Research Article

False Belief Development in Children Who Are Hard of Hearing Compared With Peers With Normal Hearing

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Purpose: This study investigates false belief (FB) understanding in children who are hard of hearing (CHH) compared with children with normal hearing (CNH) at ages 5 and 6 years and at 2nd grade. Research with this population has theoretical significance, given that the early auditory–linguistic experiences of CHH are less restricted compared with children who are deaf but not as complete as those of CNH.

Method: Participants included CHH and CNH who had completed FB tasks as part of a larger multicenter, longitudinal study on outcomes of children with mild-to-severe hearing loss. Both cross-sectional and longitudinal data were analyzed.

Results: At age 5 years, CHH demonstrated significant delays in FB understanding relative to CNH. Both hearing

status and spoken-language abilities contributed to FB performance in 5-year-olds. A subgroup of CHH showed protracted delays at 6 years, suggesting that some CHH are at risk for longer term delays in FB understanding. By 2nd grade, performance on 1st- and 2nd-order FBs did not differ between CHH and CNH.

Conclusions: Preschool-age CHH are at risk for delays in understanding others' beliefs, which has consequences for their social interactions and pragmatic communication. Research related to FB in children with hearing loss has the potential to inform our understanding of mechanisms that support social–cognitive development, including the roles of language and conversational access.

Social interactions promote children's understanding of self and others as beings who have thoughts, feelings, desires, and beliefs that guide the way they act. Children's growing discovery of the mind provides them with a tool for navigating and understanding social interaction (e.g., secrets, mistakes, surprises) and helps them reason about why people act the way they do (Astington, 1993). This ability to attribute thoughts, beliefs, and feelings to oneself and to others and to recognize that people's mental states may differ from one's own is referred to as the *theory of mind* (ToM; Premack & Woodruff, 1978). Nelson (2005) has argued that the ToM development should not be considered as a distinct cognitive domain but rather a sub-component of broader social–cognitive development. In this study, we address a single step on a lengthy continuum of social–cognitive developments (Nelson, 2005; Peterson,

Wellman, & Slaughter, 2012; Wellman & Liu, 2004), that of false belief (FB) understanding. FB understanding emerges around ages 4 to 5 years in typically developing children (see Wellman, Cross, & Watson, 2001, for a meta-analysis) and is considered a landmark accomplishment that requires a representational concept of the mind. Although FB is a major developmental step that has garnered considerable attention in the literature, it is just one aspect of social–cognitive development. When children understand that another person holds a belief that is false, they are able to hold two representations in mind at once, what is true in the world and what someone believes to be true, distinguishing what is in the mind from reality (Wellman et al., 2001).

Reasoning about what another person thinks about a real event is called a *first-order belief* (Perner & Wimmer, 1985). A later stage of belief understanding involves second-order beliefs. Both first- and second-order FBs are addressed in this study, and the following examples contrast how they work. Suppose Joey hates peas, but his babysitter gives him a generous helping because she mistakenly believes (FB) that he likes them. A child with FB understanding can reason, "She gave me peas, because she doesn't know that I hate them." Second-order FB reasoning in the same event could be expressed as, "Joey's mother *thought* that the babysitter

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already *knew* that Joey hates peas, so she did not suggest avoiding them.” Second-order reasoning involves statements about what one person thinks about another person’s belief or knowledge. According to Perner and Wimmer (1985), most typically developing 7- to 9-year-olds are able to mentally represent and understand second-order beliefs. It is important to note that the expression of second-order beliefs is quite complex grammatically, requiring multiple embedding (recursion) of complement phrases, which are not fully mastered in 6- to 7-year-olds (Hollebrandse, Hobbs, de Villiers, & Roeper, 2008).

The goal of this study is to examine first- and second-order FBs understanding and their correlates at three time points (ages 5 and 6 years, second grade) in children who are hard of hearing (CHH) compared with a matched group of children with normal hearing (CNH). Research related to FB in children with hearing loss has the potential to inform our understanding of mechanisms that support social-cognitive development, including the roles of language and conversational access.

In contrast to a rich literature on FB in children who are deaf, very few studies have examined FB understanding in children with mild-to-severe hearing loss who wear hearing aids (HAs) and rely on spoken language. Research with this group is of interest theoretically, given that the early auditory and conversational experiences of CHH are typically less restricted than those of deaf children with or without cochlear implants (CIs) who have hearing parents, but not as complete as those of CNH. Peterson (2004) suggested that children whose hearing loss is only moderate may have sufficient auditory access to spoken family conversations from an early age to support the ToM development, but this remains an empirical question. Our research team proposed that CHH experience inconsistent access to linguistic input due to several factors, which leads to reductions in cumulative auditory experience (Moeller & Tomblin, 2015). We demonstrated that factors affecting access, such as audibility with HAs and quality of linguistic input, influence spoken language learning. We concluded that CHH are at risk for spoken-language delays even when interventions are provided in infancy (Tomblin, Harrison, et al., 2015). Reduced auditory access may also create barriers for learning about others’ beliefs. Research is needed to determine whether mild-to-severe hearing loss places children at risk for delays in FB understanding, which could have consequences for social interactions (Peterson, Slaughter, Moore, & Wellman, 2016).

FB Development in Children With Hearing Loss

An extensive literature documents that deaf children who have parents with normal hearing demonstrate marked delays in FB reasoning. These delays are evident even when the verbal task demands are minimized using nonverbal formats (Schick, de Villiers, de Villiers, & Hoffmeister, 2007; Woolfe, Want, & Siegal, 2002). Suggested sources of these social reasoning deficits include limited access to conversational models and/or partners fluent in sign language,

diminished conversational experiences, and consequent spoken and/or sign language delays (see summaries in de Villiers, 2005; Peterson, 2004; Peterson & Siegal, 1995, 2000; Stanzone & Schick, 2014). There is also converging evidence that native-signing deaf children of deaf parents perform like CNH, acquiring FB understanding at expected ages (Courtin, 2000; Jackson, 2001; Meristo & Hjelmquist, 2009; Peterson & Siegal, 1999; Schick et al., 2007; Woolfe et al., 2002).

Studies of a new generation of deaf children with CIs draw mixed conclusions about FB development. Some report that FB understanding is delayed (Ketelaar, Rieffe, Wiefferink, & Frijns, 2012; Macaulay & Ford, 2006; Peterson, 2004), whereas others suggest that children with early access to CIs (before age 27 months) are less delayed in FB than those implanted later (Sundqvist, Lyxell, Jönsson, & Heimann, 2014). In conclusion, some studies find little or no delay in spoken language in children with early access to CIs (Peters, Rimmel, & Richards, 2009; Rimmel & Peters, 2009; Ziv, Most, & Cohen, 2013). Taken together, the results support the view that early access to fluent language input (via spoken language or native sign language) and social conversations plays a key role in the ToM development.

FB Development in CHH Using HAs

There is some indication in the extant literature that children with less than severe-to-profound hearing loss may be less impaired in FB than deaf children who are not native signers. Peterson and Siegal (1999) found that 9-year-old orally trained children with moderate-to-severe hearing loss performed better than late-signing deaf children and comparably with CNH and native-signing children. The authors concluded that either the children’s milder impairments in hearing or their experienced delays in preschool that were resolved by age 9 years led to sufficient access to family communication to support FB development. This study tests these alternatives by examining FB understanding at earlier and later ages in CHH compared with age-matched CNH.

To our knowledge, only one study has examined the ToM development in a contemporary group of CHH with early service access. Netten et al. (2017) measured a variety of ToM skills, including first-order FB in a group of 3- to 5-year-old children with moderate hearing loss (35–70 dB HL) compared with hearing peers. All CHH used spoken language to communicate. Although the CHH were comparable to CNH in some early ToM achievements (e.g., understanding others’ intentions), they lagged behind hearing peers in FB understanding. Interestingly, the CHH performed within the average range on a norm-referenced language measure. The authors concluded that moderate hearing loss can affect the development of ToM skills, even when children’s language is broadly age appropriate. This raises interesting theoretical questions about which factors or mechanisms other than language may account for delayed FB understanding in CHH.

Factors Influencing FB Development

Family Factors

A number of family factors have been associated with FB understanding in children. Two commonly explored factors, socioeconomic status (SES) and parental mental talk, are considered in the context of this study. Devine and Hughes (2016) recently published a meta-analysis on the basis of 93 studies of 3- to 7-year-olds regarding family correlates of FB understanding in typically developing children. They concluded that four family factors (SES, parental mental talk, parental mind-mindedness, and number of siblings) were all significantly but modestly correlated with FB understanding, and these associations held even after taking language into account. SES has also been shown to account for individual differences in FB understanding in typically developing children (Shatz, Diesendruck, Martinez-Beck, & Akar, 2003). Longitudinal evidence is limited but also supports a role for family factors in FB development.

