Confronting the language barrier: Theory of mind in deaf children

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Abstract

The current study addressed deaf children's Theory of Mind (ToM) development as measured by a battery of first- and second-order belief tasks. Both a chronological age-matched control group and a younger group of pre-school aged hearing children were compared to a group of deaf children born to hearing parents. A hearing native signer enacted each of the tasks, which were pre-recorded in video clips in English (SSE), British Sign Language (BSL) and spoken English, in order to consider all communication preferences of the deaf children. Results revealed no differences in performance between the deaf and the young hearing children. However, despite the inclusion of ToM tasks based on their preferred mode of communication, the deaf children performed significantly worse at the unexpected-content and second-order belief task compared with their age-matched controls. These findings imply a delay rather than a deficit in ToM in deaf children that could be attributed to limited opportunities to converse and overhear conversations about mental states.

Keywords: Theory of Mind, deaf children, language, false belief

1. Introduction

An essential element to successful communication is the ability to make inferences about the psychological states of others and to predict or explain their behaviour with reference to their mental states, feelings, beliefs and desires (Premack & Woodruff, 1978; Wellman, 1990).The ability to attribute mental states to others is known as "mind-reading" or having a Theory of Mind (ToM; Povinelli & Giambrone, 2001).Some evidence indicates that deaf children, in particular, late-signing or oral deaf children, have a delay or a deficit in ToM compared to hearing pre-schoolers (Peterson & Siegal, 1995) due to difficulties in language acquisition and opportunity to talk about mental states. However, some more recent studies have shown comparable performance between oral deaf and hearing children(e.g., Ziv, Most & Cohen, 2013).Language skill appears crucial to be able to pass ToM tasks, but whether difficulty in passing tasks assessing ToM is due to difference in language development (Harris, de Rosnay & Pons, 2005), or as a result of the language and/or processing demands of the tasks measuring ToM(e.g., using an interpreter)remains to be clarified(Bloom & German, 2000).

1.1 False belief and language

Central to the development of a ToM is the capacity to understand false beliefs: mistaken beliefs about situations held by another person. Typically developing children acquire this understanding between 4 and 5 years of age (Wellman, Cross & Watson, 2001). In the standard false belief task a child is told a story in which the central character holds a mistaken belief, for example the location of an object (e.g., "The Sally Ann marble task"; Baron-Cohen, Leslie & Frith, 1985), or the content of a container (e.g., "the Smarties task"; Perner, Leekham & Wimmer, 1987). As the story unfolds, the child being tested becomes aware of events that the main character does not witness. While most 5-year-olds can easily differentiate their own view from that of the main protagonist in the story, typically developing children aged 3 and younger do not understand that the character will act upon his/her mistaken belief rather than according to the child's own knowledge (Wellman & Liu, 2004). Beyond this age, children begin to extend their understanding to grasp the concept of multiple perspectives and appreciate that two people can interpret the same situation differently (Selman, 1980). By around age 7, a second-order false belief task is passed by most typically developing children, requiring the attribution of a first-order belief (Person A thinks X) to another person (Person B thinks "Person A thinks X"; Baron-Cohen, 1989). The original version of this task, the so called "ice cream-task" (Perner & Wimmer, 1985), involves a situation in which a boy ("John") knows that an ice-cream van has left the park to go to the school, but he believes that a girl ("Mary") does not know this. In order to pass this task the child must differentiate between factual reality and the knowledge of each character in the story.

There are differences in the age at which ToM develops, but a child's language ability appears to account for such variation. Evidence comes from studies showing language often develops in conjunction with ToM (Tager-Flusberg, 2000) and a deficit in ToM is commonly observed in children with difficulties in language; for example autism (Tager-Flusberg & Joseph, 2005), specific language impairment (Miller, 2001) and oral or late-signing deaf children (Woolfe, Want & Siegal, 2002).Controversy circulates the debate on how exactly language relates to children's ToM development. One interpretation is lexical enrichment, whereby a well-developed vocabulary of mental-state terms (e.g., *think*, *know*) scaffolds conversations about mental states (Ruffman, Slade & Crowe, 2002).Alternatively, it has been proposed that the verbal nature of false belief tasks accounts for the relationship between ToM performance and language (Bloom & German, 2000). It can be reasoned that failing the false belief task indicates a lack of understanding of what is being asked.

1.2 Theory of Mind in deaf children

A population that consistently shows problems in ToM is deaf children (de Villiers & de Villiers, 2000; Peterson, 2002, 2004; Peterson & Siegel, 1995, 2000; Schick, de Villiers, de Villiers & Hoffmeister, 2007). The vast majority of deaf children are born to hearing parents (more than 90%), and have typically demonstrated a delay and/or a deficit in ToM (Peterson & Siegal, 1995). More specifically, research has shown that language is a key component in the development of ToM in deaf children. For example, Peterson and Siegal (1999) found that the performance of "late-signing" deaf children (deaf children born into families in which no-one uses a sign language) was impaired relative to hearing controls, native-signing and oral deaf children, and paralleled that of a group of autistic children. In contrast, deaf signing children of deaf parents can perform similarly or better than hearing children on some ToM tasks (Courtin, 2000; Courtin & Melot, 2005).

It has been suggested that the difference in performance of deaf children with hearing parents is the opportunity to converse about mental states. For example, Peterson and Siegel (1995) proposed "the conversational hypothesis", positing that it is the lack of experience of conversing about mental states that leads to difficulty in acquiring ToM for late-signing deaf children. In addition, Courtin (2000) proposed that the grammatical structure of sign language usage promotes the visual perspective-taking and structure necessary to represent a point-of-view that is necessary to acquire ToM. Many late-signing children's hearing families have limited or no skills in sign language, so it is plausible that this reduced opportunity to converse about mental states leads to such mind-reading difficulties (Vaccari & Marschark, 1997).

