# Theory of mind development in deaf and hard of hearing elementary students.

by

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Theory of mind development in deaf and hard of hearing elementary students.

Thesis directed by Professor Brenda Schick


**Abstract**

Theory of mind plays an important role in our everyday interpretation of interactions. Being able to analyze what people desire, know, and believe and recognizing these mental aspects may be false or different from our own is a key component of language, cognitive, and social development. Studies have shown that skills that fall under theory of mind (ToM) such as recognizing diverse beliefs, knowledge access, social pretend, and false beliefs typically develop during preschool age (Peterson & Wellman 2009; Wellman & Liu 2004). Specifically, the task and ability to understand false belief has been investigated the most. This ability shows a distinct pattern of being more difficult for hearing three-year olds to understand, but not five-year olds. Within this body of literature, the influence of language and hearing ability have also been studied as key factors in how ToM develops in hearing children. However, children with hearing loss (DHH) represent a diverse population that are affected by even more aspects of environmental influences. Many studies have looked at small groups of DHH children who have hearing parents and some have compared them to deaf children of deaf parents. The present study involves 351 elementary-age children with hearing loss from across the USA. These students have diverse hearing abilities and different levels of access to spoken language and sign language. These children were given ToM tasks that include false belief, knowledge access, and social pretend. We explore the influence of language abilities, parental hearing status, amount of growth in a school year, access to language through audition, and communication modality. Through confirmatory factor analysis and structural equation

modeling, we find that language abilities predict ToM, beyond all other factors.  This information can be used clinically to help target students who may be at risk for delayed ToM and help to establish interventions to reverse or prevent delays.

## Dedication

To my Grandmother, Lorene Kremer. She saw me through the bulk of my PhD program and I know she would be proud. I got my will power, stubbornness, and dedication from her.

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# Chapter I

## Introduction

Everyday interactions can involve a variety of experiences, beliefs, desires, intentions, and knowledge. Young children as young as 12 months old can begin to show awareness of others' intentions in their environment (Lohmann & Tomasello, 2003; Wellman & Peterson, 2013b). Yet more advanced developmental achievements related to understanding others' intentions take longer to develop and rely on cognitive and linguistic maturity. Theory of mind (ToM) is one construct composed of many cognitive, emotional, and social abilities that aid us in the ability to understand these interactions. Cognitive skills related to understanding diverse desires, diverse beliefs, knowledge access, social pretend, and false belief contribute to the construct of ToM. Researchers have been studying the growth of ToM through multiple tasks that address these skills (Wellman & Liu, 2004). Most studies have focused on single types of tasks to measure ToM, usually false belief. Fewer studies have used social pretend as an element of ToM and instead have used it as a predictor for developing false belief understanding. As will be discussed later, skills associated with ToM have been connected to language development as well as language experiences. One population that has leant itself to the current knowledge of ToM, has been children with hearing loss; specifically children from hearing families compared to deaf families or hearing peers. While there are many research studies focused on this comparison, only a few studies have focused specifically on testing a large and diverse population of children with hearing loss. In addition, most studies evaluating ToM and hearing loss include children older than when ToM develops in hearing children. Many have not investigated children, even of deaf parents, younger than five years-old (but see Moeller &

Schick, 2006; Peterson, Wellman, & Liu, 2005; Schick, de Villiers, de Villiers, & Hoffmeister, 2007). As will be discussed below, only a few studies have looked at the impact of access to sound through amplification and cochlear implants or communication modality. The present study will explore the development of ToM in deaf and hard of hearing (DHH) children at the early elementary school age. We aim to explore relationships between ToM development and language abilities, auditory access, and parental hearing status along with a growth over one school year for these students.

**Theory of Mind**

Theory of mind is the ability to recognize that people have unique, individual, desires, thoughts, knowledge, and beliefs that are sometimes incongruent to reality. ToM, within psychology, is part of the belief-desire understanding that frames our everyday communications (Bartsch & Wellman, 1989). An individual's actions are understood based on an individual's beliefs and/or desires, for example, a boy goes to a park to look for his book bag (action) because he thinks that is where he left it (belief) or a girl pets a kitten (action) because she likes cats (desire). Within the field of speech language pathology, skills integral to ToM development can be seen in semantic, syntactic, and pragmatic subsystems of language. In order to explain the action of others we need to use specific mental state vocabulary that is less concrete for example, *think, know,* and *believe*. These tasks also require more syntactic complexity such as using syntactic complements like "He thinks the brush is in the drawer". This type of sentence complexity does not typically emerge until preschool age. Pragmatically, interactions are more robust when we are able take another person's perspective and understand and express thoughts, feelings, knowledge, and beliefs.

