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ORIGINAL PAPER

# Validity of False Belief Tasks in Blind Children

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**Abstract** Previous studies have reported that congenitally blind children without any additional impairment reveal a developmental delay of at least 4 years in perspective taking based on testing first-order false-belief tasks. These authors interpret this delay as a sign of autism-like behavior. However, the delay may be caused by testing blind children with false-belief tasks that require visual experience. Therefore, the present study gave alternative false-belief tasks based on tactile or auditory experience to 45 congenitally blind 4–10-year-olds and 37 sighted 3–6-year-olds. Results showed criterion performance at 80 months (6; 8 years) in blind children compared with 61 months (5; 1 years) in sighted controls. It is concluded that this 19-month (1; 7 year) difference, which is comparable with delays in other developmental areas, is a developmental delay caused by the fact of congenital blindness rather than a sign of a psychopathological disorder of autism-like behavior.

**Keywords** Alternative false-belief tasks · Blind children · Perspective taking · Autism

Perspective taking is the ability to understand the emotional and mental states of other persons and draw on these to explain and predict their behavior. This ability is considered to be a major milestone in the acquisition of social cognition and particularly of Theory of Mind (ToM).

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In children, social-cognitive perspective taking is generally assessed with two types of false-belief tasks: (a) ones with unexpected contents such as Perner et al. (1987) standard task in which a child finds crayons in a candy box instead of candies; and (b) ones in which the location of an object is switched in a person's absence, as in Baron-Cohen et al. (1985) standard task with "Sally and Anne" dolls. Perspective taking is assumed to be acquired when children predict, for example, that another child in the same initial situation as themselves will expect to find candies in the candy box, because this other child cannot know that it contains crayons. The majority of sighted children are able to solve such false-belief tasks by the age of 4–5 years according to a meta-analysis by Wellman and Liu (2004).

Research on children with congenital blindness has reported a developmental delay of 4–7 years in acquiring such a form of perspective taking in comparison to sighted children.

Individual studies report the following chronological ages in children who are totally blind or have light perception at most: (a) McAlpine and Moore (1995): 100% at a chronological age (CA) of 11 years; (b) Minter et al. (1998): 47% at a CA of 7; 11 years; (c) Peterson et al. (2000): 14% at a CA of 6; 9 years (39% correct answers), 50% at a CA of 8; 10 years (65% correct answers), and 70% at a CA of 12; 0 years (85% correct answers); (d) Green et al. (2004): 50% at a CA of 8; 7 years and a verbal mental age of 8; 11 years. Leaving aside the outlier in McAlpine and Moore (1995), the averaged CA is 8; 5 years in blind children ($b = 7$; 11 years, $c = 8$; 10 years, and $d = 8$; 7 years), that is, a delay of at least 4 years.

The authors did not attribute the observed delays to a cognitive deficit in the blind children, because almost all participants in these four studies were of at least average intelligence. They suggested that the main reason was—

comparable to autistic children—deficits or limitations in acquiring the antecedents of ToM. These limitations are: (a) the lack of visual co-orientation (Hobson 1990) such as mutual gaze (McAlpine and Moore 1995; Minter et al. 1998; Recchia 1997); (b) problems in referential nonverbal communication such as limitations to joint attention (Green et al. 2004; Minter et al. 1998); and (c) the inability to observe emotional states through, for example, facial expressions, gestures, or body postures (McAlpine and Moore 1995; Minter et al. 1998). These impairments result in a lower contingent responsiveness in parents of blind compared with sighted children (Recchia 1997), greater difficulties in social referencing (Minter et al. 1998), and less intersubjective experience (Recchia 1997).

Hobson and colleagues (Brown et al. 1997; Hobson 1993, 2005; Hobson et al. 1997; Minter et al. 1998; Pring 2005a, b) interpret these developmental delays in the acquisition of perspective taking as a major sign of autism-like behavior in congenitally blind children. The term "autism-like" is used because, although the symptoms in congenitally blind children are not as frequent, pervasive, and long-lasting as in autistic children, they still represent a psychopathological disorder (Hobson 2005).

However, other authors consider the observed delay to be a blind-specific developmental difficulty and not a psychopathological problem. They claim that almost all autism-like symptoms in blind children such as delayed symbolic play, less interaction with peers, increased stereotypic behavior, or more frequent echolalic speech, may be explained by the fact of blindness, that is, as being a consequence of their difficulties in gaining physical and social experiences (see, for detailed discussions, Brambring and Tröster 2005; Pérez-Pereira and Conti-Ramsden 2005).

Hence, the diagnosis of autism-like behavior by Hobson and colleagues (Brown et al. 1997; Hobson 1993, 2005; Hobson et al. 1997; Minter et al. 1998; Pring 2005a, b) is based essentially on the findings that reveal a markedly later acquisition of perspective-taking ability in children with congenital blindness. However, these findings could be an artifact of the standard false-belief tasks evaluated up to now. These previously applied standard false-belief tasks may disadvantage blind children, because both the materials presented and the actions to be performed are based mainly on vision and not on the way blind children experience the world. As a result, such tasks may well differ in terms of item difficulty and validity—something that Pérez-Pereira and Conti-Ramsden (2005) also mentioned explicitly: "It is difficult to find an adequate, valid and reliable task for blind children, equivalent to the tasks of false belief for sighted children" (p. 109).

This can be illustrated with Minter et al.'s (1998) teapot task. In this task, children have to predict the contents of a teapot, but, unexpectedly, when they lift it up to pour, sand comes out of the spout. The authors considered that the significantly poorer performance of blind compared with sighted children on this first-order false-belief task could not be explained through a deficit in experience, because the blind children had "no problems in recognizing the teapot" (Minter et al. 1998, p. 193). However, although it can be taken for granted that young school-age blind children will recognize the objects involved and "know" that such a pot will contain some kind of fluid, frequently, this knowledge will not be based on their own tactile experiences but on what other people have told them. When confronted with the unexpected content "sand," they may well tend to wonder whether their knowledge is incomplete. They might simply think that nobody has ever told them before that teapots sometimes contain sand. This uncertainty can be seen in the blind children's answers to the own false-belief question in Minter et al. (1998): eight (42%) answered it incorrectly, reporting that they had even suspected sand in the teapot before lifting it up and pouring. A further possible difficulty with this task is that young blind children still have insufficient knowledge and mastery of the physical act of pouring. Lewis and Iselin (2002) asked 10 parents of blind and 10 parents of sighted children (aged 6; 6–9; 0 years) how well their offspring coped independently with daily living skills. One item was "Pours from half-gallon container." Whereas nine parents of sighted children answered this item affirmatively, only two parents of blind children did so. It seems that the latter will not let their offspring pour out liquids until they are older—particularly when these are hot. Such differences in pouring competence may well impact on the difficulty of the teapot task for blind versus sighted children and even influence its validity. There are similar problems with other "standard" false-belief tasks with unexpected content, such as the hamburger box with a sock (McAlpine and Moore 1995) or the egg box with squash balls (Peterson et al. 2000). Here, as well, it can be assumed that blind children will have less experience in dealing with these objects and their possible uses than their sighted peers.

