continue to show perseverative errors, whereas those in the Aware condition might be more inclined to sort the cards according to the instructed rule. The former prediction was based on the finding by Jacques *et al.* (1999) who showed that young children were insensitive to others' mistakes in following the experimenter's card sorting instructions when the puppet's mistakes were not made explicit to them. The latter prediction was based on existing studies that have shown that even 3-year-olds are sensitive to others' knowledge states (O'Neill & Gopnik, 1991; Esbensen, Taylor & Stoess, 1997; Sabbagh & Baldwin, 2001; Sabbagh, Wdowiak & Ottaway, 2003). For example, Sabbagh and Baldwin (2001) found that 3- and 4-year-olds showed better word learning when a speaker displayed knowledge of the word-referent link than when the speaker appeared to be ignorant of it. Koenig, Clément and Harris (2004) showed that 3- and 4-year-olds were more likely to trust the color judgment of a puppet who had performed successfully on previous trials, as compared with one who had performed unsuccessfully.

### *Method*

#### Participants

Forty 3-year-old children ($M$ = 43.2 months; range = 36 months to 47 months; 29 boys) and 40 4-year-old children ($M$ = 54.1 months; range 48 months to 59 months; 30 boys) participated. Five-year-olds were not included because few of them showed any perseverative errors in Experiment 1. None of the participants in Experiment 2 took part in Experiment 1.

#### Materials and procedure

The material was the same as in Experiment 1. There were two conditions: Unaware condition and Aware condition. Each condition had the same three phases as in Experiment 1. Within each age, children were randomly assigned to one of the two conditions, resulting in 20 children per age group in each condition. There were no significant age differences between conditions in each age group.

*The Unaware condition.* The pretest phase was identical to Experiment 1. In the observation phase, the child was told that the model would sort cards first. In each trial, although the model was asked to sort cards according to one dimension (e.g. shape), she sorted cards incorrectly (according to the color dimension) in all four trials. In every trial, after the model had sorted a card, she was asked: 'Did you sort the card correctly?' The model behaved as if she was not aware of her mistakes and responded emphatically, 'Yes.' However, she was told by the experimenter that she actually did not sort the card correctly on every trial. After the observation phase, the model left the room. The experimenter told the child that the model used a wrong rule ('She used the color rule. She was wrong.'). The child was then asked to sort the cards according to the same dimension (e.g. shape) that the model was instructed to sort. The child was given five sorting trials, with no feedback about whether the cards were sorted correctly.

*The Aware condition.* The Aware condition was identical to the Unaware condition except for one difference in the observation phase. Unlike in the Unaware condition, the model in the Aware condition behaved as if she was aware of her mistakes. In every trial, after the model had sorted a card, she was asked: 'Did you sort the card correctly?' The model responded: 'No, I made a mistake', and this response was further confirmed verbally by the experimenter on every trial. Nevertheless, she continued to sort the cards incorrectly according to the color dimension in all four trials.

### Results and discussion

Four 3-year-old children (two from the Unaware condition and two from the Aware condition) and one 4-year-old child (from the Unaware condition) were excluded from the analysis because three children did not answer the knowledge questions correctly in the pretest phase and two children were distracted and did not observe the model's sorting. The rest of the children could answer the knowledge questions perfectly.

We examined whether data at each age group were different from what would be expected by chance, as in Experiment 1. Chi-square tests revealed that distributions of scores of children in each condition and each age group were significantly different from chance: $\chi^2$ (2, $N$ = 36) = 15.107, $p < .001$, $\chi^2$ (2, $N$ = 36) = 13.323,

