Autistic children's understanding of false belief: Studies based on computerized animation task

Hei-Rhee Ghim
Chungbuk National University, Cheongju, Korea, hrghim@cbucc.chungbuk.ac.kr

Hyeonjin Lee
Yeungnam University, Gyongsan, Korea, hjlee@yu.ac.kr

Sunmi Park
Seoul National University, Seoul, Korea, parksunm@chollian.net

Abstract

The first purpose of the studies reported was to compare the ability of autistic children in understanding false belief with the corresponding abilities of normal or mentally retarded children. *Unexpected location tasks* adapted from the *Sally-Anne false belief tasks* were used in experiment 1. Autistic children performed worse than normal children and the mentally retarded children, but the difference in performance between the autistic and the mentally retarded children was not significant. Similar results emerged when the *unexpected content tasks* adapted from the *Smarties tasks* were used in experiment 2.

The second purpose was to investigate whether the children understand their own false belief better than that of other's. Responses to "own false belief" questions were compared with those to "other's false belief" questions in experiment 2. There was no clear evidence that children understand their own false belief better than that of other's.

The last purpose was to investigate whether autistic children could learn to understand false belief. In experiment 3, children were taught about the principles underlying the false belief concept. After the teaching, all three groups were able to pass transfer tasks of false belief. Overall improvement was less in the mentally retarded group than in the autistic group or normal group. The results suggest that teaching the principles underlying the false belief concept is effective for autistic children.

Introduction

It has been widely accepted that children with autism have a specific impairment in their ability to understand mind. A number of studies have shown that in comparison to normal or mentally retarded children, autistic children have difficulty in understanding and reasoning mental states (Baron-Cohen, Leslie, & Frith, 1985; Charman & Baron-Cohen, 1992; Leekam & Perner, 1991). This specific deficit in autistic children has been thought to be the underlying cause of their social and communicative impairment as well as their lack of pretend play.

However, recently a number of studies have found some evidence that challenges the specificity of the theory of mind deficit in autistic children. In some studies, not only autistic children but also mentally retarded children have difficulty in understanding false belief in comparison to normal children, and the understanding of false belief and VMA(verbal mental age) are correlated (Yirmiya et al., 1998). In addition, autistic children with VMA over nine years have passed the false belief tasks, and their performance correlated with the VMA (Happé, 1995). These findings suggest that VMA plays a significant role in the understanding of false belief.

The first purpose of our studies was to test the specificity of the theory of mind deficit in autism. Because VMA has been found to be correlated with the performance in false belief, we tried to match the VMA of autistic children with those of normal children and mentally retarded children by testing the VMA of three groups. In addition, we tried to minimize the effect of VMA on the performance by using computerized false belief tasks consisting of graphic images and animation. Using this medium of presentation, we reduced the linguistic skills involved in the traditional false belief task. Children saw the computerized animation pictures that illustrated the scenarios of false belief task visually. For the test questions, the children were asked to respond by simply pointing to one of two pictures presented on the screen. We intended that by reducing the language influences, we would be able to gain more control over the effect of VMA among different groups. Additionally, this procedure would also minimize the effects of social deficit, which might prevent the autistic children from responding to the task.

The second purpose of these studies was to examine how children know other person's mind. According to the *theory of mind account*, the mind is a theoretical construction for explaining observable behavior (Perner, 1991; Wellman, 1990). Thus, this account predicts that children would understand another person's mind as well as their own mind at the same developmental point when they understand the representational mind. The alternative *simulation account* assumes that children would understand another person's mind by simulating it on their own mind. This view predicts that we understand our mind first and then begin to understand other person's minds (See Gopnik & Wellman, 1994, for this issue). We approached this issue in the second

experiment using the *unexpected content task*.

The third purpose was to test whether autistic children could learn to understand the false belief through teaching procedures. We employed a teaching method that encouraged the understanding of the principles underlying the false belief concept, for example "seeing-leads-to-knowing" principle.

Experiment 1

In the experiment 1, using two versions of *unexpected location task* adapted from *the Sally-Anne task* (Baron-Cohen et al., 1985), we tested autistic children's understanding of false belief in comparison to normal or mentally retarded children.