More recent studies comparing deaf children with different types of hearing amplification have yielded inconsistent results. While Peterson's (2004) study revealed a delay of between 3 to 5 years in ToM acquisition of deaf children with cochlear implants(CIs), studies by Peters and colleagues found only marginal delays in children with CIs between 3 and 12 years (Peters, Remmel & Richards, 2009; Remmel& Peters, 2008). In a more recent study, Ziv et al. (2013) found that younger deaf Israeli children (aged 5 – 7) with CIs performed as well as hearing children. Although it is possible that the increased auditory input from CIs benefits ToM acquisition, there is much variability in false belief performance among children with CIs. Peters et al.'s (2009) study revealed positive correlations between false belief scores and duration of implantation. In addition, Ziv et al. (2013) noted that a number of children with CIs who performed poorly also had low verbal ability. The heterogeneity of deaf oral children's communication and linguistic background warrants caution in directly linking levels of performance with CIs.

1.3 Assessment of ToM and language

Given the relationship between ToM and language development it may seem surprising that only a handful of studies of ToM development in deaf children have considered language or signing ability of their participants. However, there are several linguistic factors that can potentially affect the performance of deaf children. For example, many deaf children use a combination of sign language (e.g., American Sign Language (ASL) or British Sign Language(BSL)) and oral communication, and there is difficulty in assessing their ability simultaneously as these languages do not always directly translate names and terms of objects and actions (Schick et al., 2007). The combination of languages makes it difficult to accurately identify the language ability of a deaf child. While some researchers have taken only subjective measures of language ability such as class teacher reports (e.g., Peterson &Siegal, 1999), others have attempted to use more objective measures such as the Peabody Picture Vocabulary Test (PPVT: Dunn & Dunn, 1997) with oral deaf children (e.g., Ziv et al., 2013). However, these tasks are yet to be standardised with a deaf population and often require a minimum level of hearing to complete the tasks (Prezbindowski & Lederberg, 2003).

The combined use of oral and signed language is important as some results suggest that proficiency in sign language may facilitate communicative experiences that result in mental state understanding (Schick et al., 2007). Yet, sign language ability (e.g., receptive or productive skills) is seldom considered in many ToM studies with deaf children. A lack of inclusion of a language measure relies falsely on the assumption that all deaf parents communicate well in sign language (Tomasuolo, Valeri, Di Renzo, Pasqualetti & Volterra, 2013; Van den Bogaerde, 2000). In one comprehensive study, Schick et al. (2007) found that vocabulary, as measured by the standardised receptive ASL vocabulary test (Schick, 1997), significantly predicted ToM performance. Similarly, Jackson (2001) found that BSL receptive language scores predicted performance on false belief tests of late-signing deaf children.

Equally, it is important to consider that assessing deaf children's ToM abilities is challenging due to the inherent impact language has on the development of ToM. Many deaf children either have problems learning BSL or use English to communicate, so the possibility remains that difficulty with ToM tasks is due to problems with language comprehension. In particular, many deaf children are heavily reliant on lip-reading, which becomes more difficult when reading the lip-patterns of someone who is unfamiliar (e.g., due to a different accent). Importantly, since the majority of deaf children grow up in hearing families and attend mainstream schools, BSL is not often the primary method of communication that is adopted. With hearing amplification—increasingly, the use of CIs—many deaf children rely on lip-reading in addition to residual hearing to communicate in a hearing environment. As children with a hearing impairment are documented to have lower levels of language comprehension (Marschark & Wauters, 2008), it is possible that the difficulty with ToM performance results from the heavily verbal nature of the task. For instance, some previous studies have included children who fail control tasks: a clear indication that the task was not understood (Jackson, 2001; Steeds, Rowe & Dowker, 1997). Attempts have been made to overcome the language barrier presented by ToM tasks by adopting non-verbal (de Villiers & de Villiers, 2000; Figueras-Costa & Harris, 2001) or pictorial versions of false belief tasks (Woolfe et al., 2002), to make them more accessible to deaf children. However, one limitation of non-verbal tasks is the absence of pragmatic cues that can be gleaned from facial expressions (Napoli & Sutton-Spence, 2010).

A recent study by Hao and Su (2014) posed an alternative possibility: deaf children will be able to infer a protagonist's false belief and pass first-order ToM tasks if given clear eye-gaze cues. They proposed that a delay in language might make deaf children more sensitive to visual than linguistic cues of mental states. Hao and Su used pre-recorded video clips testing false belief understanding in an older group of (9-13 years) deaf children. Deaf children's performance was poorer than younger hearing controls (4-6 year-olds) in two conditions in which a protagonist gave either ambiguous gaze cues or no-gaze cues, but performance was similar between groups in the third condition where clear eye-gaze cues were given.