To overcome these difficulties with the content and the presentation methods of standard false-belief tasks, two new, alternative types of task were developed for the present study. These were tasks in which (a) it can be assumed with a high degree of certainty that blind children will be familiar with both the object and the attendant action through their own experience; and (b) vision plays no or only a subordinate role in the solution, because the tasks are purely tactile or auditory. The goal of this study is to test the hypothesis that when congenitally blind children are given false-belief tasks that do not depend on sight, they will display perspective-taking ability at an earlier age than that reported in prior studies.

## Methods

This study is the first assessment wave in a 3-year longitudinal study on the acquisition of ToM abilities in congenitally blind children in Germany accompanied by a cross-validation study in the Netherlands. The present article reports solution frequencies for the 9 first-order false-belief tasks out of a total of 16 ToM tasks and compares these findings with the results of prior studies on the solution of false-belief tasks in congenitally blind children (Green et al. 2004; McAlpine and Moore 1995; Minter et al. 1998; Peterson et al. 2000). It also assesses performance on these tasks in a sighted control group. The other ToM tasks will be described and analyzed in further publications and will be mentioned only in an overview.

### Participants

The blind children were recruited by writing to schools for the blind and early intervention centers responsible for their care throughout Northern Germany and the Netherlands. These institutions were asked to name children who met the following criteria: (a) aged 4–10 years; (b) congenitally blind; (c) no further sensory, cognitive, or neurological impairments; (d) no confirmed clinical diagnosis of autism (although individual autistic features such as stereotypies or difficulties in social interaction were not used as exclusion criteria); and (e) a good understanding of the national language. These criteria were comparable to those used in the previous studies. They were clarified by telephoning the parents and, during the first visit, by testing the blind children's language and memory abilities to ensure that congenital blindness was not accompanied by any verbal or cognitive impairment.

From a total of 58 blind children contacted, 13 failed to meet the recruitment criteria for the study. Three of these children were not congenitally blind but had become blind after the first year of life and one had low vision. Five children scored below the normal range on the memory test (scale score <7), two did not have sufficient command of the German or Dutch language, one scored below normal range on the language test (scale score <40), and one had severe cognitive impairments according to the early interventionist's report.

Therefore, the test group contained 45 congenitally blind children: 32 (20 girls, 12 boys) in Germany and 13 (8 girls, 5 boys) in the Netherlands. The median age of the German and Dutch samples combined was 6; 10 years (range: 4; 0–10; 1 years). The wide age range was particularly appropriate to avoid missing outliers. All children were either completely blind or possessed at most light perception that means none of them had been able to recognize even large-sized objects or faces at any time in their lives. Reported causes of blindness were complications due to extreme prematurity (retinopathy of prematurity—Stage IV/V or Stage V) in 5 cases, eye malformations (micro- or anophthalmos) in 7, Leber's congenital amaurosis in 7, glaucoma and optic hypoplasia in 6, and other single causes in 8 children. No information was available on the cause of blindness in the remaining 12 children.

We also recruited and tested 37 sighted controls (16 girls, 21 boys) with a median age of 5; 1 years (range 3; 6–6; 0 years). These children came from Northern German kindergartens, had no impairments, and possessed a good command of the German language.

### Screening

The German sample was given two verbal subtests and a memory subtest to control for verbal and cognitive performance. Preschoolers up to the age of 5; 11 years were given subtests on "phonological working memory for nonwords" (*Phonologisches Arbeitsgedächtnis für Nichtwörter*: PGN) and "memory for sentences" (*Satzgedächtnis*: SG) taken from a standard German language development test for 3–5-year-olds (*Sprachentwicklungstest für drei- bis fünfjährige Kinder*: SETK 3-5; Grimm 2001). Children from the age of 6; 0 years onward were given a subtest on "segmenting pseudowords" (*Pseudowortsegmentierung*: PWS) taken from a German test of basic reading and writing competencies (*Basiskompetenzen für Lese-Rechtschreibleistungen: BAKO 1-4*; Stock et al. 2003) and a subtest on "imitating grammatical structures" (*Imitation grammatischer Strukturen*: IGS) from a standard German language development test (*Heidelberger Sprachentwicklungstest*: HSET; Grimm and Schöler 1991).

Memory span was assessed with the subtest "number recall" (*Zahlen nachsprechen,* ZN) from the German version of the Kaufman Assessment Battery for Children (K-ABC; Kaufman and Kaufman 2001).

The Dutch sample completed a Dutch version of the "number recall" subtest and a "word formation" test (*Woordvormen-Produktietest*: WVP) taken from the Dutch-language *Taaltest voor Kinderen* (van Bon 1982).

The sighted children performed the same 16 ToM tasks and tests (PGN, SG, and ZN) in the same sequence as the blind children. The number recall subtest could not be given to the sighted under-4s, because no standard scores are available for this age group.

### Materials

#### *Overview of All 16 ToM Tasks*

A total of 16 ToM tasks were selected for the longitudinal study. First, the children were given simple tasks to assess

ToM abilities that precede the acquisition of first-order false-belief tasks (Wellman and Liu 2004). These assessed (a) diverse desires; (b) the ability to discriminate between reality and fantasy; (c) knowledge of beliefs; and (d) spatial perspective-taking Levels 1, 2a, and 2b. In addition, the children were given one-second-order-false-belief task to avoid a ceiling effect for the best performers. Some tasks assessing spatial perspective-taking Levels 1, 2a, and 2b (Flavell 1988; Wellman and Liu 2004) have already been carried out with blind children (Bigelow 1988, 1991a, b; Farrenkopf and Davidson 1992; Peterson et al. 2000). These tasks were used in this study as break-off criteria, because it could be assumed that failure would indicate that the concept of first-order false-belief tasks had not yet been mastered.

Because the key tasks for comparisons with previous studies were the nine-first-order false-belief tasks on perspective taking, only these are described in detail here. One task was a standard false-belief task as it was evaluated in the above-mentioned studies. Eight tasks were alternative tasks by using materials and a presentation that would not disadvantage congenitally blind children compared with their sighted peers. Due to a lack of empirical data on task difficulty, they tasks were presented in a theoretically assumed sequence of difficulty for blind children—beginning with what was assumed to be the easiest task. The same sequence of task presentation was applied for both the two blind samples and the sighted controls.

The construction of the alternative, first-order false-belief tasks was based on the following principles: (a) objects were selected with which blind children would be familiar through their own tactile experience such as toothbrushes or spoons. (b) Blind children should know the action to be performed with the objects, and, on the basis of their own experiences, be familiar with the fact that the unanticipated stimulus is a deception. For example, they know that the head of a toothbrush combined with a spoon at the end instead of the toothbrush handle is not found in daily life. (c) Task presentation should minimize any spatial-cognitive difficulties blind children might have in performance. (d) A new kind of first-order false-belief task had to be developed in which blind and sighted children should be equal in terms of prior knowledge by using a learning sequence during task presentation to build up the expectation that will subsequently be deceived. For example, children have to feel a succession of surfaces that are alternately rough, smooth, rough, smooth, and rough. They then have to predict what will come next. As to be expected, children report a smooth surface, but they unexpectedly feel soft absorbent cotton. This type of learning sequence task is called a *newly learned false-belief task* compared with standard false-belief tasks that are then characterized as *previously learned false-belief tasks* because they draw on learned experiences. The newly learned false-belief tasks meet the criteria for a false-belief task in exactly the same way as the previously learned tasks: (a) the child's expectation after learning the sequence is not met. (b) The question on one's own false belief reveals whether the child is able to draw on the mental representation of his or her own false belief despite the deception, thereby maintaining two divergent knowledge states. (c) The question on the other's false belief distinguishes between children with versus without perspective-taking ability. Children with perspective-taking ability report that another child subjected to the same task procedure will be guided by his or her own false belief; those without perspective taking answer only on the basis of what they now know to be true.