ToM has been explored in the literature with a variety of assessment tasks. The most common construct used to measure ToM are various false belief tasks. One example of a false belief task is the unexpected contents task. It is measured in a scenario where a child is shown a familiar box such as a Band-Aid box or crayon box, with an unusual object inside. The child is asked what they think is inside the box. The child typically says "Band-Aids" or "crayons". It is then revealed that an unexpected item is in the box (e.g. a toy shark or car). The child is then asked a series of questions; some of these are control questions such as, "what is actually in the box?" And, "before the box was opened, what did you think was in the box?" These questions establish the child understands their own reality and perception of the situation. The child is then asked what their friend or a doll who did not see what is actually in the box, would think is in there. If the child responds with what <u>should</u> be in the box (Band-Aids in a Band-Aid box) rather than what they <u>know</u> is in the box (a shark in a Band-Aid box), then that child has demonstrated they understand false belief.

Knowledge access, or judgements of ignorance, is another skill considered to be an element of ToM development. Knowledge access is often compared to false belief abilities (Fabricius & Khalil, 2003; Flavell, Flavell, Green, & Moses 1990; Friedman, Griffin, Brownell, & Winter, 2003; Hogrefe, Wimmer, & Perner, 1986). Knowledge access tasks are about realizing what someone knows is based upon their perceptual experiences. This is often compared to false belief using a task where a character puts an object in Location A, but does not see it moved to Location B (Wellman & Liu, 2004). In a knowledge access task the child is just asked if the character knows where the object is currently. The expectation is that the child will recognize that since the character did not see the object move they will not know where it is. This is contrasted with false-belief by asking the child where the character believes the object to be.

Knowledge access tasks relate to the idea that children can understand differences in knowledge versus ignorance before understanding false beliefs.

Social pretense or social pretend is another aspect of ToM that has not been explored that often in the literature. Pretend play or understanding statements that contain pretend elements, requires an individual to understand that what is being said is supposed to be different from reality (saying a brush is actually a microphone). This, in a way, is similar to false beliefs except that in beliefs, there is supposed to be an element of truth or congruence with what is actually happening in the world (Peterson & Wellman, 2009). Being social with pretend play seems to be an important role in ToM development, while individual pretend play does not seem to lend itself to predicting passing false belief tasks (Jenkins & Astington, 2000; Schwebel, Rosen, & Singer, 1999).

**Scaling of ToM**

The skills required to successfully pass ToM tasks seem to vary by what the task requires and by the age of the child. Tasks related to diversity of desires and beliefs appear to be easier for children to understand and express while abilities in understanding knowledge and beliefs that are incorrect from reality are more difficult depending on age. Several studies (Peterson & Wellman; 2009; Peterson et al., 2005; Wellman & Liu, 2004) have established a scale of development for various ToM tasks for children with typical hearing as well as compared to other diverse language populations (discussed below). It appears that false belief and knowledge access are elements of ToM that are achieved later, around the ages of four or five years old. In Wellman and Liu (2004), children were separated into three age groups (3-, 4-, and 5-year-olds). The 3-year-old group showed the most variability in their ability to understand knowledge access and false belief while the 4- and 5-year-olds showed that knowledge access was slightly easier to achieve than false belief. Other studies across different languages and cultures have shown similar rates and progressions of ToM development (Shahaeian, Peterson, Slaughter, & Wellman, 2011; Wellman, Fang, Liu, Zhu, & Liu, 2006) Studies of hearing children focusing on social pretend have found that this understanding tends to be easier to understand than false belief (Custer, 1996; Gopnik & Slaughter, 1991; Hickling, Wellman, & Gottfried, 1997).

All of the previous mentions of ordering ToM tasks have used Guttman scales (Guttman 1944) or Rasch Models (Snyder & Sheehan, 1992) in order to analyze the scalability of ToM development. In the almost 15 years since Wellman and Liu (2004) conducted these analyses new and potentially more powerful ways of interpreting not only the scalability but also the assumption that all of these test are focusing on the same construct. Confirmatory factor analysis (CFA, Brown & Moore, 2012), which is a special case of structural equation modeling (SEM, Ullman, 2001) may more accurately describe the differences between and within groups of children and their development of a skill. CFA is often used when there is a theoretical relationship that is trying to be confirmed, and has been generalized to handle categorical items. In the situation of ToM, we are confirming that multiple tasks (false belief, knowledge access, and social pretend) are measuring the same construct of ToM and that they continue to measure ToM across time. SEM allows us to systematically test multiple relationships among outcomes.