One limitation commonly observed in studies investigating ToM in deaf children is that task administration requires the use of an interpreter trained in BSL (or equivalent), due to limited ability in sign language of those researching deaf children's social cognition(e.g., Hao& Su, 2014; Peterson, 2002, 2004, 2009; Peterson &Siegal, 1995, 1999; Peterson & Slaughter, 2006). Reliance upon an interpreter adds an additional demand on children's attention, as switching back and forth between the interpreter and experimenter is required. Although an interpreted version of the task can be clear for some children, there is a large variation in BSL (or equivalent) skills in deaf children, as not all children fully learn to communicate in BSL. Many deaf children learn some form of sign language: most commonly, Sign Supported English (SSE). It uses some BSL signs alongside spoken English in the English word order, as well as using sign markers to show English grammar, for example the proposition "with" (Sutton-Spence & Woll, 1999).Further evidence is provided by Schick et al.'s (2007) study, revealing that the ToM performance of late signing and oral children was not as poor as earlier studies had indicated. Schick and colleagues compared deaf children with hearing children and found that while oral and late-signing deaf children's overall ToM performance was poorer than that of native signers and hearing children, by age 7 the oral children's performance on verbal false belief tasks was equivalent to the comparison groups. One important distinction is that the experimenter is a CODA (child of deaf adult), meaning that she has a native level of sign language (ASL) and can communicate equally well with signing and oral deaf children.

1.4The current study

Our primary aim in the present study was to test a group of deaf children on a battery of false belief tasks (two trials of unexpected-location; two trials of unexpected-content; and a second-order false belief task) presented by a native signer (a CODA) in pre-recorded video clips. Deaf children's performance was compared to that of two control groups of hearing children: one group matched for non-verbal ability and chronological age (age-matched hearing); and a second age-appropriate group for the first-order false belief task (younger hearing, i.e., 4 and 5 year olds). The group of deaf children was between 6 and 12 years of age: the age at which typically developing children can already pass first-order false beliefs, and within the age range second-order false beliefs tasks are also passed (age 7 and above). The majority of previous studies investigating ToM performance of deaf children of hearing parents' included only a group of pre-schoolers(Hao& Su, 2014; Peterson, 2002, 2004; Peterson & Siegel, 1995, 1999, 2000;Schick et al., 2007; Woolfe et al., 2002)and, to our knowledge, a second-order false belief task has been attempted only once before with deaf children (Jackson, 2001).If deaf children show difficulty in passing false belief tasks, the inclusion of two control groups enables us to determine the severity of a deficit or delay in false belief understanding by examining this in relation to the performance of both hearing preschool-age children and age-matched peers.

A second aim was to explore the relationship between language ability and false belief understanding in deaf children. In this study, the BSL receptive language measure (Herman, Holmes &Woll, 1999) was utilised with those deaf children who used sign language. As many of the deaf children relied on lip-reading, the Craig's Revised Lip-reading Inventory (Updike, Rasmussen, Arndt, & German, 1992) was also administered to control for task failure resulting from a lack of understanding of the language of the task itself.

On the basis that the language demands of the tasks would be minimised, it was predicted that deaf children would perform more closely to the levels of the hearing children on both the first-order false belief tasks and the second-order false belief task. It was also predicted that receptive language ability- BSL receptive skills or spoken English receptive skills -would predict deaf children and younger hearing children's ToM task performance respectively.

2. Method and Materials

2.1 Participants

In total, 73 children participated in the study. Twenty-seven of the children were deaf. The criteria for selection of deaf children were: 1) the presence of either moderate-severe or profound hearing loss in the better ear. Only one child was moderately deaf, but the level of hearing loss was close to the severe range, so moderate and severely deaf children were grouped together. Sixteen children were moderate-severely deaf (hearing loss above60db) and 11 children were profoundly deaf (hearing loss above 90db); aged between 6-12 years: the age at which both first- and second- order belief tasks are usually passed in a hearing sample; 3) no known learning disabilities or concomitant disorders such as attention deficit or autism; and 4) parents who were both hearing. The deaf group consisted of 16 girls and 11 boys aged between 6 years 7 months and 12 years 1 month (mean age = 9 years 0months, *SD* = 1 years 6 months). Their non-verbal ability was derived from scores on the Coloured Raven Matrices Test (CRMT; Raven, Court & Raven, 1990) and their standardised scores ranged from 70 to 125.

Table 1 displays individual demographic information for the deaf group of children. Twelve of the children had one or more parents who had some knowledge of sign, and for the other 15 children there was no member of the family identified who could sign. Of the 12children who had a family member who could sign 9 of these children had one family member and 3 had at least 2 members of the family who could sign. However, only three parents in this sample of children were proficient at BSL signing (BSL Level 2 or above; minimum requirement for school teachers). All children received auditory amplification and wore their aids during testing: 14 wore CIs and 13 wore HAs. Each participant attended one of five mainstream schools with special units for hearing impaired children. The majority of children used SSE as their communication preference (N = 25), and two communicated mainly in BSL, although none were native signers.

Table 1. Individual demographic information for the deaf children

Participant Code*	CA (years; months)	Degree hearing loss	Type amplification (CI or HA)	Communication mode preference	Parents' signing ability	Non-verbal ability (CRMT)
B1	8;2	Severe	HA	BSL	Level 2	110
G1	10;2	Severe	CI	BSL	Level 1	75
G2	10;7	Severe	HA	SSE	None	125
B2	8;11	Severe	CI	SSE	Level 1	120
G3	10;4	Severe	CI	SSE	Level 1	100
B3	6;11	Severe	HA	SSE	None	96
G4	8;1	Profound	CI	SSE	None	70
B4	8;11	Moderate	HA	SSE	None	125
G5	11;6	Severe	HA	SSE	None	100
B5	8;11	Severe	HA	SSE	None	75
B6	6;5	Severe	HA	SSE	None	100
G6	7;0	Severe	HA	SSE	None	90
G7	8;3	Profound	CI	SSE	Basic	95
G8	7;4	Profound	CI	SSE	Level 3	95
G9	9;1	Profound	CI	SSE	None	80
G10	6;7	Severe	HA	SSE	Level 1	95
G11	8;4	Profound	CI	SSE	Level 2	120
B7	9;3	Severe	HA	SSE	None	70
G12	11;10	Profound	CI	SSE	Level 1	100
B8	6;11	Profound	CI	SSE	Level 1	95
G13	11;6	Profound	CI	SSE	None	90
B9	9;1	Severe	HA	SSE	Level 1	100
B10	12;1	Severe	HA	SSE	None	115
G14	9;5	Profound	CI	SSE	Basic	95
B11	9;8	Severe	HA	SSE	None	105
G15	8;4	Profound	CI	SSE	Basic	90
G16	7;8	Profound	CI	SSE	None	95