Participants

Three groups of children participated in this experiment: children with autism spectrum condition (*N*=13), children with mental retardation (MR) of unknown etiology without specific biological defects (*N*=16), and 4- to 5-year-old normal children (*N*=16). VMA was measured by the Korean version of Peabody Picture Vocabulary Test (PPVT). The mean VMA of the autistic group was 7:0, while that of the mental retardation group was 5:3, and that of the normal group was 5:9. Chronological age (CA) and VMA of three groups are shown in Table 1.

Table 1. Participants, with CA, VMA in years and months on the Korean version of PPVT, and sex.

		Autistic	Normal	MR
CA	Mean	12:4	5:2	10:3
	SD	4:4	0:4	3:9
	Range	4:9-18:4	4:7-5:6	5:5-19:1
VMA	Mean	7:0	5:9	5:3
	SD	1:11	0:10	1:8
	Range	4:9-9:1	4:9-6:9	3:3-8:9
Sex (Male:Female)		11:2	10:6	10:6
Total Number		13	16	16

Task

Two versions of computerized animation pictures of *unexpected location task* presented through a computer monitor were used. The two animation pictures had different scenarios. The scenario of "Mother and baby" was as follows: The mother put her baby to sleep into futon. While the baby sleeps the mother goes to kitchen. Meanwhile, the baby wakes up and crawls under a desk and falls asleep again. After preparing a dinner the mother goes to check up on her baby. The scenario of "JjangKu and his crayons" was as follows: JjangKu is doing his coloring-in homework with crayons on the lounge table. At that time JaeOuk from next door comes over and asks JjangKu to play. So JjangKu goes outside to play with JaeOuk, leaving his crayons on the table. While JjangKu is outside, his mother moves the crayons from the lounge table to JjangKu's room. Finally JjangKu returns home from playing outside.

Procedure

The children were tested individually in a quiet room. Each child was first shown the main part of the animation pictures. In the main part of the pictures, a protagonist left an object in one location and then while s/he was away, other character placed it in a new location. Following the main part, the narrator in the animation pictures asked each child two control questions to ensure that s/he knew the real current location and the previous location of the object: "Where did [the protagonist] put [the object]?" and "while [the protagonist] was outside, where did [the other person] move [the object]?" For these questions, the child was asked to respond by simply pointing to one of two pictures of places presented on the monitor. For example, in the animation picture of "Mother and baby" task, the child was asked to point either to the futon or to the desk.

If the child failed to pass either of the control questions, the main part of the animation was repeated until s/he passed both of the control questions. If the child passed both of the control questions, then, the narrator in the animation pictures asked the child two test questions: the first test question was about the protagonist's belief about the location of the object ("Where does [the protagonist] think [the object] is?") and the second question was about the protagonist's action ("When [the protagonist] returns, where will s/he look for [the object]?"). The child was asked to respond to these questions by simply pointing to one of two pictures of places presented on the monitor.

Each child was tested with two animation tasks in counterbalanced order.

Results and Discussion

For the two test questions of each animation task, if the child answered correctly to both of the questions then a score of 1 was given. Thus the scores for this experiment ranged from 0 not passing any animation task, to 2 passing both animation tasks. Table 2 shows the number of subjects in each group who scored 0/1/2. On these scores, the CATMOD procedure was performed to investigate the group, animation task, group_animation task effects. The results revealed that only the main effect of group was significant ($\chi^2(2, N = 45) = 6.49, p < .05$).

Table 2. Number of subjects in each group who scored 0/1/2

	Both incorrect (score 0)	Task 1* correct (score 1)	Task 2** correct (score 1)	Both correct (score 2)
Autistic (N=13)	5	2	1	5
Normal (N = 16)	1	0	3	12
MR (N = 16)	4	2	1	9

Task 1* "Mother and baby" animation task

Task 2** "JjangKu and his crayons" animation task

Contrast analysis for the group effects showed that only the difference between the normal and autistic groups was significant. Mentally retarded children performed better than autistic children and performed worse than normal children, but the differences between the relevant groups were not significant {$\chi^2(1, N = 29) = 0.94$, n.s. for MR vs. Autistic, and $\chi^2(1, N = 32) = 2.13$, n.s. for MR vs. Normal}.

In sum, autistic children's understanding of false belief was worse than that of normal children, but was not worse than that of mentally retarded children. These results suggest that the autistic children have a deficit in understanding false belief in comparison to normal children. However, there is no clear evidence that autistic children have a deficit in comparison to mentally retarded children.