Recent studies have used CFA to examine construct validity of advanced ToM tasks or assessments. Wang and Wang (2015) used CFA to validate a parent questionnaire, Empathy and Theory of Mind Scale and its abilities to categorize responses as, Empathy, Nice ToM, and Nasty ToM. The other studies explored advanced ToM tasks called “Reading the Mind in the Eyes” and “Silent Films” (Devine & Hughes, 2013; Vellante et al., 2013). Both of the advanced ToM abilities measured in these tasks are thought to be established in adolescents (8 to 13 years old).

There is one unpublished dissertation (Stanzione, 2014), that utilized CFA to examine the extent to which the tasks of diverse desires, diverse beliefs, social pretend, knowledge access, and false belief comprise a single construct.

There have been no studies to date that use SEM to explore the construct validity of ToM abilities, but there have been studies on how ToM abilities influence school readiness based on a new assessment (Wang, Wang, & Chui, 2017) and listening comprehension of narratives (Kim, 2016).

**Theory of Mind and Language**

Within the literature, there are a few different debates regarding the relationship between ToM and language. Although ToM can be thought of as many different abilities related to desires, knowledge, and emotions, the majority of studies focus on finding connections to language and false belief exclusively. Two major points of investigation have been 1) if general language plays a role in false belief development or if specific parts of language like understanding of sentential complements are more important and 2) if earlier language predicts later ToM development and vice versa, indicating a bidirectional relationship.

To further explore these two debates of language influence, Milligan, Astington, and Dack (2007) created a meta-analysis of 104 studies from 1980 to early 2006. The final studies were narrowed from an original 324 based on inclusion and exclusion criteria of: 1) participants younger than 7 years old, 2) standardized and/or experimental measures of language, and 3) the study was using English. Training studies or studies investigating more than false belief tasks were excluded. Although memory of syntactic complements had the largest effect size, very few studies have used this predictor. Statistically, abilities in memory of syntactic complements was no greater at explaining variability than any other language predictor. The only language predictors that showed significant difference were receptive vocabulary measures compared to general language measures with general language having a stronger correlation to false belief abilities. This meta-analysis also showed that there were strong correlations between earlier language abilities predicting later ToM skills as well as ToM abilities predicting later language abilities supporting a bidirectional model of ToM and language development (see also Slade & Ruffman, 2005). However, the meta-analysis also shows that the effect size of language predicting ToM, 0.56, was significantly stronger than false belief predicting later language (effect size = 0.36, $Q_{(1, 17)} = 5.57$, $p = 0.02$).

Longitudinal studies on language and ToM abilities can also help to describe the direction and nature of this complex relationship. For example, a longitudinal study was conducted with young (three year-olds) typically developing children (Astington & Jenkins, 1999). This study followed 59 children assessing them three times over a seven-month period on language and false belief tasks. This study explored not only the directional relationship of ToM and language, but also if specific parts of language predicted ToM abilities. The study found within a single sample that earlier language abilities, specifically general semantics and syntax, strongly predicted later abilities in false-belief tasks, but this relationship was not reciprocal. Using a hierarchical regression, when using language as an outcome variable and controlling for age, adding results of earlier ToM scores did not significantly explain the variance in scores around future language abilities. Conversely, when using ToM as the outcome variable, controlling for age, earlier language abilities significantly explained the variance of later ToM scores (language at time 1 predicting ToM at time 2, $R^2 = 0.11$, $p < 0.01$; language at time 1 predicting ToM at time 3, $R^2 = 0.13$, $p < 0.001$). They similarly tested if general syntax or semantics played a more prominent role in ToM development. Language was measured using a standardized test, and sub-scores were created to represent syntax and semantic skills. Using hierarchical regression, the researchers found semantic sub scores when entered first accounted for a significant amount of the variance ($F_{(1, 55)} = 7.05$, $p < 0.05$) as did syntax sub-scores ($F_{(1, 54)} = 9.36$, $p < 0.01$). However, when Time 1 syntax scores were added before semantics ($F_{(1, 55)} = 16.84$, $p < 0.001$), the semantic scores no longer explained a significant proportion of the variance ($F_{(1, 54)} = 0.73$, *ns*). This shows that syntax is important, but this study only explored general abilities in syntax and did not explicitly test object complementation, a sentence structure that often appear in false belief tasks.