Note: *B = Boy; G = Girl

Two controls groups were included in the study, and they were categorised as an age-matched group of hearing children and a younger group. The age-matched group of controls included 23 children with no hearing loss aged between 6 years 1 month to 11 years 6 months and were matched with the deaf children on gender (15 female), chronological age (CA) (*M* = 8 years 8 months, *SD* = 1 year6 months)and non-verbal ability. Table 2 displays mean CA, age range and non-verbal ability (as measured by the CRMT)for deaf and hearing age-matched and younger control children. Independent t-tests confirmed no significant difference in non-verbal ability between the deaf and age-matched hearing children, $t(48)=-.09$, $p=.93$, or age, $t(48) =.77$, $p =.45$. The younger group consisted of 23 children (12 female) with no hearing loss, aged between 4 years 5 months and 5 years 9 months (*M* = 5 years 2 months, *SD*= 4 months). This group was purposefully included as the children were all at the age at which the first-order, but not second-order, false belief tasks are typically passed.

2.2 Language and communication measures

The deaf children's language ability was measured using the *BSL Receptive Skills Test* (Herman, Holmes &Woll, 1999) and the control group children were tested using the *British Picture Vocabulary Scale,* 3rd edition (BPVS III, Dunn et al., 2009). These measures were chosen in order to gain the best estimate of language ability in each of the groups. Deaf children were also tested on lip-reading ability using the *Craig Revised Lip-reading Inventory* (Updike et al., 1992). Table 2 displays the mean scores for language and lip-reading. Both the deaf and hearing control group children scored within the average range on these measures.

BSL Receptive Skills Test. Deaf children who communicated via sign language (including SSE) were tested for their level of receptive skill in the syntax and morphology of BSL with the BSL Receptive Skills Test (Herman et al., 1999). At the time of testing, this was the only available standardized measure that could be used with deaf children (aged 3 to 11) to estimate their "signing age." The test assesses children's responses to 40 pre-recorded signed sentences of increasing difficulty. Children respond by selecting the correct picture from a choice of three or four. The test takes approximately 20 minutes to administer and ends when a child gets four consecutive incorrect answers. The raw score is converted to a standardized score to calculate a child's signing age.

Craig's Revised Lip-reading Inventory (Updike et al., 1992) tests word and sentence recognition to ascertain the communication level of deaf children. The test includes a word test, used to record lip-reading accuracy for selected phonemes, and a sentence test to measure lip-reading for more intricate language patterns. The word recognition task consists of two subsets of words each with 33 items (e.g., "white", phoneme: /wh/). The sentence recognition task also contains two subsets each with 24 items (e.g., "a frog is hopping away from a boat"). Each word is accompanied by a pencil drawing to account for potential differences in reading ability. Children are required to identify the correct item from a choice of four. A total score is given with a maximum of 114.

British Picture Vocabulary Scale. Verbal ability of the control children was tested with the British Picture Vocabulary Scale, 3rd edition (BPVS III, Dunn et al., 2009*)*. This test measures receptive (hearing) vocabulary of Standard English of children aged 3- 16 years. For each test item the test administrator says a word and the child responds by pointing to one of four pictures that best explains the meaning of the word. The raw scores are then converted into standardized scores to calculate a child's verbal age.

Table 2. CA, age range, non-verbal ability, and language and communication measure mean scores and standard deviations (SDs) for deaf, age-matched hearing and younger hearing control groups

	Children		
	Deaf	Hearing age-matched	Hearing younger
CA (years; months)	9;0 (1;6)	8;8 (1;6)	5;2 (0;4)
Age range	6;7-12;1	6;1-11;6	4;5 – 5;9
Non-Verbal ability (CRMT)a	97.26 (15.33)	97.61 (12.51)	105.43 (11.86)
Verbal ability (BPVS)a		104.0 (13.28)	103.57 (11.47)
BSL Receptive a	96.23 (13.79)		
Craig's Lip Reading b	105.48 (10.6)		

Note: SD in parenthesis; [a] standardised score; [b] total score

2.3 First-order false belief tasks: unexpected-location

Two *unseen change-in-location*(*"unexpected-location"*)tasks were presented. The first task was a slightly modified version of Baron-Cohen et al.'s (1985) version of Wimmer and Perner's (1983) Sally-Ann false belief task: in the original paradigm, it was necessary to finger spell the name of the dolls, which places further demands on both the children's attention span and memory (Peterson &Siegal, 1995). A boy, therefore, replaced a second female character (Peterson &Siegal, 1995; Steeds et al., 1997). The child being tested was initially introduced to the characters and asked which doll was the girl and which was the boy (naming question). The task began with the girl hiding a marble in a basket and then leaving the scene. Once she departed, the boy appeared and moved the marble from the basket and put it in his own box. When the girl returned, the child was asked, *"Where will the girl look for the marble?"* followed by two control questions: *"Where is the marble now?"* (reality) and *"Where did the girl put the marble in the beginning?"* (memory). In order to pass the task, the children needed to correctly answer both the test question and the control questions.