Experiment 2

In experiment 2, we tested autistic children's understanding of false belief in comparison to normal or mentally retarded children, using different types of tasks. We used the *unexpected content tasks* adapted from *the Smarties task* (Perner, Leekam & Wimmer, 1987). In addition, we tested the children's understanding of their own vs. other people's false belief in order to examine *the simulation account* and *the theory of mind account*.

Participants

Fourteen autistic children, 16 normal children and 15 mentally retarded children participated in this experiment. The mean VMA of the autistic group was 6:3, that of the mental retardation group was 5:9, and the normal group's was 5:7. Chronological age and VMA of three groups are shown in Table 3.

Task

Two versions of animation pictures of the unexpected content task presented through a computer monitor were used. The two animation pictures had different scenarios, in which different characters and boxes were used. In one pictures, "SuJin and Chocopies," the Chocopies (popular Korean cookies) box had Pikachu doll inside. In the other pictures, "Matt and the milk carton," the milk carton contained juice inside.

Table 3. Participants, with CA, VMA in years and months on the Korean version of PPVT, and sex.

		Autistic	Normal	MR
CA	Mean	12:1	5:1	14:4
	SD	3:0	0:5	5:9
	Range	6:0-16:0	4:7-5:10	6:6-22:9
VMA	Mean	6:3	5:9	5:7
	SD	2:0	0:7	1:9
	Range	3:9-9:1	4:9-6:9	2:9-8:9
Sex (Male:Female)		14:0	12:4	8:7
Total Number		14	16	15

Procedure

Each child was first shown the main part of the animation pictures. In the main part of the pictures, a narrator showed the child a box which, when opened, was seen to contain unexpected content. After the narrator closed the box, a protagonist came into the room and found the box. Following the main part, the narrator in the animation pictures asked the child two test questions. One was about the protagonist's belief about the content: "What does [the protagonist] think is inside [the box]? Will s/he think that there is [x] inside? Or will s/he think that there is [y] inside?" (In the animation of "SuJin and Chocopies," [x] and [y] are Chocopies and the Pikachu doll.) The other was about the child's own previous belief about the content: "Before we opened [the box], what did you think was inside [the box]? Did you think there was [x] inside? Or did you think there was [y] inside?" The child was asked to respond orally.

Each child was tested with two animation tasks in counterbalanced order.

Results and Discussion

Children's performance was recorded just as in experiment 1. For the two test questions of each animation task, if the child answered correctly to both of the questions then a score of 1 was given. Thus the scores ranged from 0 not passing any animation task, to 2 passing both animation tasks. Table 4 shows the number of subjects in each group who scored 0/1/2. On these scores, the CATMODE procedure was performed to investigate the group, animation task, group_animation task effects. The results revealed that only the main effect of group was significant ($\chi^2(2, N = 45) = 7.46, p < .05$).

Table 4. Number of subjects in each group who scored 0/1/2

	Both incorrect (score 0)	Task 1* correct (score 1)	Task 2** correct (score 1)	Both correct (score 2)
Autistic (N=14)	6	1	3	4
Normal (N = 16)	2	2	0	12
MR (N = 15)	2	4	1	8

Task 1* "SuJin and Chocopies" animation task
Task 2** "Matt and the milk carton" animation task

Contrast analysis for the group effect showed that there was significant difference between the autistic and normal groups. Mentally retarded children performed better than autistic children, and the difference between the two groups was marginally significant ($\chi^2(1, N = 29) = 3.54, p = .06$). In contrast, mentally retarded children performed worse than normal children, though the

difference between the two groups was not significant ($\chi^2(1, N = 31) = 0.79$, n.s.). These results suggest that the autistic children have deficit in understanding false belief compared to normal, and possibly, to mentally retarded children.

One important purpose of the present experiment was to examine the simulation account and the theory of mind account. *The simulation account* predicts that children would understand their own mind better than other's mind. In contrast, *the theory of mind account* predicts that children would understand other's mind as well as their own mind. Thus, in order to test the simulation account vs. the theory of mind account, we have to compare the children's understanding of their own false belief against their understanding of other's false belief.