In regard to parental mental state talk, it has been proposed that, when family talk involves mental states, children become aware of thoughts, memories, and beliefs, and this influences the ToM development (Dunn, Brown, Slomkowski, Tesla, & Youngblade, 1991). Ruffman and colleagues identified links between maternal talk at an early time point and typically developing children's later ToM understanding (Ruffman, Slade, & Crowe, 2002; Taumoepeau & Ruffman, 2008). Ensor and Hughes (2008) examined mother-child interaction with 2-year-olds and then tested ToM skills at ages 2, 3, and 4 years. Mothers' use of mental state terms facilitated children's ToM development. This study was replicated with hearing mothers and their deaf, hard-of-hearing, or hearing 17- to 35-month-olds (Morgan et al., 2014). Mothers of young deaf or hard-of-hearing children (who used sign-supported and/or spoken language) used fewer mental state terms than mothers addressing CNH. In another study, the amount of maternal mental state talk was found to predict FB understanding in 4- to 10-year-old deaf children with hearing parents who signed to them (Moeller & Schick, 2006).

Little is known about parental mental state talk directed to CHH, but there is reason to suspect that access may also be limited in this group. Ambrose et al. examined parental language input in preschool-age CHH who relied on spoken language to communicate. They found that parental talk addressed to 3-year-old CHH was less complex, included fewer high-level facilitative utterances (e.g., mental term use, talk outside the immediate context), and was more directive than that addressed to CNH (Ambrose, Walker, Unflat-Berry, Oleson, & Moeller, 2015). Further exploration of mental state talk in these dyads involving parents and CHH is warranted to fully understand factors that influence FB development.

Language Development

Children's language development has emerged as a key variable explaining individual differences in FB understanding. A meta-analysis of 104 studies involving typically

developing children under the age of 7 years demonstrated a significant, moderate relationship between child language abilities and FB understanding, which was independent of age (Milligan, Astington, & Dack, 2007). Furthermore, the meta-analysis indicated that FB understanding is related to multiple aspects of language, including semantics, receptive vocabulary, syntax, and memory for complements, although the association was weakest for receptive vocabulary. The authors concluded that language plays a vital role in children's development of FB understanding. Studies of FB understanding in children who are deaf support the view that language plays a central role in the ToM development, in that children who display delays in language (either sign or spoken) also show concomitant delays in ToM (Jackson, 2001; Moeller & Schick, 2006; Rimmel & Peters, 2009; Schick et al., 2007; Woolfe et al., 2002).

In their study of ToM abilities of CHH, Netten et al. (2017) also identified language as a correlate of ToM performance. Although the CHH scored in the age-appropriate range on norm-referenced spoken-language measures, they lagged behind a control group of CNH on a parent report measure, further suggesting a role for language in FB understanding. If CHH have depressed language skills, then delays in FB understanding are to be expected. It is not known, however, if CHH will catch up with CNH in FB understanding at later ages as their language skills improve. Furthermore, our previous work documents that compared with lexical development, grammatical development is especially vulnerable in CHH (Tomblin, Harrison et al., 2015), and grammatical abilities are known to influence ToM development (de Villiers & Pyers, 2001; Milligan et al., 2007). It is also important to note that norm-referenced measures typically assess the language aspects of content (vocabulary) and form (morphosyntax). Pragmatics are generally not assessed because of the difficulties in administering decontextualized tests of the social use of language. Despite the challenge in using a standardized test to directly assess pragmatics, there is a norm-referenced measure of pragmatics or language discourse that demonstrates good concurrent and construct validity across a variety of populations, specifically the Comprehensive Assessment of Spoken Language (CASL) Pragmatic Judgment test (Gerrard-Morris et al., 2010; Losh, Martin, Klusek, Hogan-Brown, & Sideris, 2012; McKown, 2007). In general, there is a need to examine which aspects of language (form, content, or use) are consistently associated with development of FB understanding in CHH and whether early delays may resolve at older ages.

Executive Function

Executive function (EF) abilities also have been explored in an effort to explain individual differences in children's ToM development. The term *EF* refers to higher order cognitive processes that are essential for self-regulation of behavior and include holding information in working memory, inhibiting responses, and shifting or sustaining attention in order to problem solve (Blair, Zelazo, & Greenberg, 2005). Devine and Hughes (2014) conducted

a meta-analysis of over 100 studies and concluded that there is a significant, moderate relationship between EF and FB understanding in typically developing 3- to 6-year-olds. This relationship was found for standard measures of both first- and second-order FBs. Based on a small subset of longitudinal studies, results suggest that early EF predicts FB understanding more strongly than early FB understanding predicts EF. Carlson et al. proposed that some combination of inhibition and working memory may be especially important in FB tasks (Carlson, Moses, & Breton, 2002). Stronger EF skills are also associated with higher SES (Hackman, Gallop, Evans, & Farah, 2015; Sarsour et al., 2011), consistent with findings on FB understanding.

There is a limited body of research regarding EFs and their possible contribution to FB understanding in children with hearing loss. Most studies that examined this relationship included deaf school-age children and did not find an association between EF and ToM abilities. In general, the deaf children from hearing families showed intact cognitive and EF abilities but delayed FB understanding (Jackson, 2001; Meristo & Hjelmquist, 2009; Woolfe et al., 2002). Associations between EF and FB understanding have not been explored in CHH.

FB Understanding and Social Skills

Another topic in the ToM literature is whether performance on ToM tasks is associated with children's social abilities in their daily interactions. Within the autism literature, this topic has been discussed for a number of years (Fombonne, Siddons, Achard, Frith, & Happé, 1994; Frith, 1994; Hughes, Soares-Boucaud, Hochmann, & Frith, 1997), although we know less about FB and social skills in the field of hearing loss and ToM. Some researchers contend that the ToM development should not be viewed exclusively as a result of growth in cognitive abilities but rather as "inextricably tied to children's participation in social exchanges with other people" (Caputi, Lecce, Pagnin, & Banerjee, 2012, pp. 257). As such, it makes sense that children's growing understanding of others' thoughts and beliefs would support emerging pragmatic communication abilities and social behavior. Such links have only recently been explored in the literature on children with hearing loss. Peer social competence, as rated by teachers, was found to be significantly related to ToM skills in both deaf and hearing children (Peterson et al., 2016). This supports the relevance of exploring FB understanding in CHH as a possible mechanism underlying psychosocial delays in this group (see Moeller, 2007, for a review).

In addition, the association between FB understanding and pragmatic communication abilities is likely bidirectional. A number of researchers have demonstrated that social-cognitive skills emerge early on in development. For example, skills such as joint attention (Bakeman & Adamson, 1984; Butterworth & Jarrett, 1991; Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998) and imitation (Carpenter, Akhtar, & Tomasello, 1998) are precursors to the ability to recognize that individuals have thoughts and intentions

that are different from one's own. Thus, social-pragmatic skills and FB understanding have a reciprocal relationship in development.

Research Questions

In summary, little is known about FB understanding and how it changes with age in CHH. This line of research has the potential to inform theories about mechanisms that influence the ToM development in children. CHH often have early access to amplification (Holte et al., 2012) and commonly share the spoken language modality with parents. However, CHH have inconsistent access to auditory-linguistic input and are at risk for spoken language delays (Tomblin, Harrison, et al., 2015). It is unclear if these risks extend to FB development. There is a need for research on FB understanding and its correlates in a contemporary group of CHH with early service access. This study poses six research questions related to this goal.

1. How do CHH compare with CNH in their understanding of first-order FB concepts at ages 5 and 6 years? We predict that CHH will demonstrate delays in FB understanding at age 5 years compared with CNH. However, we also predict that delays at age 5 years will be resolved by age 6 years as a result of advancing language abilities.
2. What factors influence children's performance on FB tasks at ages 5 and 6 years? We predict that child language abilities and hearing status will be related to FB understanding at ages 5 and 6 years. For CHH, we predict that children with better aided audibility will have stronger FB understanding than children with poorer aided audibility.
3. Are mental state input and child language abilities at age 3 years related to children's FB understanding at age 5 years? We predict that child language abilities and exposure to mental state talk by caregivers at age 3 years will be related to FB understanding at age 5 years.
4. Is FB understanding at age 5 years related to social-pragmatic language skills at age 6 years? We predict that children with better FB understanding at age 5 years will have more advanced pragmatic abilities 1 year later.
5. How do CHH compare with CNH in their understanding of FB concepts at second grade? We predict that CHH will approximate the performance of hearing peers but will show greater variability in outcomes as a group compared with those of CNH.
6. What factors influence children's performance on FB tasks at second grade? We predict that language abilities, EF, and hearing category (normal, mild, moderate, moderately severe) will be related to FB understanding at second grade. For CHH, we predict that children with better aided audibility will have stronger FB understanding than children with poorer aided audibility.

Method

Participants

Participants included CHH and CNH who had completed FB tasks within the context of a multicenter, longitudinal study on outcomes of children with mild-to-severe hearing loss entitled, "Outcomes of Children With Hearing Loss" (OCHL; see Procedure section). To participate in the study, CHH met several criteria: (a) chronological age between 6 months and 7 years upon enrollment in the study; (b) use of a spoken communication; (c) bilateral sensorineural, permanent conductive, or mixed mild-to-moderately severe hearing loss; (d) no CI; and (e) at least one primary caregiver who spoke English in the home. For all participants, vision was within normal limits (with correction) on the basis of parent report. Children also had no major motor or cognitive impairments. Children with motor issues that precluded pointing to pictures or participating in audiometric testing were excluded from participation. Nonverbal cognition was assessed using the Block Design and Matrix Reasoning subtests of the Wechsler Preschool and Primary Scale of Intelligence—Third Edition (Wechsler, 2002) at age 4 years and the Wechsler Abbreviated Scale of Intelligence—Second Edition (WASI-2; Wechsler & Hsaio-pin, 2011) at age 6 years. Children had to be within 1.5 *SDs* of the norm-referenced mean on at least one of the two subtests at age 4 or 6 years to qualify for participation. CNH also had to have at least one primary caregiver who spoke English in the home. CNH were matched by age and SES with the CHH.