Intervention studies, in conjunction with the already established correlational studies, would highlight the relationship between language and ToM and how it develops in typical and clinical populations (Milligan et al, 2007). Lohmann and Tomasello (2003) did an intervention study to explore possible influences in improving false belief abilities in 138 children from 3 to 3;10. They explored theories related to the influence sentential complements and discourse on improving abilities related to false-belief. They created four groups of children. Children that received training with full language (using sentential complements and discourse), only sentential complements, only the act of discourse around false belief tasks, or training with no descriptive language but just exposure to false belief situations. They found from a pretest to posttest assessment that children that received full training where the examiner used sentential complements and discussed the false belief task, had the greatest improvements than all other training groups ($\chi^2_3 = 33.8$, $p < .001$). Comparing the other three groups there were no significant differences in pretest to posttest although the sentential and discourse only groups averaged 40% accuracy while the no language group averaged 25% accuracy. This shows that more than just the exposure to false-beliefs tasks are needed in order to see improvement, there needs to be discussion and use of advanced syntax structure.

ToM is a construct in typically developing children. Typically developing populations start recognizing others intentions early, but a child takes several years and maturity to understand complex reasoning related to incongruent thoughts, knowledge, and beliefs of others. Correlational and intervention studies have shown that aspects of language are of import in order to understand false belief and potentially other ToM tasks. The role of language and potentially other environmental or cognitive factors can be explored by exploring other diverse language populations and their development of ToM.

**Theory of Mind and DHH Students**

Children with hearing loss constitute a unique population to explore ToM because of the factors affecting their access to language. Many children in this group are growing up with language models that are not always accessible due to their hearing loss or an environment that lacks the ability or knowledge to address the diverse linguistic and audiological needs of the child. There have been numerous studies involving the development of ToM in children with hearing loss including: seminal scaling studies (Peterson & Wellman, 2009; Peterson et al., 2005; Wellman, Fang, & Peterson, 2011), studies involving language development or other key language factors (Courtin, 2000; Lecciso, Petrocchi, & Marchetti, 2013; Lundy 2002; Moeller & Schick, 2006; Schick et al., 2007), general overviews or literature reviews (Stanzione & Schick 2014; Wellman & Peterson, 2013b), as well as interventions (Wellman & Peterson 2013a). Collectively these studies agree that there is a potential delay in ToM development similar to the delay often seen in language development for this population. Most studies have used a small number of participants, not necessarily considered multiple skills within ToM (mostly focusing on false belief tasks), or not been able to explore predictors of ToM development such as auditory access and communication mode. Because of these discrepancies, it is hard to determine how delayed a child with hearing loss may be with ToM abilities when they reach elementary school or what factors may influence better ToM development.

While the influence of parent input and interaction is important in typically developing children, it may be magnified in the DHH population and ToM understanding. Most children with hearing loss are born to hearing families. These families may have no previous experience with hearing loss or sign language. This unique circumstance allows for a comparison of many different factors: deaf children of deaf parents (typically using sign language), deaf children of hearing parents utilizing sign language, and deaf children of hearing parents utilizing spoken language. Peterson and Siegal (1995) were some of the first researchers to report a discrepancy in ToM skills based on parent hearing status.

Courtin (2000) explored this relationship with a fairly large group of DHH children (n = 155) ranging in ages from 5 to 8 years old who were either deaf children of deaf parents (DoD) and used signed language (French Sign Language), deaf children of hearing parents (DoH) using spoken language, and DoH using sign language. This large group of DHH children were compared to a smaller (n = 39) hearing peers matched for gender and socio-economic status of the DoD group. Based on passing two out of three false belief tasks, children who were DoD performed similarly or better than hearing children of hearing parents (H/H children). Focusing on the 5 to 6 year old DoD participants (mean age of 5;6), this group scored significantly better ($\chi^2 = 6.68$, $p < .01$, $F_{1,42} = 7.5$, $p = .01$) than age matched hearing peers (mean age of 5;7). Courtin also posited a positive influence of sign language on ToM based on the linguistic features in sign language that highlight perspective taking. This was seen in significantly greater performance on the sign language DoH group compared to the oral DoH group. The researcher posited that the early exposure of quality language was also a possible influence on more successful ToM. They came to this hypothesis by comparing the DoD group to the signing DoH group ($\chi^2_1$= 18.78, p<0.001, $F_{(1, 89)}$ =25.81, p<0.001) and the H/H group to the oral DoH group ($\chi^2_1$= 32.05, p<0.001, $F_{(1, 80)}$ = 55.80, p<0.001).