In this experiment, each child had to answer two types of test questions in each animation task: One was about the protagonist's belief, that is other's belief, and the other was about the child's own belief. In order to compare children's understanding of their own false belief against their understanding of other person's false belief, we re-analyzed the children's performances. For each of the two types of test questions, if the child answered correctly to the question in both of the animation tasks then a score of 1 was given. Thus the scores ranged from 0 not passing any question, to 2 passing both the other's belief and own belief questions. Table 5 shows the number of subjects in each group who scored 0/1/2.

Table 5. Number of subjects in each group who scored 0/1/2

	Both incorrect (score 0)	Type 1 Q* correct (score 1)	Type 2 Q** correct (score 1)	Both correct (score 2)
Autistic (N=14)	4	4	2	4
Normal (N = 16)	1	3	0	12
MR (N = 15)	4	2	1	8

Type 1 Q* questions on other's false belief
Type 2 Q** questions on own false belief

The CATMOD procedure was performed to investigate the group, question, group_question effects. The results revealed that only the main effect of group was significant ($\chi^2(2, N = 45) = 8.16$, $p < .05$). Children performed better on the other's belief questions than on their own belief questions, though the main effect of question was only marginally significant ($\chi^2(1, N = 45) = 3.03$, $.05 < p < .10$). In addition, lack of the interaction effect of group_question ($\chi^2(2, N = 45) = .04$, n.s.) demonstrated that children's performance was not different among groups. The present result, which shows that the understanding of own mind is not easier than the understanding of other's, does not support *the simulation account*.

Experiment 3

In experiment 3, we investigated whether autistic children could learn to understand false belief and generalize this learning to other tasks. Recently, several studies have shown that understanding false belief could be taught to autistic children, but with some limitations. For example, in Swettenham (1996)'s study, following teaching, autistic children were able to pass the transfer task with the same scenario but not with different scenarios. In contrast, normal children and Down's syndrome children passed both transfer tasks. McGregor, Whiten, & Balkburn (1998) also found that both the normal and autistic children were able to pass a standard false belief task following teaching but the autistic children's generalization was limited to the test of their own false belief.

In this experiment, we taught principles that are essential in understanding false belief, for example the "seeing-leads-to-knowing" principle (Howlin, Baron-Cohen, & Hadwin, 1999) to children who failed to pass both animation tasks in the first experiment plus those who failed to pass both animation tasks in the second experiment. We followed the teaching procedure suggested by Howlin, Baron-Cohen, and Hadwin (1999). Then, we tested the generalization with two types of tasks for each child: The first task was of the same type as the one that the child failed previously, but with different version of animation pictures. The second task was the new type of task that the child hadn't participated previously. If the subject had participated in experiment 1, it was the animation version of *the change of content task*, and if the subject had participated in experiment 2, it was the animation version of *the change of location task.* The generalization tests were administered two times for each child: One right after the teaching session and the other two weeks later.

Participants

Sixteen autistic children, 7 normal children and 11 mentally retarded children who participated in either experiment 1 or experiment 2 and failed to pass both animation tasks.

Task

Four new versions of animation pictures of the false belief tasks, two unexpected location tasks and two unexpected content tasks, were used. Two of them were used immediately after the teaching session as immediate generalization tests, and the others were used two weeks later as delayed generalization tests. The scenarios of these four animation pictures were different versions of those used in experiment 1 and 2.

Procedure

Three principles were taught step by step. Principle 1 states that "when one sees something one knows what it is but otherwise one cannot know". Using two small black and white stones and two different boxes, the

experimenter hid the two stones in each box firstly, while the child observed, and then once again while the child had closed her/his eyes. The child was then asked whether s/he knew where the stone was. Following the child's answer, the experimenter explained the principle. This procedure was repeated with a doll one more time.

Principle 2 states that "when one saw something in a certain place one would search for that object in that place". Using a variety of materials such as a doll, a miniature bed, a dresser and flowers, this principle was taught to the children in a repetition of 4 times.

As a final step, principle 3 was taught to the children. Principle 3 states that "If one doesn't know that things have changed then s/he will think that things are just the same". In order to teach principle 3, the correct answers for the animation tasks that the child had seen in the previous experiment were explained. For example, if a child initially participated in experiment 1, the experimenter showed the pictures of unexpected location task that the child had seen before and explained why the protagonist would look for the object in the old location rather than the current location. The teaching procedure lasted for about 30 minutes.