Participants contributed FB data at up to three age levels: 5 years (CHH, $n = 142$; CNH, $n = 57$), 6 years (CHH, $n = 50$; CNH, $n = 6$), and second grade (CHH, $n = 80$, CNH, $n = 43$). Due to the study design, some children contributed data at both 5 years and second grade, and some children only participated at 5 years or second grade. Six-year data were only collected from children who could not pass FB tasks at age 5 years. In addition, 46 CHH and 19 CNH who contributed FB data at age 5 years were also tested on non-FB measures at age 3 years. Data collected at age 3 years were analyzed as predictors of FB at age 5 years. Table 1 shows the visits at which FB, language, and cognitive measures were administered. Demographic information, including audiologic data for the CHH, are provided in Tables 2, 3, and 4, with participants grouped by the time points at which they contributed FB data, as described in the Procedure section.

Procedure

As described in Holte et al. (2012), the OCHL study used an accelerated longitudinal design, in which children were enrolled in the study between ages 6 months and 7 years and followed over a period of time (at least 3 years), such that there were overlapping points for cross-sectional analysis. FB testing for OCHL took place around age 5 years, and if children did not pass the FB measures at that testing interval, they were retested on the FB measures at age 6 years.

Beginning in 2013, children were enrolled in the second cycle of the longitudinal study, Outcomes of School-Age Children who are Hard of Hearing (OSACHH; Moeller, Tomblin, & OCHL Collaboration, 2015). The OSACHH study utilized a traditional prospective longitudinal design, in which all participants were tested as a single cohort in the summer after second and fourth grades. FB testing for OSACHH took place in the summer after second grade, when most of the participants were age 8 years.

Audiologic Assessment

A pediatric audiologist completed a hearing assessment at each test visit. The audiologist attempted to obtain air-conduction and bone-conduction thresholds at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz at a minimum. The four-frequency better ear pure-tone average was calculated for subsequent analyses.

HA Verification and Audibility Measures

The audiologist determined that HAs were functioning within manufacturer specifications using ANSI S3.22-2003 conformity measures of HA function. The Speech Intelligibility Index (SII; ANSI S3.5-1997) was calculated as a numerical estimate of audibility across the frequency range of speech. SII is determined by estimating the audibility of an average speech signal compared with the listener's hearing thresholds. The calculation is completed for a discrete number of frequency bands, which are each assigned an importance weight on the basis of the contribution of that frequency band to the average speech recognition score for a group of adult listeners with normal hearing. The audibility of each band is multiplied by the importance weight for that band. The weighted audibility of all bands are summed to create a number between 0 and 1 that describes the weighted audibility of the long-term average speech spectrum, where a value of 0 indicates that *none of the long-term average speech spectrum is audible* and 1 represents *complete audibility*.

Simulated real-ear measures were used to calculate aided SII. The audiologist initially conducted probe microphone measures to quantify the real-ear-to-coupler difference (Bagatto et al., 2005). HA verification was then completed in the 2-cc coupler. Audioscan Verifit speech-mapping software (Cole, 2005) was used to calculate aided SII at users' settings using the standard male speech signal (carrot passage; Cox & McDaniel, 1989) presented at average levels (60 dB SPL or 65 dB SPL) following ANSI S3.5-1997. The better ear SII (BESII) at average speech levels was calculated for subsequent analyses.

FB Measures

At the 5-year visit, the first-order FB tasks were administered. These tasks consisted of four FB trials, each with one target question that was scored as *correct* (1) or *incorrect* (0). Examiners read the FB stories to the children. After presenting each game or story, the examiner asked control questions to confirm that the children remembered the story. If children could not pass the control questions,

Table 1. Measures, descriptions, types of scores, and visit administered for false belief, language, and cognition measures.

Measure	Description	Score	Visit administered			
			Age 3 years	Age 5 years	Age 6 years	Second grade
False belief						
First-order false belief	Unexpected contents and change of location	Total correct and pass–fail		X		
First- and second-order false beliefs	Explicit false belief	Total correct and pass–fail				X
Language						
Art gallery	Parent–child interaction	Total number and proportion of parental mental state terms	X			
CASL Basic Concepts	Lexical/semantic knowledge	Standard score	X			
CASL Pragmatic Judgment	Knowledge and use of socially appropriate language	Standard score	X		X	
CASL Syntax Construction	Expressive morphosyntax	Standard score			X	
CELF-4 Word Structure	Expressive morphosyntax	Standard score				X
PPVT-4	Receptive vocabulary	Standard score		X ^a		
PLAI-2 Total Score and Reasoning	Knowledge and use of decontextualized language discourse	Standard score		X ^b		
WJTA-III Picture Vocabulary	Expressive vocabulary	Standard score				X
Cognition						
WASI-2 Block Design and Matrix Reasoning	Nonverbal cognitive skills	Scaled score			X	
Head to toe	Behavioral regulation	Raw score			X	
AWMA Backward Digit Recall	Complex working memory span	Standard score				X

Note. Subject numbers for children with normal hearing (CNH) and children who are hard of hearing (CHH): age 3 years, CHH = 46, CNH = 19; age 5 years, CHH = 142, CNH = 57; age 6 years, CHH = 50, CNH = 6; second grade, CHH = 80, CNH = 43. CASL = Comprehensive Assessment of Spoken Language; CELF-4 = Clinical Evaluation of Language Fundamentals–Fourth Edition; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition; PLAI-2 = Preschool Language Assessment Instrument–Second Edition; WJTA-III = Woodcock-Johnson Tests of Achievement–Third Edition; WASI-2 = Wechsler Abbreviated Scale of Intelligence–Second Edition; AWMA = Automated Working Memory Assessment.

^aMissing seven scores for CHH. ^bMissing 16 scores for CHH and five scores for CNH.

the trial was ended, and children were given a score of 0 for that trial. Two of the trials were unexpected-contents games (Hogrefe, Wimmer, & Perner, 1986). Examiners showed the children physical objects (milk carton for the first trial, crayon box for the second trial). The children were asked what they thought was inside (“What do you think is in here?”). Next, the children were instructed to examine the contents of the box and see that something

unexpected was inside (a car inside the milk carton; a spoon inside the crayon box). If they passed the control question (e.g., “What was really in the box?” and “What did you think was in the box?”), they were asked to predict what another child or family member who had not looked inside the box would say was in it. The third and fourth trials were change-of-location stories (Wimmer & Perner, 1983), which were presented with picture support. In the

Table 2. Audiologic characteristics for 5-year-olds and second graders who are hard of hearing.

Variable	5 years old			Second grade		
	<i>n</i>	<i>M (SD)</i>	Range	<i>n</i>	<i>M (SD)</i>	Range
BEPTA (dB HL)*	142	46.98 (14.41)	6.25–87.50	80	47.00 (15.5)	7.5–90.00
Aided BESII	140	.78 (.14)	.27–.99	80	.79 (.13)	.35–.99
Age at confirmation (months)	140	14.93 (17.68)	0.25–61.00	78	16.90 (20.1)	0.25–67.00
Age at HA fitting (months)	134	17.65 (17.78)	2.00–63.00	77	19.43 (19.7)	2.00–68.00

Note. BEPTA = better ear pure-tone average in dB hearing level (HL); BESII = better ear Speech Intelligibility Index; HA = hearing aid.

*The criteria for study enrollment for children who were hard of hearing was BEPTA no better than 25 dB HL and no poorer than 75 dB HL. Exceptions were made to include children with mild high-frequency hearing loss (three-frequency pure-tone average less than 25 dB HL in the better ear, but thresholds greater than 25 dB HL at 3 kHz, 4 kHz, or 6 kHz). Children with BEPTA greater than 75 dB HL in this study met the criteria at their initial test visit but had progressive hearing loss resulting in BEPTA of up to 90 dB HL at the time of false belief testing.

Table 3. Descriptive data and between-groups comparisons for demographic variables and language scores at age 5 years.

Variable	CNH			CHH			Between groups	
	<i>n</i>	<i>M (SD)</i>	Range	<i>n</i>	<i>M (SD)</i>	Range	<i>p</i>	<i>d</i>
Maternal education (years)	53	15.8 (3.1)	9–20	139	15.5 (2.2)	9–20	.526	
Age (months)	57	60.9 (2.4)	58–69	142	60.9 (2.5)	57–69	.970	
PPVT-4 (SS)	56	114.4 (13.2)	85–141	137	101.9 (16.3)	61–139	.001	0.84
CELF-4 Word Structure (SS)	57	110.7 (14.2)	70–140	135	95.9 (20.2)	55–140	.001	0.85
PLAI-2 Total Score (SS)	52	113.6 (18.2)	73–139	126	100.0 (21.2)	49–151	.001	0.69
PLAI-2 Reasoning (SS)	52	119.3 (22.5)	75–150	126	104.6 (24.9)	55–150	.001	0.62

Note. CNH = children with normal hearing; CHH = children who are hard of hearing; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition; SS = standard score; CELF-4 = Clinical Evaluation of Language Fundamentals–Fourth Edition; PLAI-2 = Preschool Language Assessment Instrument–Second Edition.

change-of-location stories, one character places an object in a room and then leaves the room. A second character then moves the object to a new location and exits, unknown to the first character. When the first character returns to get the object, the participants are asked to predict where that character will first look for the object. These tasks require the child to recognize that the character did not see the object get moved and therefore has an FB regarding the object's true location.