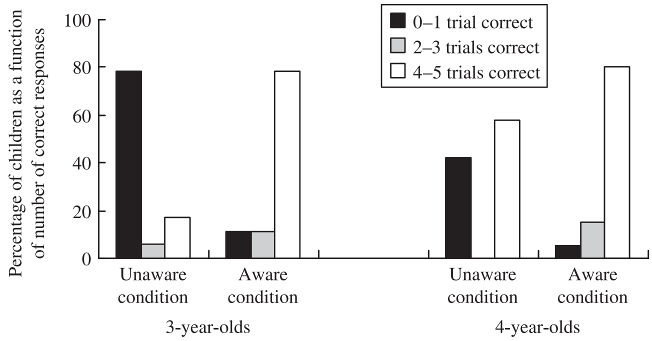


**Figure 2** *Correct response distributions of children in each age group in Experiment 2.*

$p < .001$, $\chi^2$ (2, $N$ = 38) = 17.540, p < .001, and $\chi^2$ (2, $N$ = 40) = 14.972, $p < .001$, for the 3-year-olds in the Unaware and Aware conditions, and the 4-year-olds in the Unaware and Aware conditions, respectively.

As shown in Figure 2, children performed significantly more poorly in the Unaware condition than in the Aware condition. In the Aware condition, children scored nearly perfectly. In the Unaware condition, 78% of the 3-year-olds and 42% of the 4-year-olds made perseverative errors. On at least four trials, they sorted the cards in the same manner as the model, despite the fact that they were told explicitly that the model sorted the cards incorrectly. The pattern of results was similar to that found in Experiment 1. In contrast, in the Aware condition where the model appeared to be aware of her mistake despite her continued incorrect sorting behaviors, young children no longer showed perseverative errors. The model's acknowledgement of her errors in the Aware condition led the majority of the 3- and 4-year-olds to sort the cards according to the new rule on all five trials. Fisher's exact test (two-tailed) revealed that children in the Unaware condition were significantly more likely to show perseverative errors than children in the Aware condition in each age group (3-year-olds, $p < .01$; 4-year-olds, $p < .05$). Also, there was an age difference in the Unaware condition, where 4-year-olds made fewer perseverative errors than did 3-year-olds ($p < .05$). However, no age difference was found in the Aware condition in terms of children's tendency to make perseverative errors.

It should be noted that the differential results obtained from the two conditions cannot be attributed to the fact that the model received negative feedback from the experimenter (Bohlmann & Fenson, 2005). The experimenter told the model repeatedly that she made a mistake in sorting the cards in both conditions. Also, the experimenter told the children in both conditions that the model followed a wrong rule. Nevertheless, only the children in the Aware condition became less inclined to make perseverative errors. These results suggest that the children did not blindly imitate the model's actions and ignore the experimenter's verbal instruction. Nor did they follow a simple rule that they should do what they were shown, not what they were told to do. Rather, their card sorting behaviors were mostly influenced by the information provided by the model, not the experimenter. More specifically, the model's display of social pragmatic information about her knowledge or ignorance of her mistakes affected 3-year-olds' decisions about whether to follow her erroneous behavior.

However, there might be an alternative explanation for the results found in Experiment 2. The feedback given by the experimenter might have different effects on children's performance in each condition. In the Aware condition, the experimenter agreed with the model when the model became aware of her mistakes. Thus the children might obtain feedback that the adult model had made mistakes not only from the model themselves but also from the experimenter. On the other hand, in the Unaware condition, the model did not become aware of her mistakes, but the experimenter pointed out the mistakes. The children might get confused because of the difference between the experimenter and the model, which might have led to the low performance in the Unaware condition. In other words, the experimenter's feedback, not the social pragmatic information about the model's knowledge or ignorance, might account for the different results in Experiment 2. To test this possibility, we conducted Experiment 3.

## Experiment 3

In Experiment 3, the procedure was identical to that in Experiment 2 except that the model was not given any feedback by the experimenter in the observation phase.

### *Method*

#### Participants

Thirty 3-year-old children ($M$ = 43.6 months; range = 36 months to 51 months; 9 boys) participated. New participants were recruited for this experiment.