Table 1 presents an overview of the nine-first-order false-belief tasks used in the study with each of their three parallel versions A, B, and C. The presentation of the three parallel versions was randomized for the longitudinal study.

### *Task Type I: Primarily Visually Based False-Belief Tasks*

These tasks use objects or action sequences that are completely or almost completely unfamiliar to blind children. It is assumed that their experience deficits will lead them to give fewer correct answers on these compared with more blind-adequate tasks (Task types II–IV).

*Tasks I. 1: Unexpected Outcome (Previously Learned)* This category contains three false-belief tasks used in previous studies where they are described in detail: (A) teapot with unexpected content "sand" (Minter et al. 1998), (B) hamburger box with unexpected content "sock" (McAlpine and Moore 1995), and (C) egg carton with unexpected contents "squash balls" (Peterson et al. 2000).

*Tasks I. 2: Unexpected Outcome (Newly Learned)* This category contains newly learned false-belief tasks. Figure 1 presents the learning sequence for the symbolic play objects cloud–star–cloud–star–cloud and the unexpected outcome "toy automobile" (Task I. 2A).

The children were shown a small chest of drawers. Starting at the top, they had to take the objects out of each drawer in succession and name them. If the children failed to give an appropriate name, they were corrected. After the third drawer, they were asked what they thought they would find in the fourth drawer. If the children made an incorrect suggestion, the entire sequence was repeated starting at the top and moving down to the third drawer. The same procedure was used for the fourth and fifth drawer. Before the sixth drawer, which contained the deception, the experimenter checked that all children

**Table 1** The three parallel versions of the nine false-belief tasks

| Kind of task | | 1<br>**Unexpected outcome (previously learned)** | 2<br>**Unexpected outcome (newly learned)** | 3<br>**Changed location** |
|---|---|---|---|---|
| I | Primarily visually based | (A) Teapot – sand<br>(B) Hamburger box – sock<br>(C) Egg carton – squash balls | (A) Cloud – star – … – ?? – automobile<br>(B) Shark – dinosaur – … – ?? – house<br>(C) Ship – locomotive – … – ?? – worm | --------------------- |
| II | Visually/ tactually based | (A) Book – paper handkerchief<br>(B) Toothbrush – spoon<br>(C) Telephone handset – purse | (A) Toy brick – spoon – … – ?? – toothbrush<br>(B) Cube – brush – … – ?? – pacifier<br>(C) Ring – key – … – ?? – ball | (A) Action: pencil (3 locations)<br>(B) Action: coin (3 locations)<br>(C) Action: marble (3 locations) |
| III | Primarily auditorily based | (A) Children's song – ?? – other children's song<br>(B) Numbers 1,2, …5 – ?? – ringing telephone<br>(C) Nursery rhyme – ?? – unexpected continuation | (A) Loud – quiet – … – ?? – fire siren<br>(B) Dog – crow – … – ?? – baby<br>(C) Drum – whistle – … – ?? – laughter | (A) Story: mother & child (2 places)<br>(B) Story: two children (2 places)<br>(C) Story: toy shop (2 places) |
| IV | Primarily tactually based | --------------------- | (A) Warm – cold – … – ?? – prickly<br>(B) Rough – smooth – … – ?? – cotton<br>(C) Heavy – light – … – ?? – candy | --------------------- |

See text for a detailed description of tasks. Sighted children had to wear blindfolds when working on tasks with a gray background, because otherwise they would have seen the solution straight away

**Fig. 1** Visually based (newly learned) Task I. 2A

predicted the expected object. In this example, the children predicted they would find a "cloud," although the sixth drawer actually contained a "toy automobile" instead. "Cloud" and "star" in this Category I. 2 were specially selected to be difficult for blind children to recognize and name because they are unable to perceive them in reality. They know them only through verbal descriptions or tactile models and do not associate a direct perceptual impression with them as sighted children do.

The two parallel tasks in this category contained the following sequences of model objects: shark–dinosaur–shark–dinosaur–shark and, unexpectedly, "house" (Task I. 2B) and ship–locomotive–ship–locomotive–ship and, unexpectedly, "worm" (Task I. 2C).

Sighted children performed these parallel tasks blindfolded because otherwise they would have seen the solution straight away.

The same procedure was applied in all other newly learned tasks. In other words, the children learned the sequence up to the third event, and then had to predict the fourth, fifth, and sixth events. The prediction was valid for the fourth and fifth events, but the sixth event was a deception.

### *Task Type II: Visually and Tactually Based False-Belief Tasks*

These types of task presented objects or situations familiar to sighted children from their visual experience and to blind children from their tactile experience. It is assumed that blind children will be able to solve this type of task more easily compared with tasks bearing no or only little reference to their perceptual world (Task type I).

*Tasks II. 1: Unexpected Outcome (Previously Learned)* These were three newly developed false-belief tasks. Like the previous standard false-belief tasks (Tasks I. 1), they draw on learned experiences but, in this case, ones available to both blind and sighted children. Sighted children performed these tasks blindfolded, because otherwise they would have seen the solution straight away.

The three tasks were:

(A) Book with unexpected content "paper handkerchief"—the children were given the closed book and had to predict what was inside it (Fig. 2)
(B) Toothbrush head combined unexpectedly with "spoon"—the children were first given the head of the toothbrush to touch and then had to report what they expected to find at the other end concealed in the experimenter's hand (Fig. 3)
(C) Telephone handset connected to an unexpected "purse"—the telephone handset and cable were placed in the child's hand, and the child had to predict what was at the other end of the cable (Fig. 4).

*Task II. 2: Unexpected Outcome (Newly Learned)* The objects were hidden in a sequence of six little bags and could only be felt but not seen. For example, the objects in Task II, 2A are toy brick–spoon–toy brick–spoon–toy brick and then, unexpectedly, "toothbrush" (Fig. 5).

Task instructions were analogue to those for the learning sequence with the chest of drawers (Task I, 2). The parallel task II, 2B used the sequence cube–brush–cube–brush–cube and an unexpected "baby pacifier"; Task II, 2C used the sequence ring–key–ring–key–ring followed by an unexpected "ball."