In the second trial of the false belief *unexpected-location*–"Hidden Cakes" - a boy placed a tray of cakes in a green cupboard to cool down, and then went out to play. A second character, a girl, removed the cakes from the green cupboard and placed them in the blue cupboard. When the boy returned, the child was asked the belief question, *"Where will the boy look for the cakes?"* This was followed by the same two control questions.

2.4 Standard false belief tasks: unexpected-content

The *unexpected-content* tasks were based on the Smarties task described by Perner et al. (1987) and presented in two trials. In this experiment, the first trial involved initially presenting the child with a tube of sweets and a doll who was very hungry. The sweets were the favourite of the hungry doll presented in the scene. First, the child was asked, *"What do you think is inside the tube?"* (control naming question). Once the child responded, "Smarties" (or sweets or chocolates), the tube was emptied revealing a red crayon. Once the unexpected object had been put back inside the tube, the child was asked what the hungry doll initially believed the closed tube of sweets to contain, and what their own initial belief had been. In the second trial, a cereal box was used, which actually contained two pencils.

2.5 Second-order false belief task: Ice-cream story

The second-order false belief task was based on the ice-cream story used by Perner and Wimmer (1985). A story was enacted involving two dolls: a girl and a boy. The story involved three locations: a park (where an ice-cream van was located originally), the girl's house and a school (the new location of the ice-cream van). At the start, both children are in the park and the girl wants to buy ice-cream, but realises she has no money and first must go home. While the girl is fetching her money, the ice-cream van decides to go to the school. The boy then goes to look for the girl at her house, but the girl's mother tells the boy that she has gone to buy an ice cream. Meanwhile the girl, having left the house, sees the ice-cream van and follows it to the school. The boy heads off to look for the girl. To be able to pass the task, the child needed to understand what two people were thinking sequentially: the boy will have a false belief about where the girl has gone because an element of the story has not been seen (i.e., the boy does not know that the girl knows where the ice-cream van is). The actor was pre-recorded narrating the task and asked a series of probe and control questions to ensure the key elements and sequences of the story had been understood and remembered (e.g., *"Why did Mary go home?"*). The children's responses were recorded in written format by the experimenter. Feedback and correction was given before continuing onto the next section of the narrative. The second-order ignorance question (a closed question to assess whether the child understands that the boy is "ignorant" of the girl's knowledge of the new location of the ice-cream van: *"Does the boy know that the girl knows where the ice-cream van is?"*)was then asked as the first test question and no feedback was given. Following a memory aid, the story ended with two open-ended test questions: the second-order false belief question (*"where does the boy think that the girl went to buy ice-cream?"*) and justification *("why?")*(Sullivan, Zaitchik & Tager-Flusberg, 1994).

2.6 Procedure

All the children were tested on a battery of tasks that included four standard first-order false belief tasks, (two unexpected-location tasks, and two unexpected-content tasks), and one second-order false belief task. Each child was tested individually in a quiet, vacant classroom in school. An experimenter and a teaching assistant were present during each testing session. The tasks were presented using a pre-recorded ToM script. This not only allowed for greater control over administration of the different ToM tasks, but pre-recording the tasks also removed some of the within-participant variation and disparity from the use of multiple experimenters (e.g., Schick et al., 2007). This is an important consideration due to the inherently social and emotional nature of ToM tasks.

In order to minimise potential differences in the understanding of the stories, the tasks were pre-recorded by an actor who was a CODA, fluent in both BSL and English (i.e., a hearing native signer). The actor used both animated puppets and props and narrated the stories, so to maintain one focus rather than dividing the children's attention between an experimenter and an interpreter. Three versions of each task were produced in BSL, SSE and spoken English to account for the preferred communication mode of all participants involved in this study. The stories were pre-recorded on a digital camcorder: the SSE and English versions included sound in the recordings. The inclusion of SSE provided late-signing deaf children with the option of viewing the task in their everyday mode of communication, or with additional cues instead of relying solely on lip-reading. The BSL and SSE clips were validated by two deaf adults (both at BSL Level 3).Twenty-five deaf children viewed the task in SSE and two in BSL. The version was selected based on the class teachers' assessment of communication mode. The hearing control children viewed the task in spoken English.

The children were seated in front of a computer screen and the experimenter sat beside them. The order in which the four first-order false belief tasks were presented was counterbalanced, followed by the presentation of the second-order false belief task. The children's answers to the on-screen actor's questions (signed or verbal response) were recorded in writing by the experimenter. The videos were paused to give the children time to respond to the questions. Each question could be repeated once if necessary. Although the experimenter was competent in BSL, a teaching assistant, fluent in BSL and experienced in communicating in SSE, accompanied all the deaf children to ensure accuracy of answers recorded. The teaching assistant sat behind the child and experimenter, so not to distract the child when viewing the videos. Children were given one point if they correctly answered *"where will X look?"* in response to the changed-location tasks and one point if they correctly answered their *own belief* and the *other's belief* questions on the unexpected-content tasks; a maximum of one point was awarded for each of the four first-order false belief trials. Participants were awarded one point if they correctly answered the second-order false belief task.