#### Materials and procedure

The material was the same as in Experiment 1. There were two conditions: Unaware condition and Aware condition. Each condition had the same three phases as in Experiment 2. Within each age, children were randomly assigned to one of the two conditions, resulting in 15 children per age group in each condition. There were no significant age differences between conditions in each age group.

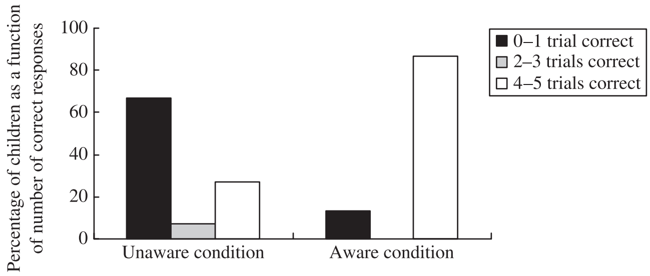


**Figure 3** *Correct response distributions of 3-year-olds in Experiment 3.*

The procedure in the Unaware condition was identical to the Unaware condition in Experiment 2 except that in the observation phase, the model was not given any feedback by the experimenter. Also, the procedure in the Aware condition was identical to the Aware condition in Experiment 2 except that in the observation phase, the model was not given any feedback by the experimenter.

### *Results and discussion*

All children who participated in Experiment 3 could answer the knowledge questions correctly. Chi-square tests revealed that distributions of scores of children in each condition were significantly different from chance: $\chi^2$ (2, $N$ = 15) = 11.046, $p < .001$, and $\chi^2$ (2, $N$ = 15) = 16.118, $p < .001$, for the children in the Unaware and Aware conditions, respectively. As shown in Figure 3, children performed significantly more poorly in the Unaware condition than in the Aware condition, which was confirmed by a Fisher's exact test (two-tailed test). Children in the Unaware condition were significantly more likely to show perseverative errors than children in the Aware condition ($p < .01$). In the Unaware condition, 67% of the 3-year-olds made perseverative errors. In contrast, in the Aware condition, 87% of the 3-year-olds no longer showed perseverative errors. These results replicated those of Experiment 2. After removing the experimenter's feedback from the procedure, young children in the Unaware condition continued to commit perseverative errors, whereas children in the Aware condition did not. This result suggested that the model's statement about her knowledge regarding whether she had followed the rule correctly, but not the experimenter's feedback, was crucial for young children's performance in Experiment 2.

However, there might be an alternative explanation for the different results found in the Aware and Unaware conditions in Experiments 2 and 3. In the Unaware condition, the model sorted the cards according to a rule that is opposite to what they were told to do. Thus, the young children might have misconstrued the rule of the game as doing the opposite of what was requested by the experimenter. After watching the model sort cards according to a rule opposite to the rule asked by the experimenter, the children did the same as the model. Indeed, Brooks, Hanauer, Padowska and Rosman (2003) found that children could ignore the instructed rules and play the opposite rule in the DCCS task if they were told to play a 'silly' game. In the Aware condition, the model repeatedly declared that she was making a mistake, which might have disambiguated the rule of the game (the fact that she was supposed to follow what she was instructed to do). As a result, the erroneous action pattern of the model was not transmitted to the children. To rule out this possibility, we carried out Experiment 4.

## Experiment 4

In this experiment, we modified the procedure of Experiments 2 and 3. During the observation phase, unlike in Experiments 2 and 3, the model sorted the cards correctly according to the rule prescribed by the experimenter. However, in the Confident condition the model expressed confidence in her sorting, whereas in the Unconfident condition the model expressed that she was not sure about whether she followed the experimenter's instructions correctly. Thus, unlike in Experiments 2 and 3, the model did not sort the cards according to a rule that was opposite to what she was told to do.

Given the fact that the existing studies have shown that very young children are already sensitive to another's expression of certainty and confidence (e.g. Moore, Pure & Furrow, 1990; Sabbagh & Baldwin, 2001; Sabbagh *et al.*, 2003), the social pragmatic information about the model's level of confidence should affect young children's tendency to sort cards according to a new rule. More specifically, they should be more inclined to sort according to the new rule and less inclined to make perseverative errors in the Unconfident condition than the Confident condition. Experiment 4 tested this possibility.