*Tasks II. 3: Changed Location Tasks* These tasks were comparable to those presented to congenitally blind children in previous studies and to sighted children in a number of studies. Three parallel tasks analogue to the "Sally and Anne task" were presented as an action task (i.e., the children themselves transferred an object to a different location after the other person had left the room). Each parallel task used three different containers and different objects to be transferred. These were (A) three tactually

**Fig. 2** Visually/tactually based (previously learned) Task II. 1A

**Fig. 3** Visually/tactually based (previously learned) Task II. 1B

**Fig. 4** Visually/tactually based (previously learned) Task II. 1C

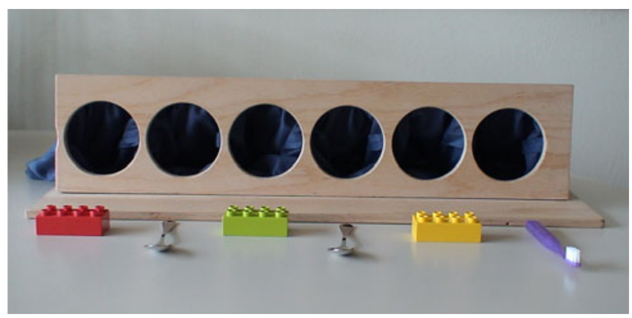

**Fig. 5** Visually/tactually based (newly learned) Task II. 2A

different boxes with the transfer of a pencil (Minter et al. 1998); (B) little basket, purse, small box with the transfer of a coin; and (C) glass jar, note box, felt bag with the transfer of a glass marble.

### *Task Type III: Primarily Auditorily Based False-Belief Tasks*

This type of task used auditory stimuli. In other words, vision was either unnecessary or of no assistance for the solution. It is anticipated that blind children will be able to solve such false-belief tasks at an earlier age than object-related tasks providing little opportunity for blind children to draw on their experiences (Task type I).

*Tasks III. 1: Unexpected Outcome (Previously Learned)* A compact disk player was used to present familiar auditory content to the children. The playback was then stopped, and they had to say how it would continue. After reporting their expectation, they heard an unexpected continuation. These were (A) a well-known German children's song (*Alle meine Entchen*) with the unexpected continuation of another well-known song (*Fuchs, du hast die Gans gestohlen*); (B) the numbers "1, 2, 3, 4, 5" with the unexpected continuation "ringing telephone"; and (C) a well-known German nursery rhyme (*Himpelchen und Pimpelchen*) with the unexpected continuation (*Affe* [ape] instead of *Zwerg* [dwarf]). Comparable Dutch songs and nursery rhymes were used to test the Dutch sample in Tasks III. 1A and III. 1C.

*Tasks III. 2: Unexpected Outcome (Newly Learned)* In these tasks, the children had to successively press a series of push buttons on a set of ascending steps. After the third button, they had to report what auditory event would come next (Fig. 6).

Task presentation was analogous to the other learning sequence tasks (I. 2 and II. 2). The children listened to the following three auditory sequences in the three parallel tasks: (A) loud tone–quiet tone–loud tone–quiet tone–loud tone followed by the unexpected outcome "fire engine siren"; (B) dog barking–cock crowing–dog barking–cock crowing–dog barking—followed by an unexpected "baby crying"; and (C) drumbeat–tin whistle–drumbeat–tin whistle–drumbeat—followed by unexpected "canned laughter."

*Tasks III. 3: Changed Location Tasks* In this version of the changed location task, children listened to stories in which one person went away and the other person changed location. The three tasks were: (A) mother puts her child to bed and leaves the room. In the meantime, the child climbs out of bed and lies down on the carpet underneath the table. The mother returns. Where will she look for the child? (B) A boy and a girl are playing in the sandbox. The boy goes to the bathroom. In the meantime, the girl goes into the kitchen. The boy comes back from the bathroom. Where will he look for the girl? (C) Mother and child are at the toyshop. There is a big playground slide, and the child keeps on sliding down it. While the mother goes to the cash till, the child goes off and plays with a teddy bear. The mother comes back. Where will she look for her child?

### *Task Type IV: Primarily Tactually Based False-Belief Tasks*

This category contained tasks involving sensory impressions such as changes in temperature, surface, or weight. It is assumed that blind children are completely familiar with perceiving such tactile sensory impressions. It contains only tasks with learning sequences, because we were unable to find or conceive any previously learned tasks of this kind. The tasks were presented to the children in a long box with a series of separate compartments, each with its own lid. The children had to uncover each compartment in succession (Fig. 7, Task IV. 2B).

Task procedure was analogous to the other learning sequence tasks (I. 2, II. 2, and III. 2). Sighted children performed these tasks blindfolded. The following three parallel tasks were presented: (A) warm surface–cold surface–warm surface–cold surface–warm surface and, unexpectedly, "prickly surface"; (B) rough surface–smooth surface–rough surface–smooth surface–rough surface and, unexpectedly "absorbent cotton"; and (C) heavy can–light can–heavy can–light can–heavy can and, unexpectedly "candy."

## Procedure

The parents of the blind children were free to choose whether the tasks should be carried out in the family home or at the preschool/school. Including breaks, sessions took no longer than 60 min for most children who worked through all 16 ToM tasks, and, of course, less time when

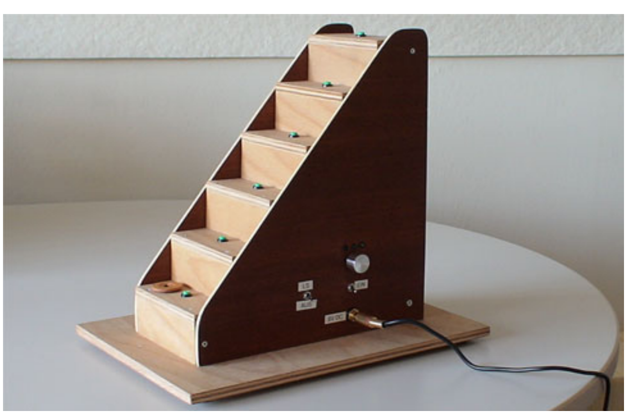

**Fig. 6** Auditorily based (newly learned) Task III. 2A, 2B, 2C

**Fig. 7** Tactually based (newly learned) Task IV. 2B

testing ended beforehand due to break-off criteria. Nearly all sessions were recorded with video cameras. Each session started with the simple ToM tasks. If the child failed spatial perspective-taking Levels 1, 2a, and 2b, testing was broken off in order to avoid causing stress, because it could be assumed that the concept of first-order false-belief tasks had not yet been mastered. If a child mastered Level 1 spatial perspective taking but not Level 2a and 2b, he or she was initially given only the first three simple first-order false-belief tasks (auditorily and tactually based). If the child mastered two out of these three-first-order false-belief tasks, he or she was given the six further first-order false-belief tasks. Children who answered both spatial perspective-taking Levels 1 and 2 correctly were given all nine-first-order false-belief tasks.

Sighted children were tested in the same way as blind children in a separate room in each kindergarten, and they were also videotaped.

### *Scoring the False-Belief Tasks*

Care was taken during task presentation to ensure that children could confidently name the objects, the auditory or tactile properties of the stimuli, or the features of the different locations. In the seven unexpected outcome tasks (previously and newly learned), the first question always addressed the child's own false belief, followed by the question on the other's false belief (perspective-taking question). These questions were not presented in random order, because earlier studies such as Minter et al. (1998) had revealed no significant sequence effect.