Right after the teaching session, an immediate generalization test was conducted with new versions of the two tasks, one with unexpected location task and the other with unexpected content task. Two weeks later, delayed generalization was tested with the new versions of the two tasks.

Result and Discussion

Each child had to respond to tests at three different stages; pre-teaching test (response in experiment 1 or 2), immediate generalization test, and two weeks delay generalization test. With these responses, three sets of scores were computed for each child; pre-teaching score, immediate generalization score, and two weeks delay generalization score. For each test, each child had to answer four test questions, two test questions for each of two animation tasks. If a child answered correctly to one test question, score 1 was given. Therefore, each score ranged from 0 to 4.

On these scores initial experiment (experiment 1 or 2), group, teaching(pre-, immediate, delayed), and group_teaching effects were analyzed by GLM procedure. The main effect of teaching was significant ($F(2, 56) = 19.98$, $p < .001$), and importantly teaching_group interaction effect was also significant ($F(4,56) = 2.95$, $p < .05$). Further analysis on the main effects of teaching revealed that both the linear trend ($F(1, 28) = 40.78$, $p < .001$) and the quadratic trend ($F(1, 28) = 5.01$, $p < .05$) were significant (See Figure 1).

These results suggest that the performance improved significantly after teaching. The teaching_group interaction effects indicated a larger learning effects on the part of autistic children in comparison to mentally retarded children. In the present experiment, the performance of the autistic children was the lowest among the three groups before teaching but after teaching, their performance level reached that of normal children.

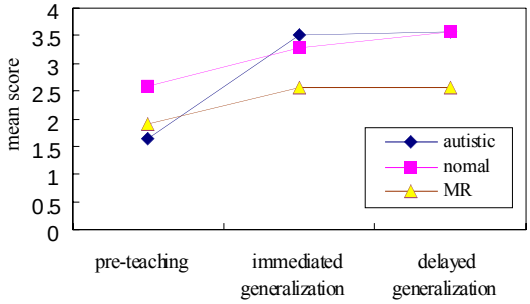

Figure 1. Teaching effect

General Discussion

The findings from these studies can be summarized as follows. Firstly, children with autism have deficit in understanding of false belief in comparison to normal children. This result was replicated across different types of tasks (*unexpected location task* of the experiment 1 and *unexpected content task* of the experiment 2). Secondly, all three groups of children understood their own false belief no better than another's false belief. Thirdly, autistic children could be taught to pass the false belief tasks and generalize their learning to other false belief tasks right after the teaching and two weeks later.

The present findings have implications for the specificity of theory of mind deficit in autistic children. Even though the performance of autistic children was not significantly lower than that of mentally retarded children in these studies, the results could not reject the specificity of theory of mind in autism for two reasons. Firstly, mentally retarded children performed better than autistic children regardless of their lower VMA. Secondly, the performance of the mental retardation group was marginally better than that of the autistic group in experiment 2, in which the mean VMA was more closely matched than in experiment 1. Therefore, it seems probable that we could get the evidence for the specificity of the theory of mind deficit to autism, if VMA would be more closely matched among groups.

In addition, the findings in experiment 2 that children do not understand their own belief better than another's belief, do not support *the simulation account*. In experiment 2, children's understanding of other's belief was slightly better than that of their own. However, we could not strongly argue for the theory of mind account because the results did not clearly evidenced that children understood another's belief as much as their own. The results of other previous studies in the literature are also inconsistent with each other. Some studies have reported that normal child understand their own belief better than another's belief

(Hogrefe, Wimmer, & Perner, 1986; Kazak, Collis, & Lewis, 1997; Perner, Leekam, & Wimmer, 1987; Wimmer, Hogrefe, Perner, 1988). Other studies have reported that children understand another's belief as much as their own (Gopnik & Slaughter, 1991; Sullivan & Winner, 1991; Wimmer & Hartle, 1991). In contrast, Gopnik and Astington (1988) have reported that children understand other's mind better than their own. Because the results are inconsistent, further study is needed for the clear conclusion about the issue of the simulation vs. theory of mind accounts.

The present studies also suggest that autistic children could learn to understand mind, even though they have a specific deficit in theory of mind. Teaching the principles underlying the false belief seems to be effective, especially to autistic children.

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