Another aspect of language development that has been targeted in these studies is the influence of hearing parents signing abilities. Moeller and Schick (2006) investigated specifically hearing mother's use of mental verbs in interactions with their deaf or hard of hearing child. This study compared a group of 22 hearing mothers with deaf children (H/D dyads) to 26 hearing mothers of hearing children (H/H dyads). The ages ranged from four to almost 10 years old for the DHH children and four to almost 6 years for the hearing children. Mother and child were videotaped for one hour in various situations that may elicit mental verbs such as, *think*, *remember, know, believe* etc. The mothers were also given a sign vocabulary test to assess how many of the mental states they knew in sign language. Both of these tasks were done without informing the mother that the researchers were specifically investigating the mother's use of mental state verbs. The child's language was also assessed using spontaneous utterances obtained through a story telling task and the mother-child interaction. The researchers used the Index of Productive Syntax (IPSyn; Scarborough, 1990) in order to evaluate the child's grammatical complexity. These abilities were compared to the child's ability to pass verbal and nonverbal false belief tasks. For the children who scored a 75% or better on the false belief tasks compared to their hearing counterparts, there was not difference in the variety or amount of mental states that the mother used during the interaction. However, DHH children who scored poorer than 75% on the false belief tasks had mothers that used fewer instances (t (41) =6.24, p=0.001) and diversity of mental state terms (t (41) =5.07, p=0.001) compared to the H/H dyads. Although causality cannot be claimed with these results, the ability and importance of using mental state verbs can still be seen.

**ToM and Language of DHH**

As mentioned previously the connection between ToM and language is not only intuitive, but also a common topic for studies. This is no different for the DHH population. The influence of language on ToM in DHH populations have not been definitive. Exploring both communication modality and language performance Jackson (2001) examined the language ability of multiple small groups of DHH children with differing school placements and modality modes. Although this study tried to look at the function of communication modality, almost none of their participants were deaf children from deaf families (n=4 out of 50) so most children that were labeled as "native" signers were not truly native. This study did not find the same sign language advantage (British sign language) as Courtin (2000) found, but again did not have a similar DoD population to compare the other groups. Jackson (2001) did find correlations between receptive language abilities and passing ToM tasks especially in groups where there was a delay in language abilities. Age was a more significant predictor for ToM skills in children who had typical language development, regardless of communication modality or hearing status.

There have been studies that often contradict each other on this matter as well. Lundy (2002) found that there was not a significant relationship to language ability, as assessed by a teacher-completed non-standardized rating scale, and a child's ability to pass multiple false belief tasks. Rather age of the child was a more important factor in predicting ToM outcomes for the DHH population. However, the rating scale might have lacked sensitivity. In contrast, Tomasuolo, Valeri, Di Renzo, Pasqualetti, and Volterra (2012) found that narrative language skills significantly predicted if a signing child passed false belief tasks. These two studies differed in not only language but also type of language assessment used. Lundy (2002) used a teacher questionnaire to determine expressive language abilities while Tomasuolo et al (2012) used two adapted standardized vocabulary measures and an informal narrative language measure revised by Bello, Capirci, and Volterra (2004). In Lundy's study, language was correlated with ToM development, but this was negated when controlling for age. When age was entered into the analysis, it accounted for 40% of the variability. For the Italian study, expressive and receptive language measures significantly correlated to ToM results for their hearing participants, but only narrative skills predicted ToM for the DHH population, but it was unclear if age was controlled when making these predictions.

The largest study to explore language influence on ToM in a DHH population was Schick et al. (2007). This study considered language ability not only as predictive, but possibly, that a certain complexity of language is needed in order to complete false-belief tasks due to the nature of the tasks requiring embedded clauses, if/then statements, and mental state verbs. This study used 176 DHH students (the largest single published DHH population to date) ranging in age from four to seven years and divided into communication and parental hearing groups. All of the students who used spoken communication only, happened to be from hearing families (DoH, n=86) while the group that attended ASL only school programs (n=90) were split between those who had deaf parents (n=49) and those who had hearing parents (n=41). These groups were also compared to 42 hearing control students, ranging from four to six year-old. To decrease the verbal load needed for most false-belief tasks, two of the seven false-belief tasks were considered "low verbal" tasks. Tests for language were conducted depending on communication preference with the Oral DoH children receiving standard versions of the PPVT-R (Dunn &

Dunn, 1981) , EOWPVT (Gardner, 1990), Sentence Structure subtest of the CELF-preschool (Wiig, Secord, & Semel, 2004), and comprehension of false complement clauses (used in research by de Villiers & Pyers, 2002). For children using ASL, both DoD and DoH, equivalent tests in ASL were given similar to standardized tests (but unstandardized). The hearing control group and the DoD group performed similarly on the ToM tasks and scored significantly better than the Oral or ASL DoH groups. This was also true of the low verbal ToM tasks with the exception of the 7-year-old ASL-DoH group looked more similar to the ASL-DoD group. Finally, language measures that significantly predicted false-belief abilities, regardless of communication modality and controlling for age and non-verbal IQ, were receptive vocabulary scores and complement processing, while general syntax did not significantly explain variance.