### *Method*

#### Participants

Forty 3-year-old children ($M$ = 42.0 months, range = 36 months to 47 months, 27 boys) and 40 4-year-old children ($M$ = 54.2 months, range 48 months to 59 months, 26 boys) participated. Again, new participants were recruited for this experiment.

#### Materials and procedure

The material was the same as in Experiment 1. There were two conditions: Confident and Unconfident conditions. Each condition had the same three phases as in Experiment 1. Within each age group, children were randomly assigned to one of the two conditions, resulting in 20 children per age group in each condition. There were no significant age differences between conditions in each age group.

*The Confident condition.* The procedure of the Confident condition was identical to that of Experiment 1 except that a child was given information as to whether a model was confident about the rule she was using in the observation phase. In the observation phase, the experimenter told the model the rule of the game, randomly selected a sorting card and asked her to sort the card. The model sorted correctly according to the prescribed rule. In every trial the experimenter asked the model: 'Is your sorting correct?' The model emphatically: 'Yes.' The model was given positive feedback on every trial ('Well done').

*The Unconfident condition.* The Unconfident condition was identical to the Confident condition except that in the observation phase the model was not confident about the rule she was using. In every trial the experimenter asked the model 'Is your sorting correct?' Although the model sorted correctly according to the prescribed rule, she said 'I don't know. I am not sure.' Nevertheless, the experimenter gave positive feedback ('Well done').

### *Results and discussion*

One 3-year-old child in the Unconfident condition was excluded from the analysis because she did not answer the knowledge questions correctly on the pretest phase. The rest of the children could answer the knowledge questions perfectly. Scoring was the same as Experiment 1. Preliminary analyses showed no significant differences in children's scores in the shape and color games, and therefore the data for the two types of games were combined for the subsequent analyses.

We examined whether data at each age group were different from what would be expected by chance as in Experiment 1. Chi-square tests revealed that distributions of scores of children in each condition and each age group were significantly different from chance: $\chi^2$ (2, $N$ = 40) = 20.02, $p$ < .001, $\chi^2$ (2, $N$ = 38) = 17.54, $p$ < .001, $\chi^2$ (2, $N$ = 40) = 13.45, $p$ < .001, $\chi^2$ (2, $N$ = 40) = 18.838, $p$ < .001, for the 3-year-olds in the Confident and Unconfident conditions, and the 4-year-olds in the Confident and Unconfident conditions, respectively.

The results of Experiments 2 and 3 were replicated. As shown in Figure 4, the 3-year-olds in the Confident