For the own false-belief question, children were given a temporal cue: "What did you expect would come out of the teapot (what sound did you expect to hear when pressing the last button) *before* you poured it out (pressed it)?" For the other's false-belief question, the blind children were free to refer to either another blind child or a sighted child as their friend (serving as the other). Sighted children were simply asked to refer to their best friend. The children were given a temporal cue here as well: "What would your friend say is in the teapot (what sound would your friend expect to hear when pressing the last button) *before* he or she poured it out (pressed it)?"

Answers to the own false-belief question were rated as correct when children gave their own original expectation despite the unexpected outcome. For the other's false-belief question, answers were rated correct when children reported that their friend would expect what was to be anticipated in the task or something semantically similar, for example, milk instead of tea in the teapot task. Answers to the own and other's false-belief questions were rated as incorrect when children named the unexpected real stimulus or something semantically similar.

After the change of location in the action tasks, the children first answered two control questions ("Where is the pencil/coin/marble now? Does your mother know it's there?") and then the other's false-belief question ("Where will your mother start looking for the pencil/coin/marble?"). In the story tasks, the children had to answer only the perspective-taking question. Children were praised for their performance on each task regardless of how well they had done.

More details on the procedure and the evaluation guidelines for all ToM tasks can be obtained from the authors on request.

## Results

Results of the language and memory tests are presented separately for the German and Dutch congenitally blind samples and the sighted controls in Table 2.

The average test scores and scale values (M) for the blind children were slightly higher than either the norms for sighted children or the scores of sighted controls.

Table 3 reports the solution frequencies on the false-belief tasks split according to age groups.

The upper block presents the findings for 4–5-year-old blind children. These 14 children had clearly not yet acquired the concept of false-belief perspective taking. No child answered the other's false-belief question correctly on more than one-half of the tasks. Three children failed completely on the spatial perspective-taking tasks as well; 10 solved only the Level 1 spatial perspective-taking tasks;

**Table 2** Test scores for speech and memory tests

| Test | *M* (*n*) | *SD* | Range |
|---|---|---|---|
| PGN[1] | 58.1 (13) [O] | 7.0 | 46 - 72 |
| SG[1] | 59.2 (13) [O] | 10.5 | 36 - 74 |
| PWS[2] | 53.4 (19) [O] | 9.8 | 32 - 68 |
| IGS[2] | 58.8 (19) [O] | 4.3 | 48 - 64 |
| ZN[1,2] | 9.9 (32) [O] | 2.0 | 7 - 14 |
| ZN[1,2] | 10.4 (13) [OO] | 2.1 | 7 - 15 |
| WVP[1,2] | 6.9 (13) [OOO] | 1.1 | 5.5 - 9 |
| PGN[1] | 57.5 (37) [O] | 8.6 | 37 - 674 |
| SG[1] | 56.5 (34) [O] | 10.9 | 37 - 81 |
| ZN[1] | 7.3 (35) [O] | 3.3 | 0 - 14 |

$n = 32$ congenitally blind German children (white background); $n = 13$ congenitally blind Dutch children (light gray background); $n = 37$ sighted German children (dark gray background). See text for explanations of German and Dutch tests

Tests: [1] up to 5; 11 years. [2] From 6; 0 years

[O] Norm-*T* scores (normal range: $M = 40$–60)

[OO] Scale scores (normal range: $M = 7$–13)

[OOO] Scale scores (normal range: $M = 3$–7)

**Table 3** Solution frequencies for the false-belief tasks in blind children split according to age groups

4- to 5-year-old blind children

| Type of task | | | III 1 Auditory CD player | III 2 Auditory steps | IV 2 Tactile long box | III 3 Story 2 places | II 1 Visual/tactile objects | II 2 Visual/tactile little bags | I 2 Visual chest of drawers | I 1 Visual objects | II 3 Action 3 locations | Solution P 7 out of 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Age | Crit. | O/P | O/P | O/P | P | O/P | O/P | O/P | O/P | C/P | P |
| 1 | 4;0 | ++ | +/+ | –/– | +/+ | – | +/+ | +/+ | –/– | +/– | +/– | n |
| 2 | 4;1 | + | +/– | –/– | –/+ | – | | | | | | n |
| 3 | 4;4 | + | +/+ | –/– | +/– | – | | | | | | n |
| 4 | 4;4 | – | | | | | | | | | | n |
| 5 | 4;5 | + | –/– | +/– | +/– | – | | | | | | n |
| 6 | 4;5 | – | | | | | | | | | | n |
| 7 | 5;0 | + | –/+ | –/– | +/– | – | | | | | | n |
| 8 | 5;3 | – | –/– | +/– | +/– | + | | | | | | n |
| 9 | 5;7 | + | –/– | –/– | | – | –/– | | | | | n |
| 10 | 5;7 | + | +/+ | +/– | +/– | – | | | | | | n |
| 11 | 5;9 | + | +/+ | –/+ | +/– | + | +/+ | –/– | –/– | +/+ | +/– | n |
| 12 | 5;10 | + | +/+ | –/– | | + | +/+ | | | | | n |
| 13 | 5;11 | + | +/– | –/– | –/– | – | –/– | | | | | n |
| 14 | 5;11 | + | +/+ | –/– | –/– | – | | | | | | n |
| % P correct | | | 50 | 7.1 | 14.3 | 14.3 | 21.4 | 7.1 | 0 | 7.1 | 0 | 0 |
| valid % P | | | 58.3 | 8.3 | 20 | 16.7 | 60 | 50 | 0 | 50 | 0 | 0 |

6-year-old blind children

| Type of task | | | III 1 Auditory CD player | III 2 Auditory steps | IV 2 Tactile long box | III 3 Story 2 places | II 1 Visual/tactile objects | II 2 Visual/tactile little bags | I 2 Visual chest of drawers | I 1 Visual objects | II 3 Action 3 locations | Solution P 7 out of 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Age | Crit. | O/P | O/P | O/P | O/P | O/P | O/P | O/P | C/P | P | P |
| 15 | 6;0 | + | –/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 16 | 6;0 | ++ | +/+ | +/+ | +/+ | – | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 17 | 6;2 | ++ | +/+ | +/– | +/+ | + | +/+ | +/+ | +/+ | +/+ | –/+ | y |
| 18 | 6;3 | + | +/+ | +/– | +/– | – | +/– | | | | | n |
| 19 | 6;4 | ++ | +/+ | +/+ | +/+ | – | +?/+ | +/+ | +/+ | –/– | +/+ | y |
| 20 | 6;5 | ++ | +/+ | !/! | +/+ | – | +/– | +/+ | +/+ | +/+ | +/+ | y! |
| 21 | 6;5 | ++ | +/– | +/+ | +/+ | + | –/+ | +/+ | +/+ | +/+ | +/+ | y |
| 22 | 6;6 | + | +/+ | –/– | +/+ | – | | | | | | n |
| 23 | 6;7 | ++ | +/+ | +/+ | +/+ | – | +/– | +/+ | +/+ | +/+ | +/+ | y |
| 24 | 6;10 | ++ | +/+ | +/+ | +/+ | – | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 25 | 6;10 | ++ | +/+ | +/+ | +/+ | – | +/+ | +/+ | +/+ | +/+ | +/– | y |
| 26 | 6;11 | + | +/+ | +/– | +/– | – | +/– | | | | | n |
| 27 | 6;11 | ++ | +/+ | +/– | +/+ | – | +/+ | +/– | +?/+ | +/+ | | n |
| % P correct | | | 92.3 | 53.8 | 84.6 | 23.1 | 61.5 | 69.2 | 76.9 | 69.2 | 61.5 | 69.2 |
| valid % P | | | 92.3 | 58.3 | 84.6 | 23.1 | 66.7 | 90 | 100 | 90 | 88.9 | 69.2 |