Children received one point for correctly answering the target questions on each FB trial, for a total of four points. FB performance was analyzed as an ordinal variable (total correct out of four possible points) and dichotomously (scores of 3 and 4 represented a passing score; scores of 0, 1, and 2 represented a failing score). If children did not receive a passing score at the 5-year visit, the first-order FB task was administered again at the 6-year visit.

At the second-grade visit, first- and second-order FB tasks were administered via two stories. Both stories involved explicit FB tasks (de Villiers, Hobbs, & Hollebrandse, 2014). As described in the introduction, first-order FB involves reasoning about what another person thinks about an actual event (Perner & Wimmer, 1985). Second-order FB is more challenging because it involves reasoning about what another person thinks a third person knows or believes about an event. In this study, examiners read the stories to the children using picture support. There were 16 questions in each FB story. Each question was worth one point, for a raw

total of 16 points. The questions could be divided into three subgroups: four knowledge/ignorance (e.g., “Does Sam know that Maria bought some brownies?”), eight first-order FB (e.g., “Maria thinks they are selling brownies at the bake sale”), and four second-order FB (e.g., “Sam thinks [that Maria thinks they are selling chocolate chip cookies]”). Consistent with the simpler FB task at the 5-year visit, performance was analyzed continuously using the raw total, as well as dichotomously (pass–fail) for the second-order FB. Scores of 3 or 4 represented a passing score and scores of 0, 1, or 2 represented a failing score. Also consistent with the 5-year protocol, children were required to pass control questions to continue with the task.

Language and Cognitive Assessment

Test protocols were developed to be appropriate for specific ages. The language and cognitive assessments utilized for this study are summarized in Table 1.

Three-year visit. Parents and their children participated in the art gallery task (Adamson, Bakeman, & Deckner, 2004). In the art gallery task, which took approximately five minutes, parents were instructed to lead the child around the testing room and draw the child's attention to pictures that were displayed in the room. After talking about each picture, the parent returned to the child's favorite picture and the child's least favorite picture. Research assistants transcribed the interactions using coding conventions from the Systematic Analysis of Language Transcripts software

Table 4. Demographic, language, and cognitive variables for the subgroups of children who passed and did not pass FB at age 6 years.

Variable	Passers of FB at age 6 years			Nonpassers of FB at age 6 years			Between groups	
	<i>n</i>	<i>M (SD)</i>	Range	<i>n</i>	<i>M (SD)</i>	Range	<i>p</i>	<i>d</i>
Maternal education (years)	31	14.71 (2.7)	9–20	24	14.83 (2.2)	9–18	.852	
Age (months)	31	72.87 (2.0)	71–80	25	72.76 (1.5)	71–76	.820	
Head to toe (raw score)	29	31.5 (5.4)	19–39	24	20.5 (14.3)	0–38	.001	1.02
WASI Matrix Reasoning (T score)	29	54.9 (8.3)	41–74	25	47.6 (7.9)	37–74	.002	0.90
CASL Syntax (standard score)	31	98.0 (16.6)	69–133	25	74.0 (15.6)	50–110	.001	1.49

Note. FB = false belief; WASI = Weschler Abbreviated Scale of Intelligence; CASL = Comprehensive Assessment of Spoken Language.

(Miller & Chapman, 1998). For the purposes of this article, we obtained the total number and proportion of mental state terms (primarily cognitive) produced by the parent. The art gallery task has been used with CNH and children with hearing loss (Ambrose et al., 2015; Quittner, Leibach, & Marciel, 2004). Additional information regarding inter-judge reliability for the current data set can be found in Ambrose et al. (2015). Children's language skills were assessed using the CASL (Carrow-Woolfolk, 1999), which is a standardized measure of global language skills. Subtests evaluate receptive and expressive languages. For this study, we utilized scores from the CASL Basic Concepts (lexical/semantic knowledge) and Pragmatic Judgment (social use of language) subtests. Social use of language is assessed less frequently in children compared with lexical/semantic knowledge, likely due to challenges in accurately measuring pragmatics in a structured, decontextualized setting. However, the CASL Pragmatic Judgment subtest has been shown to have good construct validity with ToM (Losh et al., 2012) and social functioning (McKown, 2007) across a wide age span, indicating that it is possible to obtain a proxy measure of social use of language in a standardized testing format.

Five-year visit. The Clinical Evaluation of Language Fundamentals–Fourth Edition Word Structure subtest (CELF-4; Semel, Wiig, & Secord, 2003) assesses expressive morphology. The child is prompted to say a targeted phrase or sentence that completes a spoken model provided by the examiner, using picture stimuli as support. The Peabody Picture Vocabulary Test–Fourth Edition (PPVT-4; Dunn & Dunn, 2007) is a standardized measure of receptive vocabulary, in which the examiner says a word that describes one of four pictures on a page, and the participant identifies the correct picture. The Preschool Language Assessment Instrument–Second Edition (PLAI-2; Blank, Rose, & Berlin, 2003) is a standardized assessment of children's discourse and pragmatic abilities. Assessment items are categorized into four levels of abstraction, increasing in difficulty. The fourth level, Reasoning subtest, represents the highest level of abstraction. Children must predict outcomes or provide justifications for responses, similar to the decontextualized language that may be used in the classroom setting (e.g., “What will happen to the cookies when we put them in the oven?”). Scaled scores for the PLAI-2 Reasoning subtest were derived from the raw score on the basis of the chronological age of the child and were converted to standard scores for ease of interpretation of results. The total score represents an overall estimate of discourse ability.

Six-year visit. We explored whether cognitive and/or language skills predicted passing FB in the subgroup of 6-year-olds who did not pass FB at age 5 years. Cognitive assessments included the WASI-2 (Wechsler & Hsiao-pin, 2011), which assesses nonverbal problem solving, and the head-to-toe task (McClelland et al., 2007; Ponitz et al., 2008), which assesses behavioral regulation, an aspect of EF. In the head-to-toe task, children are asked to follow commands, such as “touch your head” or “touch your toes.” After a period of training, children are asked to switch

and do the opposite of what they are told (when told to touch their head, they must touch their toes and vice versa). The CASL Syntax Construction subtest assessed expressive morphosyntax via verbal prompts from the examiner and picture stimuli. CASL Pragmatic Judgment was also administered at age 6 years.

Second-grade visit. The Woodcock-Johnson Tests of Achievement–Third Edition (WJTA-III; Woodcock, McGrew, & Mather, 2001) Picture Vocabulary subtest measured expressive vocabulary via picture naming. Expressive syntax was assessed with the CELF-4 Word Structure subtest. The Automated Working Memory Assessment (AWMA; Alloway, 2007) Backward Digit Recall subtest is a standardized, norm-referenced measure of a complex, working memory span. The child repeats digits in backward order from the original presentation. The digits are presented in auditory only via a recorded female talker. Standard scores are derived based on the chronological age of the child.

Statistical Analyses

Research Questions 1 and 5 compared performance of CHH with CNH on FB tasks, utilizing cross-sectional data at ages 5 and 6 years and at second grade. FB performance was analyzed both continuously and dichotomously (i.e., scores of 3 or 4 represented passing performance; 0, 1, or 2 represented failing scores). We conducted chi-square analyses to compare score distributions with the ordinal data and the dichotomous pass–fail criteria.

We also addressed factors that were associated with FB performance, utilizing both cross-sectional and longitudinal data. Questions 2, 3, and 6 explored associations between predictor variables and the dependent variable. For pass–fail performance on FB, we conducted logistic regression. To explore associations between FB scores as a predictor and later language outcomes as the dependent variables (Question 4), we conducted hierarchical linear regression analysis. Model assumptions were tested for all analyses with no violations of assumptions detected.

Results

Research Question 1: FB Understanding in CHH Compared With CNH at Ages 5 and 6 Years

Age 5 Years

Figure 1A shows the percentage of children in each group who obtained scores of 0, 1, 2, 3, or 4 on the first-order FB tasks. CNH cluster at the upper end of the score range, whereas CHH are evenly dispersed across the range. A chi-square test of independence indicated a significant difference between the score distributions of the groups, with CNH outperforming CHH, $\chi^2 = 33.00$, $p < .001$. When FB performance is dichotomized based on the pass–fail criterion, 84% ($n = 48/57$) of CNH passed, compared with 41% ($n = 57/139$) of CHH. Results from a chi-square analysis using the pass–fail criterion are consistent

Figure 1. Percentage of children with normal hearing (CNH; black bars) and children who are hard of hearing (CHH; gray bars) who obtained scores of 0, 1, 2, 3, or 4 on false belief tasks at ages 5 (Column A) and 6 years (Column B) and on second-order false belief in second grade (Column C). Scores of 3 or 4 were regarded as passing. Scores below 3 are nonpassing.

with the continuous data, $\chi^2 = 30.34$, $p < .001$. Compared with CHH, CNH were more likely to pass the FB task.