**ToM and Auditory Access**

The population of children with hearing loss is diverse in many different ways, especially within the realm of hearing loss itself. Audiological abilities, amplification, and age at identification of amplification are all variables often considered when studying DHH children and their language development. These factors often vary and for children developing spoken language, degree of hearing loss often predicts language abilities. While there are many factors that influence language development, studies have shown that milder hearing loss tend to coincide with mild or no language delay while severe-profound hearing loss in DHH children with hearing parents is correlated with more severe language delays (Ching et al 2010; Tomblin et al 2015)

In more recent years, comparisons of children with cochlear implants and hearing aids are very important both in describing the outcomes of cochlear implants, possible benefits, and population variability. Key factors, such as age of identification and implantation are factors that predict the trajectory of language development. Only a handful of studies have explored the accessibility of sound as well as language in the environment on a child's ToM development. Three studies have explored groups that differ by auditory access.

The oldest study, Peterson (2004) had a group of 26 children with severe to profound hearing loss, half with cochlear implants and half with hearing aids. Within these two smaller groups of 13, the children were further split into students that were mainstreamed, oral only, and those in total communication (TC) programs. The children ranged in age from 4 years to 11 year old with receptive language approximately six or seven years old. Only the ToM skill of false belief was tested in this study. There were no differences found between language abilities or ToM skills of these groups. As the researcher notes, this could be due to the relatively late implantation of CI group of greater than two years to five years old and small sample size. Peterson commented on the variability within this small sample, children who were able to complete all of the false belief tasks while others failing all of them. In addition, this study was published close to 15 years ago, so an update in technology along with younger ages of implantation would be an interesting comparison.

The second and the only other study to explicitly look at children using cochlear implants was Remmel and Peters (2009). In this study, 30 DHH children with CIs were given a complete battery of ToM tasks. This study looked at children only using spoken English from northwest United States and divided them into younger and older groups. The age range at testing for the younger group was 3; 0 to 7; 8 and the age range for the older group was eight years to twelve years-old at testing. These two groups were compared with 30 preschool hearing children in a similar analysis as Wellman and Liu (2004) and Peterson et al. (2005) for five ToM tasks. Comparing passing rates of the CI group as a whole compared to the control group of typically hearing preschoolers, there was no significant difference in the passing rate on the false belief task. All passing rates were similar except for the Real-Apparent emotion task, which the CI group scored significantly better than the typical hearing group (69% compared to 33%). This is also one of the only studies that considers hearing acuity through a speech recognition task, using scores from the Phonetically Balanced Kindergarten Test (PBK, Haskins 1949). Although PBK scores were correlated with other tests given in this study, the hearing acuity did not significantly correlate with ToM scores. The average accuracy for the PBK was 0.79 with only 0.19 SD meaning that the lack of variability and high score in this small sample may not be enough to show any differences. ToM scores were also significantly positively correlated with years of amplification (0.72, $p < 0.01$) and years since implantation (0.68, $p < 0.01$). This is the only study to investigate impact of length of amplification on ToM skills. Although Remmel and Peters found that children with CI did not significantly differ from their hearing peers there are still some confounds that may need to be considered. The majority of the children (26 out of 30) were white and from well-educated families, which does not represent the general population as a whole. In addition, the age range of the CI group was very broad compared to the typically hearing counterparts only being preschool age. Furthermore, the communication modality was limited to only children using spoken language with cochlear implants.

Finally, the most recent study to investigate hearing abilities as a major predictor for ToM development was done in the Netherlands with 44 DHH with moderate hearing loss (MHL, Netten et al, 2017). This study used ToM tasks based on intention understanding (following joint attention, completing an action based on failed attempts, and responding to point gestures), desire understanding (similar verses dissimilar desires pertaining to snack food i.e. does a character want to eat tomatoes compared to ice cream based on a stated preference) and false belief in their analysis. All 44 participants, ages 3 – 5 years old had unaided hearing thresholds ranging from 35 – 70 dB HL, and all children used amplification. These children were compared to 101 typically hearing children with similar age ranges. Using logistic regression, the analysis showed the odds of completing the false-belief task was lower for children with MHL (odds ratio 0.41, $p=0.002$) although this odds of completion increased with age. As a whole through all of the ToM tasks, the MHL group passed the tasks less frequently resulting in 54% of the typically developing children passing all of the tasks while only 25% of the MHL doing the same ($\chi^2(4)=25.632$; $p<0.001$)