7-year-old and older blind children

| Type of task | | | III 1 Auditory CD player | III 2 Auditory steps | IV 2 Tactile long box | III 3 Story 2 places | II 1 Visual/tactile objects | II 2 Visual/tactile little bags | I 2 Visual chest of drawers | I 1 Visual objects | II 3 Action 3 locations | Solution P 7 out of 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Age | Crit. | O/P | O/P | O/P | P | O/P | O/P | O/P | O/P | C/P | P |
| 28 | 7;3 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 29 | 7;4 | + | +/+ | +/– | +/+ | – | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 30 | 7;5 | ++ | +/+ | +/– | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 31 | 7;6 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 32 | 7;7 | + | +/+ | +/+ | +/+ | – | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 33 | 7;11 | + | +/+ | !/! | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y! |
| 34 | 8;0 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 35 | 8;1 | ++ | +/– | +/+ | +/+ | – | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 36 | 8;2 | ++ | +/+ | +/+ | +/+ | + | +?/+ | +/+ | +/+ | +/+ | +/+ | y |
| 37 | 8;5 | + | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 38 | 8;6 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 39 | 8;6 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 40 | 8;6 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 41 | 9;2 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 42 | 9;6 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | –/+ | +/+ | y |
| 43 | 9;9 | ++ | +/+ | +/+ | +/+ | + | +?/+ | +/+ | +/+ | +/+ | +/+ | y |
| 44 | 9;10 | ++ | +/+ | +/+ | +/+ | – | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 45 | 10;1 | ++ | +/+ | +/+ | +?/+ | + | +/– | +/+ | +/+ | +/– | +/+ | y |
| % P correct | | | 94.4 | 83.3 | 100 | 77.8 | 94.4 | 100 | 100 | 94.4 | 100 | 100 |
| valid % P | | | 94.4 | 88.2 | 100 | 77.8 | 94.4 | 100 | 100 | 94.4 | 100 | 100 |

Type of task: see Table 1 and explanations in text. The children from the Dutch sample are marked in gray background. No, number of child; Age, age of child; Crit., spatial perspective-taking tasks (−, Level 1 and 2 not solved;+, Level 1 solved, Level 2 not solved; ++, Levels 1 and 2 solved); O, own false belief; P, perspective-taking question (other's false belief); C, control question. In the cells: Solution of false-belief questions: +, correct; −, false or "don't know"; !, task not presented due to technical problem; blank, task not presented due to break-off criteria; +?/−?, missing values in own false-belief question replaced by child's most frequent answer. Attainment of success criterion for the perspective-taking question (other's false belief) 7 out of 9: n, no; y, yes; y!, criterion 6 out of 8 and only one child solved all spatial perspective-taking tasks correctly.

The central block in Table 3 reports the solution frequencies for 6-year-olds. Blind children were clearly starting to acquire the concept of false-belief perspective taking at this age. Nine of the 13 children (69.2%) correctly answered the question on the other's false belief on at least seven of the nine false-belief tasks (at least 77.8% correct answers). For one child, the solution criterion was only six out of eight tasks, because one task had to be dropped due to a technical problem.

The bottom block in Table 3 presents findings on the 18 blind children from 7 years onward. The solution frequencies show that all 18 children not only attained the solution criterion of seven out of nine (or six out of eight) correctly solved tasks, but also answered nearly all the other's false-belief tasks correctly (93.8% correct answers). In other words, they had acquired the concept of false-belief perspective taking.

Comparisons of task difficulty across the nine false-belief tasks revealed that the compact disk player task in which the children had to predict the continuation of a series of numbers or of a nursery rhyme (Task III, 1, Table 1) proved to be significantly simpler than all other tasks (Wilcoxon matched-pairs signed-ranks, all $p < .05$, two-tailed). In contrast, the story task (Task III, 3, Table 1) was significantly more difficult (Wilcoxon matched-pairs signed-ranks, all $p < .05$, two-tailed) than Tasks II, 1; IV, 2, I, 2; and II, 2 (Table 1). No other comparisons between tasks differed significantly.

Table 3 also reveals that the solution frequencies showed a high level of cross-validation between German (white background) and Dutch children (gray background). In other words, blind children acquire the ability to take another person's perspective correctly at the same age in both countries.

The statements derived from Table 3 hold for both the other's false belief and the own false belief. The answers to the two questions in both the German and Dutch samples combined had an average interrelation of $Phi = .78$, which was highly significant ($p < .001$).

The following computations of the correlation between perspective taking and the other biographical, family, or test variables in both samples combined were based on the number of correct answers to the other's false-belief question: (a) age: $r = .73$, $p < .001$; (b) gender: $r_{bis} = -.27$, ns., with a trend toward better performance in girls; (c) memory: $r = .12$, ns. (d) language skills in German children: $r = .25$, ns. (up to 5; 11 years); $r = -.16$, ns. (from 6; 0 years); in Dutch children: $r = .47$, ns.

Table 4 reports performance on the false-belief tasks in the sighted controls.

The 3-year-olds solved hardly any tasks correctly. Only two (20%) 4-year-olds attained the criterion of seven out of nine tasks compared with sixteen of the twenty-four 5- to 6-year-olds (66.7%). From 5; 6 year onwards, all sighted children attained the criterion—solving seven out of nine perspective-taking tasks. The false-belief tasks were significantly more difficult to solve when blindfolded than without a blindfold (Wilcoxon matched-pairs signed-ranks test: $z = 2.547$; $p < .05$, two-tailed).

Mean scores for correctly solving the false-belief tasks did not differ significantly between the sighted ($M = 5.54$, SD = 3.09) and the blind ($M = 5.44$, SD = 3.56) children, $t(80) = .129$, $p > .05$. However, the two groups differed highly significantly in terms of age ($M_{sight} = 60.5$ months, $SD_{sight} = 7.5$ months; $M_{blind} = 81.6$ months, $SD_{blind} = 19.4$ months), $t_{net}(58, 96) = 6.729$, $p < .001$; that is, the sighted children acquired the ability to engage in perspective taking at a markedly earlier age than blind children on the false-belief tasks.

Alongside statistical significance, the age difference between blind and sighted children in acquiring perspective-taking ability is of the decisive importance. The data in Tables 3 and 4 indicate that blind children seem to acquire perspective-taking ability when they are 6 years old and sighted children when they are 5 years old.