3. Results

The data was not normally distributed and there was a lack of homogeneity of variance within groups, so non-parametric tests were carried out. Table 3 displays the means and standard deviations (SDs) of scores on the unexpected-location, unexpected-content and second-order false belief tasks for the three groups. Kruskall Wallis tests were carried out comparing the three groups of children – deaf, hearing younger, and age-matched hearing – on each of the false belief tasks (Table 3). No significant difference was found between the groups' performance on the unexpected-location trials. Group differences did, however, emerge in performance on the unexpected-content trials and the second-order false belief task.

Table 3. Mean scores and Kruskall-Wallis tests of difference comparing deaf and hearing children's performance on the false

belief tasks

Task	Mean rating			H	p	η²
	Deaf	Hearing younger	Hearing age-matched	(df= 2)		
Unexpected-location a	1.59 (.69)	1.35 (.93)	1.87 (.34)	4.23	.12	.06
Unexpected-content a	1.41 (.84)	1.43 (.79)	1.96 (.21)	9.08	.01	.13
Second-order b	.04 (.19) (n = 1)	.13 (.34) (n = 3)	.70 (.47) (n = 16)	30.14	.005	.42

Note: SDs in parenthesis; [a] maximum 2 points; [b] maximum 1 point

Post-hoc Mann Whitney U tests (with Bonferroni corrections of *p*<.02) testing differences between groups on the unexpected-content task showed that the age-matched hearing children performed significantly better than the deaf children (U = 206.0, *z* = -.2.81, *p* = .005,*r* = .21) and the younger hearing children (U = 170.0, *z* = -2.87, *p* = .004, *r* = .42), but there was no significant difference between the younger hearing children and the deaf group children (U = 310.0, *z* = -.01, *p* = .99, *r* = .001).

Table3 shows a greater proportion of age-matched hearing children (*n* = 16) passed the second order false belief task compared to both the deaf children (*n* = 1) and the hearing younger children (*n* = 3). Chi-square tests of independence confirmed that the number of age-matched hearing children passing the tasks was significantly greater than both deaf and hearing younger children (deaf: χ^2 = 24.01, df = 1, *p* <.001, Φ = .69; hearing young: χ^2 = 30.56, df = 1, *p* <.001, Φ .82). There was no significant difference between the number of deaf and hearing young children passing the second-order false belief task (χ^2 = 1.47, df = 1, *p* = .22, Φ = .17).

The deaf and age-matched hearing control children were all within the age range at which both first- and second-order false belief tasks are typically passed. These results therefore suggest that deaf children's performance on the unexpected-content and second-order false belief tasks lagged behind the age-matched hearing control group, but paralleled that of the younger group of hearing children who were within the age range that is typical for passing the first-order, but not the second-order, false belief task. A within subject analysis (Wilcoxon) of deaf children's unexpected-content and unexpected-location task scores found no significant difference (*z* = -1.08, *p* =.28, r = .21), suggesting that the unexpected-content task was not more difficult than the unexpected-location task for the deaf group children.

Factors predicting performance

Means and SDs of scores of the subgroups of deaf children grouped on hearing amplification and whether a member of their family signed are displayed in Table 4. The deaf children were compared on their first-order false belief performance according to level of deafness – profound (*N* = 11) or moderate-severe (*N* = 16) (Table 4). Mann Whitney U tests showed no significant difference between moderate-severely deaf and profoundly deaf children on either the unexpected-location tasks, U = 68, *z* = -1.23, *p* = .34, *r* = .18, or the unexpected-content tasks, U = 75.5, *z* =-.72, *p* =.54, *r* =.11.

Table 4. Means and SD of subgroups of deaf children (divided by hearing amplification, level of deafness and whether a family member signed)

	CI or HA		Level of deafness		Signing family member	
	CI	HA	Moderate-Severe	Profound	Yes	No
	(N = 14)	(N = 13)	(*N* =16)	(*N* = 11)	(*N* = 12)	(*N* = 15)
Unexpected-location	1.57 (.65)	1.62 (.77)	1.67 (.70)	1.45 (.69)	1.5 (.80)	1.64 (.63)
Unexpected-content	1.43 (.85)	1.38 (.87)	1.5 (.82)	1.27 (.90)	1.17 (.94)	1.64 (.74)

Note: SDs in parenthesis

Further analysis was conducted with multiple regression analyses to investigate the relationship between age, non-verbal ability (CRMT), verbal ability (BSL receptive language for deaf children and BPVS for hearing children) and performance on each of the false belief tasks. For the deaf children, lip-reading, type of hearing amplification (coded as 0 = CI, 1 = HA) and signing ability of the parents (coded as 0 = no experience, and 1 = at least one of the parents can sign) were also included for the sample of deaf children. Analysis revealed that for deaf children's scores on the unexpected-location false belief task, lip-reading ability score was the only significant predictor of performance of the group of deaf children (Table 5). For the age-matched and younger hearing children, none of the factors significantly predicted performance.

For the unexpected-content task, the BSL receptive score was a positive and significant predictor of deaf children's performance, and lip-reading ability marginally predicted performance, but the remaining factors were non-significant (Table 6). None of the factors significantly predicted the age-matched hearing children's performance. Verbal ability was found to be a strong, positive predictor of the performance of the younger hearing on the unexpected-content task, and both age and non-verbal ability were marginal predictors.