The DHH population, as a group, shows delayed development of ToM. There appears to be an influence of language on ToM development but it is uncertain the nature of this relationship. Most studies pertaining to the development of ToM in the DHH population have focused on small groups while few studies have had participants younger than five years old. The DHH group has many other unique variables related to hearing loss such as the family's ability to communicate with their DHH child from birth and access to amplification for spoken language. These factors may impact ToM directly or indirectly, but we are uncertain from the research that has already been completed.

**Present Study**

This study aims to investigate the influence of language abilities, auditory access, and parent hearing status on the ability for a DHH child to pass a variety of ToM tasks. A larger sample of children that is able to represent the diversity within the deaf population not only ethnically and regionally, but also auditory access, communication modality, and parental hearing status would provide much-needed data, especially given the lack of research regarding amplification and hearing aids, as well as general auditory access to oral language. This study aims to expand the current knowledge of ToM development in DHH children in multiple ways. This study pulls from a large geographically and ethnically diverse group of DHH children. The population for this study is representative of the general population. Our measurements for ToM target more than just false belief, including social pretend and knowledge access with a group of students that should have these tasks mastered based on established ToM development of hearing peers (Wellman & Liu, 2004). We will be able to explore a variety of relationships to ToM including growth over a school year, communication modality including access to auditory input, parental hearing status, and language abilities. Given this plethora of data, we want to ask the questions:

1. Do these three tasks measure the construct ToM and do ToM abilities change over one school year in DHH children 5 – 7 years old?
2. Do language skills, controlling for age and cognition, predict ToM in this population?
3. Does communication modality and parent hearing status help to predict ToM development?
4. How does the relationship of language, age, cognition, communication modality, and parental hearing status predict ToM development?

# Chapter II

## Methods

### Participants

Data for this study were obtained through the Center on Literacy and Deafness (CLAD) Study 1. The information on participants, procedures, and measurements follow this larger study.

Three hundred and fifty-one DHH children (164 boys, 46.7%) participated in the study (see demographics in Table 1). Children were enrolled in 40 schools located in nine states in U.S. and one Canadian province. For race and ethnicity, 41% of the participants were White, 30% identified, as Hispanic or Latino, and 17.7% were African American. The remaining 11.3 % were made up of Native American (1.1%), Asian (6.6%), and Mixed Race (3.4%). Criteria to participate was (a) enrollment in kindergarten through second grade, (b) hearing loss (better ear-pure tone average or BE-PTA) greater than 25 dB, and (c) and no severe disabilities (e.g., autism or cognitive impairment). DHH children were identified as having severe disabilities (and excluded from this study) either by teacher report or by a score of more than two standard deviations below the mean on a nonverbal IQ test (see below). The mean chronological age (M age) was 80.3 months (SD = 12.1 months); there were 145 kindergarteners (M age = 69.5; SD age = 5.5), 112 first graders (M age = 81.8; SD age = 6.4), and 94 second graders (M age = 95.2; SD age = 6.9).

One hundred and twenty-three (35%) children had cochlear implants. Among the 228 DHH children who did not have a CI, 7.5% had mild hearing loss (BE-PTA between 20 and 40 dB), 18.9% had moderate hearing loss (between 41 and 55 dB), 17.1% had moderately severe hearing loss (between 56 and 70 dB), 14.9% had severe hearing loss (between 71 and 90 dB), and 30.3% had profound hearing loss (91 dB or greater). Audiological information was missing for 26 children. Approximately 56% of children were identified with hearing loss before six months of age, 14% between six and 23 months, and 12% between age of 24 and 35 months. Causes of hearing loss were reported as genetic (30%), connexin (3.0%), CMV (2.1%), Meningitis (1.2%), other (15.3%) and unknown (48.3%). The cause of hearing loss was missing from 5.1% of the total population.