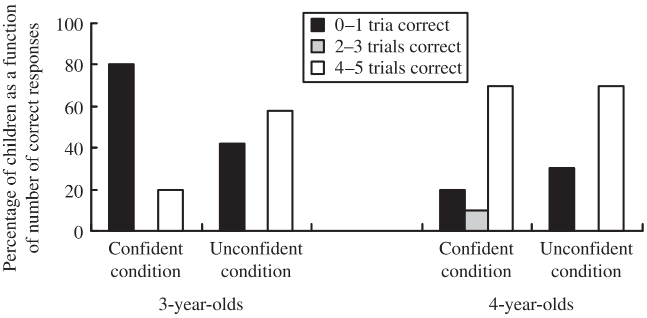


**Figure 4** *Correct response distributions of children in each age group in Experiment 4.*

condition, like those in the Unaware condition of Experiments 2 and 3, consistently made perseverative errors (80% of them made at least four errors). In contrast, in the Unconfident Condition, more than half of the 3-year-olds scored nearly perfectly (Figure 4). Fisher's exact test (two-tailed) revealed that the 3-year-olds in the Confident condition were significantly more likely to show perseverative errors than those in the Unconfident condition ($p < .05$). Fisher's exact test (two-tailed) also revealed that there was a significant age difference in terms of children's perseverative errors in the Confident condition ($p < .001$), but no age difference in the Unconfident condition ($p > .05$). These results suggest that the social pragmatic information about the model's confidence affected younger children's perseverative tendencies. With regard to the 4-year-olds, the two conditions yielded similar results: 70% of the older children sorted most of the cards correctly according to the instructed rule, which is highly similar to the results of Experiments 1 and 2 for this age group. This lack of difference between the two conditions might be due to the fact that the 4-year-olds were already capable of inhibiting the use of an old rule and executing sorting according to a new rule or simply due to a ceiling effect.

## General discussion

The present study investigated the social factors that may contribute to the development of young children's inhibitory control abilities. Specifically, we examined whether young children's card sorting behaviors in the DCCS task could be influenced by their observation of another person performing the same task. Experiment 1 showed that after children watched an adult sorting cards according to one rule, although they were instructed to sort the cards according to a new rule, most 3-year-olds made perseverative errors and used the observed, old rule to sort the cards instead of the new rule on most of the trials. In contrast, only some 4-year-olds and few 5-year-olds made the same mistake.

Experiments 2, 3 and 4 showed that the younger children did not blindly imitate the adult model's sorting behavior. Rather, they took into consideration the social pragmatic information displayed by the adult model when deciding whether to use the old rule or the new rule. When the adult was fully aware that she sorted the cards incorrectly (Experiments 2 and 3) or appeared uncertain whether she sorted cards correctly (Experiment 4), most 3-year-olds no longer committed perseverative errors; they were able to switch to use a new rule to sort the cards. However, when the adult model was confident about her sorting or oblivious to her sorting errors, most 3-year-olds made perseverative errors. In these situations, many 3-year-olds and even some 4-year-olds were influenced by the adult model's behavior and made perseverative errors. In addition, the young children's perseverative errors in Experiment 4 were similar to those found in Experiment 1, which suggests that the children in Experiment 1 might have made inferences about an adult's confidence even when the adult model said nothing about it. This result is also consistent with the finding of Jacques *et al.* (1999) that young children failed to detect that another individual had made a sorting error.

Our results taken together suggest that social observation can lead to disinhibitions in the DCCS task in a manner similar to the typical finding that young children, after having themselves sorted the cards according to an old rule, will fail to inhibit the use of the old rule and switch to use a new rule to sort cards. In other words, disinhibition can be transmitted not only from one task to another within the same child, but also socially from one person to another. Further, given the significant role of social pragmatic information in the present findings, this social transmission of disinhibition is highly likely done cognitively, rather than behaviorally as is the case for some interpersonal transmission of actions (e.g. yawning).

To the best of our knowledge, the present study is the first to demonstrate social transmission of disinhibition in tasks that assess children's inhibitory control abilities. Also, it is the first to provide direct evidence that children take into consideration the social pragmatic information provided by others when performing executive operations. Specifically, when such information reveals the person's knowledge state (e.g. being aware of their mistakes) or confidence about their actions, children's execution of their own actions is affected. The present results are consistent with the existing finding in the literature that children's performance in social cognitive tasks is consistently correlated with their performance in executive functioning tasks (Carlson *et al.*, 2002; Carlson, Mandell & Williams, 2004; Perner *et al.*, 2002; Sabbagh *et al.*, 2006). Further, our study suggests that the close relationship between children's social cognitive ability and their executive functioning abilities may be bi-directional and interdependent. Whereas inhibitory control abilities might provide a crucial foundation for the development of social cognitive abilities (Carlson *et al.*, 2004; Sabbagh *et al.*, 2006), social cognitive abilities might in turn contribute to the development of executive functioning.