Age 6 Years

Figure 1B shows scores for the subgroup of 56 children who were retested on FB measures at age 6 years after not passing the measure at age 5 years. Four out of the six¹ CNH (67%) passed FB at age 6 years, while the remaining two CNH (33%) did not pass. For the CHH, 54% ($n = 28/50$) obtained passing scores, whereas 46% ($n = 23/50$) of the group did not pass. A Fisher's Exact test revealed no significant relationship between hearing status and FB raw score at age 6 years ($p = .68$). Non-passers, however, were significantly lower than passers on measures of language, nonverbal cognitive skills, and EF (all p values $< .001$). It is notable that 21.4% of the CHH did not demonstrate FB understanding at age 5 or 6 years, a higher rate than the CNH (4%). This suggests that some CHH are at persistent risk for delays in the ToM development.

Research Question 2: Factors Contributing to Variability in FB Understanding

Age 5 Years

A logistic regression analysis was conducted to determine whether child language abilities and hearing status predicted FB outcomes in 5-year-olds. The outcome variable

was represented categorically as pass-fail on the FB tasks. The predictor variables were hearing status, CELF-4 Word Structure standard scores, PLAI-2 Reasoning standard scores, PPVT-4 standard scores, and maternal education. Table 3 summarizes descriptive statistics, including between-groups comparisons evaluated using independent sample t tests.

CELF-4 Word Structure ($p = .02$), PLAI-2 Reasoning ($p = .02$), and hearing status ($p = .002$) were statistically significant predictors of passing or failing FB tasks, whereas PPVT-4 and maternal education were not. The concordance index is a measure of predictive power. It was .88 for this model, indicating excellent discrimination between pass and fail. The odds of passing FB were 5.1 times higher for CNH than for CHH. The odds of passing FB were 1.05 times higher for each increase of one standardized unit on CELF-4 Word Structure. The odds of passing FB were 1.04 times higher for each increase of one standardized unit on PLAI-2 Reasoning. We also ran this model as a standard linear regression with FB represented as a continuous variable. The results were consistent with the logistic regression. CELF-4 Word Structure ($p < .001$), PLAI-2 Reasoning ($p = .005$), and hearing status ($p = .008$) were significant predictors of FB score with the model explaining 47% of the variance. Table 5 summarizes both regression models.

For the CHH, we separately examined the potential contribution of auditory variables to FB understanding by conducting between-groups (passers, nonpassers) t tests. The mean BESII for FB passers was .81, while the mean for nonpassers was .75, which was significant, $t(133) = -2.70$, $p = .008$. The remaining factors (better ear pure-tone average,

¹Note that three CNH and 32 CHH who were nonpassers at age 5 years did not receive the FB measure at age 6 years.

Table 5. Summary of regression models (logistic on left, standard linear on right) with false belief at age 5 years as the dependent variable and language scores, maternal education level, and hearing status (NH, HH) as independent variables.

Variable	False belief (pass-fail)			False belief (raw score)			
	Wald chi-square	Pr > chi-square	Odds ratio	β	SE	t	p
Intercept				-1.193	0.922	-1.29	.198
CELF-4 Word Structure SS	5.959	0.015	1.050	0.031	0.009	3.61	<.001
PLAI-2 Reasoning SS	5.191	0.023	1.191	0.095	0.032	2.94	.004
PPVT-4 SS	0.173	0.678	0.990	-0.006	0.011	-0.56	.579
Maternal education	0.000	0.996	1.000	0.029	0.040	0.73	.467
Hearing status (NH, HH)	9.505	0.002	5.139	-0.591	0.218	-2.71	.008

Note. NH = normal hearing; HH = hard of hearing; CELF-4 = Clinical Evaluation of Language Fundamentals–Fourth Edition; SS = standard score; PLAI-2 = Preschool Language Assessment Instrument–Second Edition; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition; Pr = probability.

age at confirmation, and age at HA fitting) did not differ between passers and nonpassers (p values = .08, .83, .60, respectively).

BESII was found to be significantly correlated with FB scores ($r = .23$, $p = .007$) and with language (CELF-4 Word Structure, $r = .29$, $p = .001$; PLAI-2 Reasoning, $r = .25$, $p = .006$; PPVT-4, $r = .35$, $p = .001$) for the CHH. To explore whether language mediates the relationship between BESII and FB, we conducted a multiple linear regression for the CHH only with FB raw score as the continuous, dependent variable. Predictors were maternal education, language scores (CELF-4 Word Structure, PLAI-2 Reasoning, PPVT-4), and BESII. The overall model was significant, explaining 45% of the variance in FB scores, $F(5, 109) = 18.46$, $p < .001$. Only two of the language measures were significant predictors of FB scores, CELF-4 Word Structure, $b = 0.45$, $t = 3.38$, $p = .001$; PLAI-2 Reasoning, $b = 0.31$, $t = 2.52$, $p = .01$. The semipartial correlations indicated that CELF-4 Word Structure uniquely explained 23.8% and that PLAI-2 Reasoning explained 17.7% of the variance in FB scores. BESII was not a significant predictor after controlling for the language variables, $b = 0.06$, $t = 0.75$, $p = .45$. The results indicate that the effect of BESII on FB raw score is fully mediated by child language abilities.

Age 6 Years

A logistic regression analysis was conducted to determine whether nonverbal problem solving, EF, and/or language abilities predicted passing FB in the subgroup of 6-year-olds who did not pass FB at age 5 years. The outcome variable was represented categorically as pass-fail on the FB tasks at age 6 years. Independent variables, all of which were univariately correlated with FB raw score, included nonverbal problem solving (WASI Matrix Reasoning), language (CASL Syntax Construction), and EF (head-to-toe task). Descriptive results are summarized in Table 4. Between-groups differences were explored using independent sample t tests.

CASL Syntax Construction ($p = .002$) was the only significant predictor of passing or failing FB tasks. The concordance index was .88 for this model, indicating excellent

discriminating between pass and fail. Results indicate that the odds of passing FB were 1.10 times higher for each one unit increase on the CASL Syntax Construction. We also ran this model as a standard linear regression with FB represented as a continuous variable (FB raw score). The results were consistent with the logistic regression. CASL Syntax Construction ($p = .001$) was the only significant predictor in the model, explaining 43.8% of the variance in FB raw scores.

Research Question 3: Language Factors (Child Language Abilities, Caregiver Mental State Talk) at Age 3 Years and FB at Age 5 Years

Between-Groups Comparisons and Correlations

Before examining the relationship between language factors at age 3 years and FB understanding at age 5 years using a regression model, we examined between-groups comparisons and correlations for the factors of interest. This was a necessary preliminary step because of expected bidirectional effects of child language abilities on caregiver talk and possible differences in these effects by hearing status (Morgan et al., 2014). These analyses involved a subgroup of children who contributed data at both points (CNH, $n = 19$; CHH, $n = 46$). At age 3 years, the groups did not differ significantly in language abilities on CASL Basic Concepts, $t(62) = 1.75$, $p = .09$, or CASL Pragmatic Judgment, $t(62) = 0.65$, $p = .52$. In spite of this comparability, significant differences were observed in the total number and proportions of mental state terms used by caregivers addressing CNH compared with CHH in the art gallery, $t(63) = 3.21$, $p = .004$ for total terms; $t(63) = 3.69$, $p = .001$ for proportion of terms (see Table 6). Consistent with the findings reported above, the groups differed significantly, $\chi^2 = 14.55$, $p < .001$, in passing FB at age 5 years, with CNH outperforming CHH.

Number and proportions of caregiver mental state terms used with 3-year-olds were significantly correlated with the children's FB scores at age 5 years ($r = .33$, $p = .007$ and $r = .33$, $p = .008$, respectively). Proportion of mental state term use was also significantly correlated with CASL Basic Concepts ($r = .36$, $p = .004$), but not CASL Pragmatic

Table 6. Descriptive data for art gallery task at age 3 years.

Variable	CNH			CHH			Between groups	
	<i>n</i>	<i>M (SD)</i>	Range	<i>n</i>	<i>M (SD)</i>	Range	<i>p</i>	<i>d</i>
Total number of mental state terms by caregivers	19	13.05 (8.90)	0–35	46	6.04 (5.30)	0–20	.004	0.96
Proportion of mental state terms by caregivers	19	.11 (.07)	0–.23	46	.06 (.05)	0–.17	.001	0.82

Note. CNH = children with normal hearing; CHH = children who are hard of hearing.

Judgment ($r = .14$, $p = .26$). Both 3-year-old language measures were significantly correlated with FB scores at age 5 years (CASL Basic Concepts [$r = .55$, $p = .001$] and CASL Pragmatic Judgment [$r = .46$, $p = .001$]). These language measures were also significantly correlated with each other ($r = .56$, $p = .001$), leading to the decision to include only one of the language measures in the regression model.