To quantify the mean statistical age for the acquisition of perspective-taking ability, we computed the mean between the earliest age at acquisition and the age when acquisition was certain in both groups. To avoid distorting the mean through outliers, we based this on the average age at which the first three and the last three children attained the criterion in each case.

Table 3 reports a mean age for the earliest acquisition in blind children of 72 months (6; 0 years) (Children 15, 16, and 17) and 88 months (7; 4 years) for the time of certain acquisition (Children 28, 29, and 30). We took the mean between these two timepoints as an index for the average acquisition age for blind children. This was 80 months (6; 8 years).

Table 4 gives the values for sighted children: the mean for the earliest age of acquisition was 56 months (4; 8 years) (Children 4, 12, and 14); and for certain acquisition, approximately 66 months (5; 6 years) (Children 28, 29, and 30). Hence, the average age of acquisition for sighted children was 61 months (5; 1 years).

Based on this computation, the blind children showed a delay of 19 months (1; 7 years) in the acquisition of perspective-taking ability.

## Discussion

Findings confirm the central hypothesis of this study that congenitally blind children are able to solve first-order false-belief tasks at an earlier age than previous research

**Table 4** Solution frequencies for false-belief tasks in sighted children split according to age groups

3-year-old sighted children

| Type of task | | | III 1 Auditory CD player | III 2 Auditory steps | IV 2 Tactile long box | III 3 Story 2 places | II 1 Visual/tactile objects | II 2 Visual/tactile little bags | I 2 Visual chest of drawers | I 1 Visual objects | II 3 Action 3 locations | Solution P 7 out of 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Age | Crit. | O/P | O/P | O/P | P | O/P | O/P | O/P | O/P | C/P | P |
| 1 | 3;7 | + | -/- | +/- | +/- | - | -/- | | | | | n |
| 2 | 3;7 | ++ | +/+ | +/- | +/+ | - | +/+ | -/- | -/+ | +/- | +/- | n |
| 3 | 3;10 | + | -/+ | +/- | +/- | - | | | | | | n |
| % P correct | | | 66.6 | 0 | 33.3 | 0 | 33.3 | 0 | 33.3 | 0 | 0 | 0 |
| valid % P | | | 66.6 | 0 | 33.3 | 0 | 50 | 0 | 100 | 0 | 0 | 0 |

4-year-old sighted children

| Type of task | | | III 1 Auditory CD player | III 2 Auditory steps | IV 2 Tactile long box | III 3 Story 2 places | II 1 Visual/tactile objects | II 2 Visual/tactile little bags | I 2 Visual chest of drawers | I 1 Visual objects | II 3 Action 3 locations | Solution P 7 out of 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Age | Crit. | O/P | O/P | O/P | P | O/P | O/P | O/P | O/P | C/P | P |
| 4 | 4;2 | ++ | +/+ | +/+ | +/+ | + | +/- | +/+ | +/+ | +/+ | +/- | y |
| 5 | 4;3 | + | -/- | -/- | -/- | - | | | | | | n |
| 6 | 4;5 | ++ | -/- | +/- | +/+ | - | -/- | +/+ | +/- | +/+ | +/+ | n |
| 7 | 4;6 | ++ | +/+ | -/- | -/- | - | +/- | +/+ | -/- | -/- | +/- | n |
| 8 | 4;7 | ++ | +/+ | +/- | -/- | + | -/- | -/+ | -/- | +/- | +/+ | n |
| 9 | 4;7 | ++ | -/- | +/- | +/- | - | +/- | -/+ | -/+ | -/+ | +/+ | n |
| 10 | 4;9 | ++ | +/+ | -/- | -/- | - | -/- | +/- | -/- | +/+ | +/- | n |
| 11 | 4;10 | ++ | -/- | +/+ | +/+ | - | +/- | +/+ | +/+ | +/+ | +/+ | n |
| 12 | 4;11 | ++ | +/+ | -/+ | +/+ | + | -/- | +/+ | +/+ | +/+ | +/+ | y |
| 13 | 4;11 | ++ | +/- | -/- | -/- | + | +/- | -/- | -/- | +/- | +/+ | n |
| % P correct | | | 50 | 30 | 40 | 40 | 0 | 70 | 40 | 60 | 60 | 20 |
| valid % P | | | 50 | 30 | 40 | 40 | 0 | 77.8 | 44.4 | 66.7 | 66.7 | 20 |

5-year-old sighted children

| Type of task | | | III 1 Auditory CD player | III 2 Auditory steps | IV 2 Tactile long box | III 3 Story 2 places | II 1 Visual/tactile objects | II 2 Visual/tactile little bags | I 2 Visual chest of drawers | I 1 Visual objects | II 3 Action 3 locations | Solution P 7 out of 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Age | Crit. | O/P | O/P | O/P | P | O/P | O/P | O/P | O/P | C/P | P |
| 14 | 5;0 | ++ | +/+ | -/- | +/+ | + | -/- | +/+ | +/+ | +/+ | +/+ | y |
| 15 | 5;0 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 16 | 5;1 | ++ | +/+ | +/+ | -/- | - | +/+ | -/- | +/- | +/+ | +/+ | n |
| 17 | 5;1 | ++ | +/- | +/+ | +/+ | - | +/+ | +/- | +/- | +/+ | +/+ | n |
| 18 | 5;1 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 19 | 5;1 | ++ | -/- | -/- | -/- | - | +/- | +/+ | +/- | +/- | +/+ | n |
| 20 | 5;1 | ++ | +/+ | -/- | +/- | - | -/- | +/- | -/- | -/+ | +/- | n |
| 21 | 5;2 | ++ | +/+ | +/- | -/+ | - | -/- | +/- | +/+ | +/+ | +/+ | n |
| 22 | 5;2 | ++ | +/- | +/- | -/- | - | -/- | -/- | +/- | +/+ | +/+ | n |
| 23 | 5;3 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 24 | 5;3 | ++ | +/- | +/- | +/- | + | +/+ | +/- | +/- | +/- | +/+ | n |
| 25 | 5;4 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 26 | 5;4 | ++ | +/+ | +/+ | +/+ | - | -/- | +/+ | +/+ | +/+ | +/+ | y |
| 27 | 5;5 | ++ | +/- | +/- | +/- | + | +/+ | +/- | +/- | +/- | +/+ | n |
| 28 | 5;6 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 29 | 5;6 | ++ | +/+ | +/+ | +/+ | - | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 30 | 5;7 | ++ | +/+ | +/+ | +/+ | + | +/- | +/+ | +/+ | +/+ | +/+ | y |
| 31 | 5;7 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 32 | 5;8 | ++ | +/+ | +/+ | +/+ | + | -/+ | +/+ | +/+ | +/+ | +/+ | y |
| 33 | 5;10 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 34 | 5;10 | ++ | -/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 35 | 5;11 | ++ | +/+ | +/+ | -/+ | - | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 36 | 5;11 | ++ | +/+ | +/+ | +/- | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| 37 | 6;0 | ++ | +/+ | +/+ | +/+ | + | +/+ | +/+ | +/+ | +/+ | +/+ | y |
| % P correct | | | 79.2 | 70.8 | 70.8 | 62.5 | 70.8 | 70.8 | 70.8 | 87.5 | 95.8 | 66.7 |