The present results also contribute to our understanding of why young children show perseverative errors in tasks such as DCCS. Consistent with the suggestion of Kloo and Perner (2005), our results confirm that children's perseverative errors are not due to their failure to inhibit a well-established response tendency or action schema. Despite the fact that young children did not first perform card sorting according to one rule in our experiments, they still perseverated and used the observed rule to sort the cards even though they were instructed to do so using another rule. Our results are inconsistent with the theory of Zelazo *et al.* (2003), which suggests that children's perseverative errors are due to their inability to construct a hierarchical rule system. In our Experiments 2, 3 and 4 young children were less inclined to make perseverative errors in conditions where the adult model was aware of her mistakes or was not confident about her sorting than in conditions where the adult was confident of her sorting or oblivious to her mistakes. However, the task complexity in terms of rule use was the same for all conditions.

The attentional inflexibility theory (e.g. Kirkham *et al.*, 2003; Towse *et al.*, 2000) might explain the results of our study. When children watched an adult model's sorting, their attention might have been directed to the dimension according to which the model sorted the cards. When asked to sort the cards according to a new dimension, children's attention might still be engaged with the old dimension, resulting in perseverative errors. In the Aware condition of Experiments 2 and 3, the model's declaration about her mistake might help the children disengage their attention from the 'wrong' dimension, resulting in the decrease in perseverative errors. Similarly, when the model expressed her uncertainty about the correctness of her card sorting, the children might have reduced attention to the old dimension, which allowed them to redirect their attention more readily to the new dimension.

The representational strength theory proposed by Munakata and Yerys (2001) could also explain the result of this study. In Experiment 4, children in the Confident condition might have shown perseverative errors because they made a strong representation of a previously used rule whereas children in the Unconfident condition did not show perseverative errors because they might have had a relatively weak representation of a used rule. In Experiments 2 and 3, children in the Aware Condition were repeatedly informed by the model that she was not following the rule correctly, which might also have led to a relatively weak representation of the incorrect rule, which in turn made it possible for young children to switch to use the new rule. At this point, both the attentional flexibility theory and the representational strength theory can account for the findings of the present study as well as many of the previous ones (e.g. Kloo & Perner, 2005).

Specifically designed studies are hence needed in the future to test the validity of these theories. The typical DCSS task needs to be modified such that the attentional and representational components involved in performing the task can be experimentally isolated to provide unequivocal evidence to ascertain the validity of the theories. Such experimental manipulations can be done via changing the task demand or structure of the DCSS task, which has been the typical strategy adopted by researchers in the field (e.g. Kloo & Perner, 2005; Zelazo *et al.* 2003). However, the findings of our study (and also those of Jacques *et al.*, 1999) suggest that social factors can be introduced to the task, potentially offering unique insights into the exact nature of children's success and failure in the DCCS task. For example, with specifically designed studies, we could examine what exactly is socially transmitted to children after they have observed a model's behavior in the Unaware and Confident conditions and why social transmission of disinhibition did not occur in the Aware and Unconfident conditions. More generally, experimental studies of the effect of social factors on children's inhibitory control abilities are also needed, because they might provide causal explanations about why children's socio-cognitive abilities are consistently found to be correlated with their executive functioning.

## Acknowledgements

The research reported here was supported by Basic Research 21 for Breakthroughs in Info-Communications and a grant from JSPS (No: 13610087, 16500161) to Shoji Itakura, and by the 21st Century COE Program (D-2 to Kyoto University), MEXT, Japan. The authors thank Ayako Goto, Chiyo Ito, Misa Kuroki and Wakako Sanefuji for help with data collection and Anjanie McCarthy for comments on an earlier version of this paper.

## References

Barkley, R.A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychological Bulletin*, **121**, 65–94.

Blair, C. (2002). School readiness: integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist*, **57**, 111–127.

Bohlmann, N.L., & Fenson, L. (2005). The effects of feedback on perseverative errors in preschool aged children *Journal of Cognition and Development*, **6** (1), 119–131.