Regression

A logistic regression explored the influence of CASL Pragmatic Judgment, hearing status, maternal education, and proportion of use of mental state terms by caregivers, all of which were univariately related to FB, on passing or failing at age 5 years. The concordance index was .875, showing excellent discrimination between pass–fail. Only hearing status ($p = .01$) and CASL Pragmatic Judgment ($p = .007$) were significant predictors of passing or failing FB. For this subgroup, the odds of passing FB were 28.13 times higher for CNH than for CHH. The odds of passing FB were 1.09 times higher for a child scoring one unit higher on CASL Pragmatic Judgment.

Research Question 4: Relationship of FB Understanding at Age 5 Years to Later Pragmatic Language Skills

A linear regression was conducted to determine whether FB understanding at age 5 years contributed unique variance in pragmatic language skills (CASL Pragmatic Judgment) at age 6 years after controlling for maternal education and language (CELF-4 Word Structure) at age 5 years. The model was significant, $F(3, 152) = 83.56$, $p = .001$. CELF-4 Word Structure ($p = .001$) and FB scores ($p = .01$) were significant predictors of CASL Pragmatic Judgment scores and the full model accounted for 61.5% of the variance. FB explained 1.6% of additional variance over and above the contribution of expressive syntax.

Research Question 5: First- and Second-Order FB Understanding in CHH Compared With CNH at Second Grade

The FB measure administered at age 8 years has 16 total items. Table 7 provides descriptive data for the total FB score and the item subgroups (knowledge/ignorance, first-order FB, second-order FB); between-groups comparisons are illustrated in Figure 2. Although CNH had higher

average scores than CHH on each measure, independent sample *t* tests revealed no significant differences on the total scores or subgroup scores for first-order and second-order FB. Statistical comparisons were not made for the knowledge/ignorance subgroup items because both groups were at or near ceiling for this subgroup. For second-order FB, Figure 1C shows the percentage of children in each group who obtained scores of 0, 1, 2, 3, or 4, respectively. Responses were fairly evenly dispersed across the range for both groups. A chi-square test of independence comparing the between-groups distributions revealed no clear evidence of a relationship between hearing status and FB score, $\chi^2 = 7.38$, $p = .12$. The same holds true when we dichotomized second-order FB performance into pass–fail criterion, $\chi^2 = 1.23$, $p = .25$. As illustrated in Figure 1C, 60.5% of the CNH obtained passing scores on the advanced FB measure, and 50% of the CHH did so. Results indicated that the groups did not differ, on average, in FB performance at second grade.

Research Question 6: Factors Contributing to Variability in FB Understanding at Second Grade

Total Score

This question was first addressed by examining total FB scores (out of 16) as a continuous variable. Independent variables of interest were maternal education, working memory, and language (CELF-4 Word Structure, WJTA-III Picture Vocabulary; see Table 8). Before conducting the multiple regression analysis, we used a standard regression to examine if there was a difference by hearing subgroups (normal hearing, mild, moderate, and moderately severe) in FB (see Figure 3), in case treating hearing loss as one category masked differences resulting from degree of hearing loss. Groups 1 (*normal hearing*) and 4 (*moderately severe*) were significantly different ($p = .02$) from one another, as were Groups 3 (*moderate*) and 4 (*moderately severe*; $p = .04$). However, after using a Tukey-Kramer adjustment for multiple comparisons, neither of these remained statistically significant, $p = .11$ and $p = .18$, respectively.

The multiple regression exploring the full set of factors included maternal education level, AWMA Backward Digit Recall, CELF-4 Word Structure, and WJTA-III Picture Vocabulary, which were all univariately related to FB. In addition, the hearing categories were explored. In this model, only CELF-4 Word Structure was statistically significant, $F(1, 111) = 30.59$, $p < .001$.

Table 7. Descriptive data for scores on the false belief measure at second grade.

Score type	CHH subgroup	No. of items	CNH (<i>n</i> = 43)		CHH (<i>n</i> = 80)		Between groups	
			<i>M</i> (<i>SD</i>)	Range	<i>M</i> (<i>SD</i>)	Range	<i>p</i>	<i>d</i>
Knowledge/ignorance		4	3.98 (0.2)	3–4	3.80 (0.5)	1–4		
First-order FB		8	6.47 (2.3)	0–8	6.25 (2.5)	0–8	.640	0.09
Second-order FB		4	2.79 (1.4)	0–4	2.39 (1.5)	0–4	.147	0.27
Total		16	13.23 (3.1)	6–16	12.44 (3.8)	2–16	.241	0.23
	Mild (<i>n</i> = 34)	16			12.68 (3.8)	2–16		
	Moderate (<i>n</i> = 26)	16			13.19 (3.3)	5–16		
	Mod-Sev (<i>n</i> = 20)	16			11.05 (4.3)	3–16		

Note. For the full groups, scores are presented by item type and total score. Total scores are also reported as a function of degree of hearing loss category. CHH = children who are hard of hearing; CNH = children with normal hearing; FB = false belief; Mod-Sev = moderately severe.

For the CHH, we separately examined the potential contribution of audibility to FB understanding. BESII was found to be significantly correlated with total FB scores, $r = .24$, $p = .03$. To determine whether language and/or working memory mediated the relationship between BESII and FB total scores, we first examined the relationships of these variables with BESII. BESII was significantly correlated with CELF-4 Word Structure ($r = .26$, $p = .02$), WJTA-III Picture Vocabulary ($r = .25$, $p = .03$), and AWMA Backward Digit Recall ($r = .27$, $p = .02$). We then utilized multiple linear regression for the CHH only to explore the unique contributions of these variables to FB. The overall model was significant, explaining 42% of the variance in FB scores, $F(4, 74) = 13.55$, $p < .001$. Only CELF-4 Word Structure was a significant predictor of FB total scores, CELF-4, $b = 0.54$, $t = 4.41$, $p = .001$, with the semipartial correlation indicating that CELF-4 Word Structure uniquely explained 38.9% of the variance in FB scores. BESII did not contribute significantly to the model over and above CELF-4, $b = 0.08$, $t = 0.82$, $p = .42$, nor did working memory, $b = 0.05$, $t = 0.51$, $p = .61$. Consistent with the 5-year-old analysis, the results again indicate that the effect of BESII

on FB total score was fully mediated by child language abilities.

First- and Second-Order FBs

Two different logistic regression models were used to examine first- and then second-order FB items as dichotomous (pass–fail) variables, with hearing category (normal, mild, moderate, moderately severe), maternal education, AWMA Backward Digit Recall, CELF-4 Word Structure, and WJTA-III Picture Vocabulary as the independent variables. Results from these models are presented in Table 9.

Using logistic regression, CELF-4 Word Structure was a significant predictor of passing the first-order FB item subgroup ($p = .005$), as was WJTA-III Picture Vocabulary ($p = .05$), but maternal education, degree of hearing loss, and AWMA Backward Digit Recall were not. The concordance index was .79. The odds of passing first-order FB was 1.07 times higher for a child for each one unit increase on either the CELF-4 Word Structure or the WJTA-III Picture Vocabulary subtest.

Using logistic regression, only CELF-4 Word Structure was a significant predictor of passing the second-order FB item subgroup ($p = .002$). The concordance index was .76. The odds of passing second-order FB were 1.07 times higher for each one-unit increase on the CELF-4 Word Structure measure.

Figure 2. Percent correct for knowledge/ignorance, first-order false belief, and second-order false belief subgroup items for the second grade children with normal hearing (CNH) compared with the children who are hard of hearing (CHH). FB = false belief.

Discussion

The primary objective of this study was to examine FB understanding in CHH compared with CNH at ages 5 and 6 years, and again at second grade. FB skills are of interest because they support children's abilities to take the perspective of others and understand that their actions are guided by their thoughts, feelings, and beliefs. Being able to reason in regard to one's own and others' mental states is an advancement that contributes to social-cognitive development and maturing social interactions. We also explored correlates of FB abilities in these children to gain insights into factors that explain individual differences.

Our first question explored the degree to which CNH and CHH were comparable in their FB understanding at

Table 8. Demographic and performance outcome variables for second graders in both groups.

Variable	CNH			CHH			Between groups	
	<i>n</i>	<i>M (SD)</i>	Range	<i>n</i>	<i>M (SD)</i>	Range	<i>p</i>	<i>d</i>
Maternal education (years)	40	15.6 (2.8)	9–20	80	15.6 (2.2)	9–20	.937	
Age (months)	43	99.9 (3.5)	93–107	80	101.5 (4.9)	91–114	.042	
AWMA Backward Digits (SS)	43	105.3 (13.5)	82–143	80	100.5 (15.9)	61–139	.094	
CELF-4 Word Structure (SS)	43	109.7 (8.7)	80–125	79	103.9 (15.9)	55–125	.012	0.37
WJTA-III Picture Vocabulary (SS)	43	102.7 (10.2)	80–125	80	99.4 (10.2)	69–125	.092	0.33

Note. CNH = children with normal hearing; CHH = children who are hard of hearing; AWMA = Automated Working Memory Assessment; SS = standard score; CELF-4 = Clinical Evaluation of Language Fundamentals–Fourth Edition; WJTA = Woodcock-Johnson Tests of Achievement–Third Edition.

age 5 years. The vast majority (84%) of the CNH demonstrated first-order FB understanding at age 5 years, which is consistent with the literature on typically developing children (Wellman et al., 2001). In contrast, significantly fewer CHH (41%) demonstrated the same level of understanding as a comparison group of CNH. The results suggest that a sizeable subgroup of CHH were delayed in FB understanding at age 5 years, which supports the findings of Netten et al. (2017). In both this study and Netten et al., FB understanding was delayed in spite of CHH performing broadly within the average range on norm-referenced language measures. However, CHH in this study were significantly lower than matched controls (CNH) at age 5 years on all language measures administered. Our research team has stressed the importance of comparing CHH to peers matched on SES

rather than to normative samples (Moeller, Tomblin, & OCHL Collaboration, 2015). Normative standards have been found to distribute differently for children from low-income families (Qi, Kaiser, Milan, & Hancock, 2006) compared with more advantaged groups. Given that this study population was more advantaged than a typical U.S. population (Tomblin, Walker, et al., 2015), it is most appropriate to make conclusions about their language in comparison to SES-matched CNH. From this perspective, language abilities factor into the explanation of FB delays in CHH.