Table 5. Summary of multiple regression analyses for variables predicting the groups' (deaf; age-matched hearing; younger hearing) performance on the unexpected-location false belief task

	Deaf			Hearing age-matched			Hearing younger		
	B	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Non-verbal (CRMT)	.01	.01	.17	-.01	-.01	-.03	.02	.02	.03
Age	.02	.01	.43	.01	.01	.47	.06	.05	.26
BPVS	-	-	-	.01	.01	1.8	.02	.03	.32
BSL receptive	-.01	.01	.30	-	-	-	-	-	-
Craig's Lip-reading	.04	.02	.54*	-	-	-	-	-	-
Hearing amplification	-.26	.36	-.20	-	-	-	-	-	-
Family signing level	-.26	.38	-.19	-	-	-	-	-	-
R^2		.38			.19			.27	
F		1.42			1.48			2.36	

Note: * p<.05

Due to floor effects in both the deaf and younger hearing children's scores on the second-order false belief task, it was not possible to examine factors predicting the performance of these groups of children. For the age-matched hearing children's performance on this task (R^2= .21, F = 1.72, MSE = .20, p = .20), age was found to be a significant predictor (β = .52, p =.04), whereas non-verbal ability (β = .20, p =.42) and verbal ability were not (β = .00, p =.99).

Table 6. Summary of multiple regression analyses for variables predicting the groups' (deaf; age-matched hearing; younger hearing) performance on the unexpected-content false belief task

	Deaf			Hearing age-matched			Hearing younger		
	B	*SE*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Non-verbal (CRMT)	-.02	.01	-.31	.01	.01	.17	-.03	.01	-.44†
Age	-.01	.01	-.14	.00	.01	-.01	.07	.04	.40†
BPVS	-	-	-	-.01	-.01	-.33	.05	.01	.67**
BSL receptive	.03	.01	.47*	-	-	-	-	-	-
Craig's Lip-reading	.03	.02	.37†	-	-	-	-	-	-
Hearing amplification	-.07	.38	-.05	-	-	-	-	-	-
Family signing level	.29	.40	.18	-	-	-	-	-	-
R^2		.46			.09			.39	
F		2.84*			.65			3.96*	

Note: †p<.10;* p<.05; ** p<.01

3. Discussion

The main aim of the current study was to compare the performance of a group of deaf children on a battery of pre-recorded first- and second-order false belief tasks with that of two groups of hearing control children: a younger group of pre-schoolers who were the age at which first-order false belief tasks are typically passed, and an age-matched group who were within the age range that second-order false belief tasks are also passed (7 years and above).Attempts were made to minimise the language demands of the task by employing a native signer (a CODA)who was pre-recorded conducting the tasks in all the communication modes used by the children included in the study: BSL, SSE and spoken English. The appropriate film clips were then presented to each participant.

The results showed that the deaf children's performance on the first-order false belief tasks – both the unexpected-location and unexpected-content trials – paralleled the younger group of hearing children. Comparable performance with pre-school aged children contrasts with the results of several previous studies using interpreters to test ToM in late-signing and oral deaf children (Hau & Su 2014; Peterson, 2002, 2004; Peterson &Siegal, 1995, 1999). The better performance of the deaf children in comparison to pre-schoolers in the present study suggests an advantage of employing a CODA to record the administration of false belief tasks to maximise clarity and understanding, and to minimise the demands on visual attention.

The purpose of the second control group – the age-matched controls – was to determine whether the deaf children had age-appropriate ToM skills. Despite minimising the language demands of the task, the deaf children in this study showed poorer performance than the age-matched controls on the unexpected-content task, but there was no significant difference in the group's performance on the unexpected-location task. These results are similar to those found by Schick et al. (2007), suggesting a delay rather than a deficit in ToM.

The deaf children were within the age range typically developing children are able to pass second-order false belief tasks (age 7+ years), however, only the age-matched hearing children were able to pass the second-order belief trial (70% pass rate): only one deaf child and three younger hearing group children passed this task. Criticism could be directed for the use of a second-order false belief task with deaf children due to its highly verbal nature, yet some studies have suggested that verbal ToM tasks might facilitate children's understanding. For example, Hollebrandse, van Hout and Hendriks (2012) found that typically developing hearing 7-year-old children performed better in the verbal than the non-verbal false belief tasks. Hollebrandse and colleagues suggest that language supports explicit reasoning about beliefs possibly assisting the cognitive system to monitor and keep in mind beliefs attributed by people to other people; in contrast, the non-verbal task did not have the questions throughout that helped to keep track of this process of reasoning. In keeping with this hypothesis, deaf children have been found to perform no better on non-verbal than verbal first-order false belief tasks in a number of previous studies (de Villiers & de Villiers, 2000; Figueras-Costa & Harris, 2001; Woolfe et al., 2002).

The second aim of this study was to investigate the relationship between the language ability of the participants and false belief performance. A significant positive relationship between lip-reading ability and performance on the unexpected-location tasks was found, and lip-reading also marginally predicted performance on the unexpected-content tasks. This suggests that access to spoken language (as indicated by lip-reading) is linked to better success of the deaf children on false belief tasks. Importantly, these results are unlikely to be attributed simply to the children's lack of understanding of the task requirements: unlike previous studies, which have chosen to include children who failed control tasks (Jackson, 2001; Steeds et al., 1997), all the children in this study had passed the control questions. In addition, care was taken to minimise the language demands of the task.

As predicted, a significant positive relationship was found between performance on the unexpected-content task and deaf children's language skills as measured by the BSL receptive skills test. These results are consistent with other studies that have shown a relationship between deaf children's language capacity and success in passing false-belief tasks (Jackson, 2001; Schick et al., 2007; Woolfe et al., 2002).Similarly, receptive vocabulary (as measured by the BPVS) also predicted the younger hearing children's unexpected-contents task performance, supporting the literature investigating ToM and receptive language in typically developing children (Gola, 2012; Nelson, 2005; Walkenfield, 2000). The accumulation of our findings with that of previous literature clearly highlights an important role of language in understanding false beliefs. In the case of deaf children, their understanding of false beliefs appears to be affected by language ability related to language development rather than poorer levels of language impacting ability to understand the task itself.