Brooks, P.J., Hanauer, J.B., Padowska, B., & Rosman, H. (2003). The role of selective attention in preschoolers' rule use in a novel dimensional card sort. *Cognitive Development*, **18**, 195–210.

Carlson, S.M. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*, **28**, 595–616.

Carlson, S.M., Mandell, D.J., & Williams L. (2004). Executive function and theory of mind: stability and prediction from ages 2 to 3. *Developmental Psychology*, **40**, 1105–1122.

Carlson, S.M., & Moses, L.J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, **72**, 1032–1053.

Carlson, S.M., Moses, L.J., & Breton, C. (2002). How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development*, **11**, 73–92

Dempster, F.N. (1992). The rise and fall of the inhibitory mechanism: toward a unified theory of cognitive development and aging. *Developmental Review*, **12**, 45–75.

Denckla, M.B. (1996). Research on executive function in a neurodevelopmental context: applications of clinical measures. *Developmental Neuropsychology*, **12**, 5–16.

Dennis, M., Barnes, M.A., Donnelly, R.E., Wilkinson, M., & Humphreys, R.P. (1996). Appraising and managing knowledge: metacognitive skills after childhood head injury. *Developmental Neuropsychology*, **12**, 77–104.

Diamond, A. (1991). Frontal lobe involvement in cognitive changes during the first year of life. In K.R. Gibson & A.C. Petersen (Eds.), *Brain maturation and cognitive development: Comparative and cross-cultural perspectives* (pp. 127–180). New York: Aldine de Gruyter.

Diamond, A., Kirkham, N., & Amso, D. (2002). Conditions under which young children can hold two rules in mind and inhibit a prepotent response. *Developmental Psychology*, **38**, 352–362.

Diamond, A., Prevor, M.B., Callender, G., & Druin, D.P. (1997). Prefrontal cortex cognitive deficits in children treated early and continuously for PKU. *Monographs of the Society for Research in Child Development*, **62** (4), Serial no. 252.

Eisenberg N., Fabes R.A., Murphy, M., Maszk, P., Smith, M., & Karbon, M. (1995). The role of emotionality and regulation in children's social functioning. *Child Development*, **66**, 1239–1261.

Esbensen, B.M., Taylor, M., & Stoess, C. (1997). Childen's behavioral understanding of knowledge acquisition. *Cognitive Development*, **12**, 53–84.

Fletcher, J.M., Brookshire, B.L., Landry, S.H., Bohan, T.P., Davidson, K.C., Francis, D., Levin, H., Brandt, M., Kramer, L., & Morris, R. (1996). Attentional skills and executive functions in children with early hydrocephalus. *Developmental Neuropsychology*, **12**, 53–76.

Harnishfeger, K.K., & Bjorklund, D.F. (1993). The ontogeny of inhibition mechanisms: a renewed approach to cognitive development. In M.L. Howe & R. Pasnak (Eds.), *Emerging themes in cognitive development. Vol. I: Foundations* (pp. 28–49). New York: Springer-Verlag.

Hughes, C. (1998). Executive function in preschoolers: links with theory of mind and verbal ability. *British Journal of Developmental Psychology*, **16**, 233–253.

Hughes, C., Dunn, J., & White, A. (1998). Trick or treat?: uneven understanding of mind and emotion and executive dysfunction in 'hard to manage' preschoolers. *Journal of Child Psychology and Psychiatry*, **39**, 981–994

Jacques, S., Zelazo, P.D., Kirkham, N.Z., & Semcesen, T.K. (1999). Rule selection versus rule execution in preschoolers: an error-detection approach. *Developmental Psychology*, **35**, 770–780.

Kirkham, N.Z., Cruess, L., & Diamond, A. (2003). Helping children apply their knowledge to their behavior on a dimension-switching task. *Developmental Science*, **6**, 449–476.

Kloo, D., & Perner, J. (2003). Training transfer between card sorting and false belief understanding: helping children apply conflicting descriptions. *Child Development*, **74**, 1823–1839.