Children who did not demonstrate understanding of FB concepts at age 5 years were retested 1 year later. The majority of nonpassers at age 5 years were successful at age 6 years, supporting the characterization of their 5-year-old FB abilities as a delay in development. This is consistent with Peterson and Siegal's (1999) hypothesis that their participants with moderate hearing loss may have experienced early FB delays that resolved at later ages. However, almost one quarter of CHH showed protracted delays by not passing at age 6 years, suggesting that a subgroup of these children are at risk for longer-term delays in FB understanding, which could affect social development.

We conclude, on the basis of the regression results, that hearing status, morphosyntax abilities, and pragmatic/discourse skills all contribute to FB performance in 5-year-olds. The CNH were five times more likely to pass FB tasks than the CHH, and the odds of passing the FB measures were higher for children with stronger concurrent grammatical abilities (CELF-4 Word Structure) and stronger verbal reasoning scores (PLAI-2). It is challenging to tease apart the ways in which hearing loss itself and language abilities contribute independently to the findings, as these variables are interrelated. Both variables are likely to present challenges for gaining FB understanding. We did not find a role for vocabulary or maternal education, which contrasts with other studies (Devine & Hughes, 2016; Milligan et al., 2007). Recall that in the language FB meta-analysis, receptive vocabulary was the weakest association (Milligan et al., 2007). In addition, we have suggested that vocabulary abilities of CHH may be less impaired than aspects of language functioning (like language form and use) that rely on access to subtle acoustic characteristics in the input and conversational interactions (Tomblin, Harrison, et al., 2015). Therefore,

Figure 3. Total false belief raw scores at second grade as a function of hearing subgroups (normal hearing [NH], mild, moderate, moderately severe).

Table 9. Summary of two logistic regression models with passing or failing first-order and second-order false beliefs at second grade as the dependent variable and language scores, working memory, maternal education level, and hearing category (normal hearing, mild, moderate, moderately severe) as independent variables.

Variable	First-order false belief			Second-order false belief		
	Wald chi-square	Pr > chi-square	Odds ratio estimate	Wald chi-square	Pr > chi-square	Odds ratio estimate
Hearing category	1.211	0.751	1.281–2.173 ^a	0.437	0.932	0.728–1.014 ^a
Maternal education	0.001	0.971	1.004	2.920	0.088	1.167
AWMA Backward Digits SS	0.002	0.970	1.001	1.733	0.188	1.020
CELF-4 Word Structure SS	7.924	0.005	1.068	9.244	0.002	1.071
WJTA-III Picture Vocabulary SS	3.867	0.050	1.068	1.305	0.252	0.971

Note. AWMA = Automated Working Memory Assessment; SS = standard score; CELF-4 = Clinical Evaluation of Language Fundamentals–Fourth Edition; WJTA = Woodcock-Johnson Tests of Achievement–Third Edition.

^aCompared subgroups with normal hearing to subgroups with mild, moderate, and moderately severe hearing. Because no comparisons were significant, the range is provided.

it may be that the vocabulary measure was less sensitive to individual differences in FB. It is also possible that we did not have sufficient variance in maternal education to find a contribution of SES.

Given the hypothesized role for auditory access in children's language and FB deficits, we examined levels of aided audibility in the CHH only. Contrary to our prediction, audibility did not contribute to FB after controlling for children's language abilities. However, children who passed FB had better aided audibility than those who did not, and we also found that audibility was significantly related to FB. These findings suggest that audibility indirectly influences FB development through language abilities. Children with stronger aided audibility develop better language skills, which, in turn, influence FB understanding. It is possible that audibility and language exert combined effects as well. It is known that both audibility and language skills contribute to children's ability to recognize words in noisy contexts (McCreery et al., 2015). The combined effects of good audibility and strong linguistic skills may enhance children's access to following conversations in noisy settings. Harris (2005) suggests that conversations often highlight differing viewpoints, and this shifting back and forth of viewpoints from one talker to another promotes the understanding of alternative thoughts that are necessary for passing FB tasks. Peer conversations, negotiations, and pretend play are also contexts that are likely to expose children to alternative viewpoints (Harris, 2005). These conversational interactions often occur in noisy settings (day care, dinner tables), which may make it challenging for CHH to follow details and social nuances, especially with multiple talkers. More research is needed to explore social communication access in CHH in complex listening situations and their potential influence on development of FB understanding.

In the 6-year-old subgroup, we also examined EF as a possible predictor of FB. The head-to-toe task incorporates demands on working memory and inhibition of responses, and previous studies link these abilities and FB (Carlson et al., 2002; Devine & Hughes, 2014). Although concurrent EF abilities were significantly and moderately correlated

with FB in this study, EF was not a significant contributor after accounting for children's grammatical abilities. Cognitive, EF, and language variables were highly intercorrelated and may influence FB understanding in combined ways. Our data suggest that cognition and EF share variance with language, and their influences do not explain variability already accounted for by language abilities. It is interesting to note, however, that the children who did not pass FB at age 6 years had the combined disadvantages of lower language, cognitive, and EF abilities than children who passed, and the effect sizes of these differences were large ($d = 0.90$ – 1.48). On the basis of these data, we cannot rule out the influence of EF as an indirect contributor to FB understanding. Children with delays on all three variables may be at particular risk for delays in FB.

Because we were interested in exploring mechanisms that underlie individual differences in FB outcomes, we posed the third question to examine longitudinal language factors at age 3 years and their relationship with FB at age 5 years. It is important to note that the CNH and CHH were comparable in language abilities at age 3 years on norm-referenced language measures, but adults communicating with CHH used significantly fewer mental state terms. What accounts for this difference in the quality of input if it is not driven by child language? One possible explanation is that standardized measures are insensitive to existing differences in the children's world knowledge, which affect the quality and depth of parent-child conversations. Another possibility is that parents of CHH may differ from parents of CNH in their views of the complexity of topics their child can manage. This explanation was proposed by Morgan et al. (2014), who found that their deaf or hard-of-hearing participants who had large vocabularies still had more limited quality of conversational experience with their mothers than hearing children. They concluded that it is possible that it is not only the child's vocabulary that is important but also how the parent views the child's conversational and cognitive abilities.

There may be other ways that the children's hearing status exerts influence on parental expectations and

communication practices. Parents of CHH may have a heightened awareness of the need to engage the child's attention to maximize auditory access, which could result in refraining from pursuing or including the child in conversations deemed not to be "within earshot." Although speculative, it also may be that some parents are overly focused on exposing the child to specific intervention goals (vocabulary, speech production), while limiting talk about thoughts or topics beyond the immediate context (Ambrose et al., 2015). Such practices could potentially create imbalances in developing systems.

Hoffman, Quittner, and Cejas (2015) promoted the need to understand the development of children who are deaf from a dynamic systems framework. Dynamic systems theory proposes that deficits in one domain of development have a cascading impact on other domains, disrupting balance in the developing systems. Following this logic, deficits in language would be expected to have cascading effects on social development, especially given the view that language is considered a major route to joining a community of minds (Nelson, 2005). Language is a primary means by which children enter and maintain social interactions, especially as they increase in complexity. Hoffman et al. also found that both hearing status and language age were predictors of social competence in deaf and hearing preschoolers.

Environmental barriers (noise, reverberation) could also affect the child's access to shared viewpoints involving multiple talkers. Further research is needed to explore these possibilities. The view that the child's hearing status may be exerting influence is borne out in the longitudinal analysis, which showed much higher odds of passing FB at age 5 years if the child had normal hearing at age 3 years than if the child had hearing loss at that age. In summary, we propose that hearing status could be exerting influence through child conversational language abilities, conversational quality within dyads, parental expectations, and/or environmental barriers to hearing that parents may accommodate in ways that affect the input complexity.

Contrary to our prediction, the proportion of mental state terms used by caregivers with their 3-year-olds was not associated with children's FB understanding at age 5 years once language abilities were controlled. Although others have found associations between parental mental state talk and FB understanding in CNH (Devine & Hughes, 2016; Ruffman et al., 2002) and concurrently in children who are deaf (Moeller & Schick, 2006), our results again suggest the possibility of indirect influences. It may be that parental mental state talk influenced children's language abilities, which in turn influenced FB at age 5 years. It is also possible that the semistructured art gallery context was limited in opportunities for eliciting cognitive terms or the kinds of explanations found to promote FB understanding (Peterson & Slaughter, 2003). However, 11% of the utterances directed to CNH contained cognitive references within this limited context, yet only 6% of those directed to CHH did so. Further longitudinal research is needed with longer interaction samples and attention to

connectedness of conversations and explanatory utterances (Ensor & Hughes, 2008; Peterson & Slaughter, 2003).