Interestingly, verbal ability as measured by the BPVS did not predict the age-matched hearing children's performance in the second-order false belief task as has previously been found (Filippova & Astington, 2008; Hasselhorn, Mähler & Grube, 2005), but the age-matched hearing children did show a significant improvement with age. Factors other than language may underlie hearing children's improvement in performance with age and the deaf children's inability to perform at this task. While some believe that increased social knowledge from interactions with siblings may be essential to the transition from first- to second- order false belief, others argue that the critical difference may lie in improvements in executive functions (e.g., working memory and inhibition) as well as language (Miller, 2009, 2012).

There are a number of constraints to the language measures for deaf children utilised in this study. While the deaf children scored within the average range on the BSL receptive skills test, it is possible that this measure did not capture the extent of their language abilities. Many deaf children use a combination of sign (ASL/BSL) and spoken English to communicate, and there is difficulty in assessing these languages simultaneously as the languages do not always directly correspond in level of difficulty. There is currently no standardised measure of receptive or productive vocabulary for deaf children. There is a definite need for the development of language measures that are standardised for deaf children using both spoken and signed language that can be responded to in both modalities (Haug & Mann, 2008; Schick et al., 2007).

The specific relationship between ToM and language remains unclear (Harris et al., 2005) and it is important to note that this study has not attended to a number of language hypotheses of ToM. The BSL receptive language test that was utilised does not, for instance, investigate the syntax of sentence complementation. To understand this aspect of language requires the ownership of syntactic structures including those that allow the embedding of false propositions within true statements (e.g., "the boy knows that the girl [falsely] thinks he's gone to the park.").In addition to vocabulary, Schick et al. (2007) found this ability to be predictive of deaf children's ToM performance, suggesting that complements may have a role in the ability to discuss and represent mental state concepts. More recently, de Villiers and de Villiers (2012) found that a sentential complements task with verbs of communication was the best predictor amongst language measures over and above vocabulary or general syntax. Similarly, while receptive vocabulary has been shown to be related to false belief understanding in both hearing (e.g., Gola, 2012) and deaf children (ASL: Schick et al., 2007), Nelson (2005) has suggested that these general measures of language reflect children's conversation with adults, including topics revolving around mental states, making them better equipped to utilise mental verb inputs. The current study's results suggest that more specific measures of mental state vocabulary may therefore be necessary given that general language ability may not be the only factor in the development of ToM.

While some studies have shown comparable performance between hearing and deaf children with CIs (Ziv et al., 2013), there is great variability in performance. In the present study, hearing amplification (HA or CI) did not predict success on the false-belief tasks. The heterogeneity of the deaf population both in terms of communication mode (spoken language, signed language, bilingual) and type of hearing amplification makes it difficult to generalise the findings to all deaf children. A far larger sample would be necessary to compare children from a range of communication backgrounds and explore important factors such as age and duration of cochlear implantation.

It is important to note that a number of studies have demonstrated that late-signing and oral deaf children are not entirely mind-blind, looking at the broader picture by examining early and later emerging aspects of mental state understanding. For instance, Want and Gattis (2005) found the non-verbal skill of goal-directed imitation (i.e., imitating by inferring a goal of an observed behaviour, such as touching an ear)to be in tact in late-signing deaf children, and de Villiers and de Villiers (2012) demonstrated that deaf children were on par with their hearing peers on deception games. Interestingly, complement syntax was found to predict performance on false-belief tasks, but not deception games. It was reasoned that deception can be handled by behaviour rules without needing to reference mental states. Deaf children's delay in ToM appears to be exclusive to the representation of cognitive states that do or do not resemble perceived reality (Schick et al., 2007).

The results of this study suggest that the language delay evident in some deaf children is related to their ToM understanding. It is of particular importance that clinicians and teachers working with deaf children are aware of the potential difficulties deaf children may have in understanding the mental states of others. This awareness is especially important in the context of increasing numbers of deaf children being educated in a mainstream setting (approximately 85%; National Deaf Children's Society, 2010).While the exact role of language still needs to be clarified, the results of this study nevertheless highlight the importance of the relationship between language skill and mental state understanding.

Intervention work has recently begun to improve deaf children's false belief understanding by using thought bubbles to represent mental state understanding (Wellman & Peterson, 2013). In addition, recent group intervention studies in typically developing populations encouragingly suggest that targeted conversation about mental states significantly improves ToM performance(Lecce, Bianco, Devine, Hughes & Banerjee, 2014). Future research should be extended to adapting training to deaf children in need of support in ToM development; for example, with the use of picture books that require knowledge of false belief (e.g., Little Red Riding Hood; Stanzione & Schick, 2014) and implementing tasks and group work that fosters interactions prompting mental state talk.

Acknowledgements

Grateful thanks go to Antony Hall for helping to create and sign ToM videos used as stimuli in this project and to Chalky Wan colleagues at Cambridge Regional College for reviewing the videos. Thank you also to all of the participating children and parents. This project was funded by an Anglia Ruskin University (Cambridge, UK) research bursary and their support is greatly appreciated. The support of the Economic and Social Research Council (ESRC) is also gratefully acknowledged. XXXXXXXX was supported by the ESRC Deafness and Cognition and Language Research Centre (DCAL) GrantRES-620-28-0002.

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