Kloo, D., & Perner, J. (2005). Disentangling dimensions in the dimensional change card-sorting task. *Developmental Science*, **8**, 44–56.

Kochanska, G., Murray, K.T., & Harlan, E.T. (2000). Effortful control in early childhood: continuity and change, antecedents, and implications for social development. *Developmental Psychology*, **36**, 220–232.

Kochanska, G., Murray, K.T., Jacques, T.Y., Koenig, A.L., & Vandegeest, K.A. (1996). Inhibitory control in young children and its role in emerging internalization. *Child Development*, **67**, 490–507.

Koenig, M.A., Clément, F., & Harris, P.L. (2004). Trust in testimony – children's use of true and false statements. *Psychological Science*, **15**, 694–698.

Levin, H.S., Fletcher, J.M., Kufera, J.A., Harward, H., Lilly, M.A., Mendelsohn, D., Bruce, D., & Eisenberg, H.S. (1996). Dimensions of cognition measured by the Tower of London and other cognitive tasks in head-injured children and adolescents. *Developmental Neuropsychology*, **12**, 17–34.

Moore, C., Pure, K., & Furrow, D. (1990). Children's understanding of the modal expression of speaker certainty and uncertainty and its relation to the development of a representational theory of mind. *Child Development*, **61** (3), 722–730.

Munakata, Y., & Yerys, B.E. (2001). All together now: when dissociations between knowledge and action disappear. *Psychological Science*, **12**, 335–337.

O'Neill, D.K., & Gopnik, A. (1991). Young children's ability to identify the sources of their beliefs. *Developmental Psychology*, **27**, 390–397.

Ozonoff, S., Pennington, B.F., & Rogers, S.J. (1991). Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. *Journal of Child Psychology and Psychiatry*, **32**, 1081–1095.

Perner, J. (1998). The meta-intentional nature of executive function and theory of mind. In P. Carruthers & J. Boucher (Eds.), *Language and thought: Interdisciplinary themes* (pp. 270–283). Cambridge: Cambridge University Press.

Perner, J., Lang, B., & Kloo, D. (2002). Theory of mind and self-control: more than a common problem of inhibition. *Child Development*, **73**, 752–767.

Sabbagh, M.A., & Baldwin, D.A. (2001). Learning words from knowledgeable versus ignorant speakers: links between preschoolers' theory of mind and semantic development. *Child Development*, **72**, 1054–1070.

Sabbagh, M.A., Wdowiak, S.D., & Ottaway, J.M. (2003). Do word lerners ignore ignorant speakers? *Journal of Child Language*, **30**, 905–924.

Sabbagh, M., Xu, F., Carlson, S., Moses, L., & Lee, K. (2006). The development of executive functioning and theory-of-mind: a comparison of Chinese and US preschoolers. *Psychological Science*, **17** (1), 74–81.

Thatcher, R.W. (1992). Cyclic cortical reorganization during early childhood. *Brain and Cognition*, **20**, 24–50.

Towse, J.N., Redbond, J., Houston-Price, C.M.T., & Cook, S. (2000). Understanding the dimensional change card sort: perspectives from task success and failure. *Cognitive Development*, **15**, 347–365.

Zelazo, P.D., Frye, D., & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive Development*, **11**, 37–63.

Zelazo, P.D., Jacques, S., Burack, J.A., & Frye, D. (2002). The relation between theory of mind and rule use: evidence from persons with autism-spectrum disorders. *Infant and Child Development*, **11**, 171–195.

Zelazo, P.D., & Müller, U. (2002). Executive function in typical and atypical development. In U. Goswami (Ed.), *Blackwell handbook of childhood cognitive development* (pp. 445–469). Oxford: Blackwell.

Zelazo, P.D., Müller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function in early childhood. *Monographs of the Society for Research in Child Development*, **68** (3), Serial No. 274.

Received: 9 July 2005
Accepted: 21 June 2006