Our fourth question sought to determine if children's performance on FB tasks at age 5 years was related to the children's later social language abilities as measured by the CASL Pragmatic Judgment subtest at age 6 years. Consistent with our prediction, children with better FB skills at age 5 years had stronger social-pragmatic language abilities at age 6 years. Children's FB understanding contributed a small but significant, unique variance (1.6%) over and above the effects of language. We are not suggesting a unidirectional influence of FB on pragmatic language. As we discussed earlier, it is likely that these relationships are bidirectional, with early and ongoing social interactions informing both language and FB understanding. However, this finding of a contribution of FB to social language use is in agreement with other studies showing a relationship between FB tests and teacher reports of children's ability to use mindful conversation skills in everyday interaction (de Rosnay, Fink, Beeger, Slaughter, & Peterson, 2014). Furthermore, Peterson et al. (2016) demonstrated that peer competence, as rated by teachers, was related to the ToM understanding in both hearing and deaf children, even after controlling for age and language abilities. Together, the results support the relevance of measuring children's understanding of others' viewpoints and ability to take them into account in conversations, as these abilities give insight into their social functioning.

Our final question examined the performance of second graders on measures that tapped later developing FB understanding, including first- and second-order FB presented in narrative contexts with picture support. Consistent with our prediction, the performance of the CHH on first- and second-order FBs did not differ from the CNH. Although the groups differed in grammatical abilities, this difference was quite small ($d = 0.37$), which may account for the ability of the CHH to perform at levels comparable to the CNH on FB tasks. Both groups were at ceiling performance on knowledge/ignorance items, were at near-ceiling performance for the first-order FB narratives, and exhibited lowest performance on the second-order FB. Sixty percent of the CNH and 50% of the CHH passed the second-order FB questions, showing that a number of children in both groups did not demonstrate this later understanding. This rate of passing on the second-order FB task is similar to that reported for 6- to 7-year-old CNH on this same task (Hollebrandse et al., 2008). In contrast to our prediction, variability was similar across the groups. Some children in both groups struggled with advanced FB concepts. The results are supported by the finding that neither children's hearing status nor their degree of hearing loss was a predictor of individual differences in outcome. Contrary to our prediction, aided audibility did not contribute uniquely to FB understanding after controlling for language, but significant correlations between BESII and FB again suggest indirect effects through language. Grammatical abilities, and not vocabulary or EF, surfaced again as the single predictor.

One explanation for these results at second grade is that the CHH show resilience and have caught up to their hearing peers in FB understanding. Such a conclusion would suggest that CHH do not show the protracted delays observed in late-signing deaf children (see Peterson, 2004, for a review). The CHH were less delayed in spoken language compared with controls than they were at earlier ages, and this might account for resilience in FB outcomes. Peterson (2004) suggested that rate of language development may be influential in that faster language learning gives children greater access than children with language delays to conversations and verbally mediated play that promote knowledge of others. Some of the CHH in this study may have been in a period of accelerated growth in language between ages 5 years and second grade that allowed for increased complexity of interaction (Tomblin, Harrison, et al., 2015). On the other hand, we are reluctant to make strong claims about normalization of ToM skills in this group. Failure to find a significant difference in second grade does not necessarily indicate that FB skills are equivalent at this age or that CHH arrived at FB understanding via the same underlying mechanisms as CNH. In part, such a claim is ill advised given the narrow way in which we examined children's ToM skills. Many other aspects of advanced ToM beyond FB understanding remain unexplored in this group, and it is unclear if the groups would be comparable on a wider array of measures. Furthermore, it is unknown whether the nonpassers of second-order FB in each group will proceed to understanding at the same rates. Future studies are needed to put these results in a broader context of later-developing ToM abilities, including advanced social reasoning, reasoning about ambiguity, and recognizing when social norms are violated (Osterhaus, Koerber, & Sodian, 2016). Studies should also focus on mechanistic explanations of the ToM development.

Limitations and Future Directions

Although this is the first study to examine FB understanding at several time points in a large sample of CHH, there are several limitations that should be acknowledged. The most obvious limitation is the singular focus on FB understanding, which provides a limited view of the children's ToM development. It would have been preferable to administer a battery of measures, like the ToM Scale (Peterson et al., 2012; Wellman & Liu, 2004), but time limits in the broader longitudinal study precluded a more granular approach. Some research teams have advocated for the use of parent report scales to examine social-cognitive skills in an ecologically valid manner (Hutchins, Allen, & Schefer, 2017; Peterson & Slaughter, 2003). Another option is direct observation of peer interactions (Bobzien et al., 2013; Minnett, Clark, & Wilson, 1994) or inclusion of tasks that measure social functioning and/or perceived social competence and self-esteem. The latter constructs could potentially be measured using self-report tasks, such as the Harter Self-Perception Profile for Adolescents (Harter, 2012), or parent report measures, such as the Children's Communication

Checklist–Second Edition (Bishop, 2003). We recognize the merit of these approaches for future studies.

Another limitation may be our reliance on complex story narratives to measure later-developing FB understanding. Some researchers have criticized second-order stories as being overly demanding on working memory, planning, and complex syntax abilities just to follow the procedure, making it unclear if we are measuring what we intend to be measuring (Peterson et al., 2012). However, the stories we used controlled the expressive demands because they did not require that the children process second-order complement language. Rather, children needed to make connections across the story discourse in order to answer the second-order questions by representing second-order beliefs (de Villiers et al., 2014). Comprehension of the stories was supported by cartoon picture stimuli. In spite of these adaptations, task complexity may contribute to the reason that 40%–50% of each group did not pass the second-order FB task.

We acknowledge a limitation with our use of standardized measures to assess social communication. For this study, we used the CASL Pragmatic Judgment subtest as a proxy measure of social communication at ages 3 and 6 years. The CASL Pragmatic Judgment subtest has been shown to demonstrate good validity and reliability as a measure of pragmatic skills in children 5 years and older (Losh et al., 2012; McKown, 2007). One can argue, however, that it is not appropriate to measure social communication using a norm-referenced standardized test, which relies on decontextualized methods of assessment. *Social communication*, by its very definition, involves context. It is also unclear from the current research literature if the CASL Pragmatic Judgment subtest is assessing the same construct at age 3 years as it is at older ages (McKown, 2007). We note, therefore, that we were restricted in our ability to directly assess social communication, particularly at age 3 years.

Another limitation of this study is that we lacked EF measures at ages 3 and 5 years, which relegated us to measuring the impact of these skills on concurrent FB measures at the later ages. It would have been useful to explore the impact of EF longitudinally, given that EF skills early in preschool are known to affect later FB understanding (Devine & Hughes, 2014). Furthermore, the art gallery samples used to judge amount of cognitive talk were short in duration and were laboratory based, which may have affected how representative they were of the typical dyadic interactions in these families. Further research is needed using more extensive caregiver–child interaction samples that can be explored for both connectedness and parental use of explanatory discussions. The art gallery task could have also presented problems for children with limited audibility who relied on visual cues to communicate with caregivers, due to the need to divide attention between the communication partner and the art gallery pictures. However, we find it unlikely that the results of the art gallery task were affected by difficulties with divided visual attention, given that the participants had mild-to-moderately severe

hearing loss, used spoken language to communicate, and were less dependent on visual cues to communicate than children who are deaf.

A final point worth noting is that this study matched the CHH and CNH on SES. As we stated earlier, the participants in this study were more advantaged than a typical distribution of children from the United States. It is not clear if the results extend to children from less-advantaged circumstances. It is also not clear if the FB differences would remain if the CHH were compared with younger, language-matched peers with normal hearing. Future research should address these issues.

Clinical Implications

The current findings suggest that early intervention programs should support families in developing and promoting the conversational use of mental state talk (e.g., about thoughts, feelings, desires) and to elaborate that talk with explanations related to mental states when the child is developmentally ready. Parents can also be coached to engage their children in pretend play and provide opportunities for pretend play with peers, which involve exposure to varied perspectives and dual representations (what is real and what is pretend). Promoting early joint attention skills may also have a positive impact on later ToM development; research supports the notion that shared interest and social engagement facilitates the early understanding of other individuals as independent social agents (Mundy & Newell, 2007; Schertz & Odom, 2004). Furthermore, efforts to optimize children's audibility with amplification will benefit spoken-language development (Tomblin, Harrison, et al., 2015), which in turn will support development of FB understanding. Families should also be coached to anticipate how the child may miss conversational nuances and subtle social details in noisy situations and to provide ways for the child to be informed of what was missed.

Summary

Preschool-age CHH appear to be at risk for delays in understanding others' beliefs. The lack of a significant difference between CHH and CNH on FB tasks at second grade indicates that these delays may resolve by early elementary school. However, some CHH are at risk for FB delays that do not resolve in a timely manner, and those with delayed language are at heightened risk. Further research into the underlying mechanisms of ToM delays in preschool-age CHH, as well as broader ToM development in school-age CHH, are warranted.

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