Tasks in the gray columns were performed blindfolded. No, number of child; Age, age of child; Crit., spatial perspective-taking tasks (+, Level 1 solved, Level 2 not solved; ++, Level 1 and 2 solved); O, own false belief; P, perspective-taking question (other's false belief); C, control question. In the cells: Solution of false-belief questions: +, correct; −, false or "don't know"; blank, task not presented due to break-off criteria. Attainment of success criterion for the perspective-taking question (other's false belief) 7 out of 9: n, no; y, yes would indicate (Green et al. 2004; McAlpine and Moore 1995; Minter et al. 1998; Peterson et al. 2000). By the age of 7 years, all the blind children in this study are able to solve nearly all nine tasks on perspective taking (Table 3, lower block). Also when answering the own false-belief question, blind children give exclusively correct answers (100%) from the age of 7 years onward. Even almost 70% of the blind 6-year-olds attain the set criterion of seven out of nine tasks (Table 3, middle block). The comparison between the blind children's scores and those of sighted controls on the same tasks reveals a developmental delay in the blind children of 1; 7 years (6;8 versus 5; 1 years).

A possible criticism of this kind of comparison between blind and sighted children could be that the types of tasks used here disadvantage the sighted children—particularly those they have to perform blindfolded—and that this prevents them from performing as well as they could.

Hence, it seems meaningful to compare the average acquisition age in blind children on the alternative tasks that are more adequate for them with the acquisition age of sighted children on the standard false-belief tasks that are evidently adequate for them. According to Wellman and Liu's (2004) meta-analysis, the average acquisition age for standard false-belief tasks in sighted children is 4; 6 years. This reveals a difference for the blind children in the present study of 2; 2 years, which is still far less than the 4–7 years reported in earlier studies.

There are two possible explanations for the far smaller delay of blind compared with sighted children in this study: a task and presentation effect and/or a sampling effect.

### Task and Presentation Effect

Using alternative tasks that do not depend on sight and presenting them in a way that makes hardly any spatial orientation demands reveals that blind children are obviously able to achieve the ability to engage in perspective taking at a far earlier age than previously reported.

The second hypothesis in the present study—different solution frequencies according to the task modality—cannot be confirmed in the blind sample. There are no differences in solution frequency between primarily visually based tasks and tasks based on tactile or auditory experience. The only exceptions are that the auditory compact disk player task is easier than all other tasks, and the story task is more difficult than most other tasks. Results confirm that by the 7th year of life, blind children possess a stable concept for solving false-belief tasks that has consolidated across all types. The blind children seem to quickly learn the pattern for solving such tasks and to transfer and generalize it to later tasks.

### Sampling Effect

The second possible explanation for the present finding is that it might be a sampling effect. Perhaps the blind children in the present study are developmentally more advanced than those in earlier research. However, most previous studies also recruited only congenitally blind children with no further impairments and at least average intelligence. Only Peterson et al.'s (2000) study contained six children (26%) with slight learning impairments according to teacher reports. The test scores of our blind children deviate only slightly from those in earlier research, indicating that the divergent findings are most probably not due to a sampling effect, but primarily to a task and presentation effect. In addition, the authors of the earlier studies (Green et al. 2004; McAlpine and Moore 1995; Minter et al. 1998; Peterson et al. 2000) did not attribute the developmental delays to any cognitive impairment in the blind children, but exclusively to the fact of congenital blindness. Therefore, even if a sampling effect regarding cognitive abilities were present in this study, the outcome would still be valid, because all the children have been totally blind or, at most, only able to perceive light since birth.

The delay of approximately 2 years in the acquisition of perspective taking in blind compared with sighted children does not seem long enough to merit any interpretation as an autistic-like feature. The most likely explanation is that the delay reflects a blind-specific developmental problem in the acquisition of sociocognitive abilities rather than a psychopathological disorder as Hobson (2005) and Pring (2005a) postulate. Innate blindness leads to comparable delays in many developmental domains, e.g., gross-motor or manual abilities (Brambring 2006, 2007). Therefore, it can be assumed that innate blindness also impedes the acquisition of sociocognitive abilities due to the above-mentioned limitations to mutual gaze, nonverbal referential communication (joint attention), and the observation of emotional states. These limitations provide a sufficient explanation for the observed developmental delays in solving false-belief tasks without any need to postulate a psychopathological disorder. Despite their difficulties in acquiring sociocognitive abilities in the same way as sighted children, blind children seem to possess compensatory options with which they acquire a correct appraisal of mental and emotional states in other persons a bit later than sighted children. In this connection, language is regarded as a major source of information to compensate for lack of vision in social interaction (Brambring 2003; Pérez-Pereira and Conti-Ramsden 1999, 2005; Tobin 1992). Alongside verbally conveyed content, however, it is probably prosodic components such as speech melody, tempo, or flow that particularly enable blind children to recognize other persons' feelings, beliefs, and opinions and apply them adaptively to acquire ToM abilities.

The slight developmental delay in the acquisition of perspective taking in this study can be explained by referring to Baron-Cohen's (1994) mind reading system. He points out that although the "eye direction detector" is obviously lacking in congenitally blind children, the "shared attention mechanism" is still present, even if impaired due to the greater difficulty in establishing a common focus of attention between children and parents either tactually or auditorily rather than visually through shared direction of gaze. This theoretical analysis led Baron-Cohen (1994, p. 539) to anticipate "a slight delay" in the acquisition of a theory of mind in congenitally blind children, although he fails to specify exactly what a "slight delay" might be. The present study backs Baron-Cohen's (1994) suggestion empirically.

### Limitations of the Study

One limitation of the study is that the tasks are presented in the theoretically posited sequence of difficulty, because a complete permutation of the nine false-belief tasks in order to distinguish between task and sequence effects was not possible due to the low sample size and the large number of tasks. The false-belief tasks with primarily visually based contents (teapot–sand; hamburger box–sock; egg carton–squash balls) from earlier studies are ranked in 13th position in the total set of 16 ToM tasks. Support for the modality-specific hypothesis might be obtained if these false-belief tasks with primarily visually based contents were to be presented as the first tasks. The blind children's acquired learning patterns may have made it possible for them to solve such false-belief tasks as well, despite the theoretical assumption that they should be more difficult for them.

Another limitation to this study concerns the selection of the blind sample. To match the earlier studies, we have tested only congenitally blind children with no further impairments, although most children born blind in the industrialized nations are multiply impaired nowadays. Therefore, the results are only valid for blind children without any additional impairment.

A third limitation concerns the possibility, that the difference found between blind and sighted children might even be smaller, if we were able to find even more suitable false-belief tasks.

## Summary

In sum, this is the first study to show that when appropriate ToM tasks are employed, blind children are perhaps only delayed for 2 years in developing ToM. Furthermore, the study confirms that when comparing developmental achievements in children with versus without impairments, it is not the equivalence of test items (Peterson et al. 2000) that delivers a valid assessment of competencies in children with impairment—in this case, children who are blind—but the equivalence in testing the latent dimension of competency—in this case, the theory of mind.

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