Table 1
Participant Demographics

| Variable | Male | Female |
|---|---|---|
| Gender | 46.7% | 53.3% |

| | White | Latino | African American | Asian | Mixed Race | Native American |
|---|---|---|---|---|---|---|
| Race | 41% | 30% | 17.7% | 6.6% | 3.4% | 1.1% |

| | Total (n=351) | Kindergarten (n=145) | First Grade (n=112) | Second Grade (n=94) |
|---|---|---|---|---|
| Mean Age Yrs;mo (SD= mo.) | 6;8.3 (12.1) | 5;9.5 (5.5) | 6;9.8 (6.4) | 7;11.2 (6.9) |

| | 1>CI | Profound | Severe | Mod-Severe | Mod | Mild |
|---|---|---|---|---|---|---|
| Amp/HL | 35% | 30.3% | 14.9% | 17.1% | 18.9% | 7.5% |

| | < 6 months | 6 mo-23 mo. | 24-35 mo. | ≥ 36 mo. |
|---|---|---|---|---|
| Age ID | 56% | 14% | 12% | 18% |

| | Genetic | Connexin | CMV | Meningitis | Other | Unknown |
|---|---|---|---|---|---|---|
| Causes | 30% | 3.0% | 2.1% | 1.2% | 15.3% | 48.3% |

Notes: yrs;mo = years ; months, SD = mo.= standard deviation given in months

Children were divided into three language groups based on their access to spoken language and availability of sign language. We determined that a child had at least some auditory access to spoken language if he or she was able to identify the referent of single words and/or multi-syllable spoken words presented through audition alone on the Early Speech Perception (ESP).

Specifically, a child had to score either three (some word identification) or four (consistent word identification) on the ESP to be judged as having auditory access to spoken language (see Speech Perception under Measurements). Children were determined as have access to sign language if their teachers used sign, with or without spoken language, to communicate with them. The classification system divided children into three language groups:

(1) Sign group. Children who had teachers who signed and who did not have auditory access to speech (n = 136, 46.3% had at least one parent with hearing loss),

(2) Spoken language group. Children with auditory access to speech enrolled in listening and spoken language classrooms (n = 106, 6.6% had at least one parent with hearing loss), and

(3) Bimodal group. Children who had teachers who signed and who had auditory access to speech (n = 109, 24.8% had at least one parent with hearing loss).

Initial analyses of group comparisons on demographic backgrounds across modality groups showed that the groups did not differ in terms of grade, gender, or ethnicity. There were some differences (see Table 2). The groups differed in age of diagnosis of hearing loss ($\chi^2$ (6) = 12.8 p = .046). The spoken language group had significantly fewer students identified at 6 months or younger than the other language groups. The groups also differed in whether they have at least one DHH parent ($\chi^2$ (2) = 52.61, p < .0001); the sign group was likely to have DHH parent while the vast majority of spoken-language group had hearing parents. Children in the spoken-language group were more likely to have a cochlear implant than the other groups ($\chi^2$ (2) = 30.73, p < .0001).

Table 2
Demographics by Communication Groups

| Variable | Sign only | Spoken only | Bimodal |
|---|---|---|---|
| Number of children | 136 | 106 | 109 |
| Percent with one DHH parent | **46.3%*** | 6.6% | 24.8% |
| Age Id | | | |
| <6 month | 57.9% | **43.7%*** | 66% |
| 6 -24 months | 15.7% | 25.2% | 16.5% |
| 25- 35 months | 17.4% | 21.3% | 13.6% |
| $\geq$ 36 months | 9% | 9% | 3.8% |
| Amplification | | | |
| CI | 21% | **55%*** | 35% |

Notes: *DHH Parent sign vs two groups= $\chi^2$ (2) = 52.61, p < .0001, Age Id less than 6 months spoken vs two groups = $\chi^2$ (6) = 12.8 p = 0.046; CI (Cochlear Implant) spoken group vs two groups= $\chi^2$ (2) = 30.73, p < .0001

**Procedures**

We recruited schools primarily from the home or neighboring states of the research team. We targeted schools that had a concentration of DHH children. Students were assessed in the fall and early spring of the academic year on a battery of language and literacy tests appropriate to their language knowledge. Examiners administered the tests individually in a quiet, familiar room in the school building. All examiners were either certified teachers of DHH children or speech-language-pathologists and had extensive experiences in the language of the child they assessed. The assessors were extensively trained in standard administration procedures and the modifications based on children's language knowledge (e.g., acceptable sign in vocabulary assessments). Examiners who administered the tests to signing children were provided videos of a deaf examiner signing the stimuli. All examiners had to administer the tests to an expert before they could test children.

## Measures

**Speech perception.** We used the *ESP* (Moog & Geers, 1990) to identify children who had functional hearing. Children were required to select correct referents of spoken words from closed sets of pictures or objects. The performance on the ESP was classified into four speech perception categories: 1 = no pattern perception (e.g., not able to distinguish between one and two syllable spoken words; $n$ = 135; 38.5%), 2 = pattern perception ($n$ = 2; 0.6%), 3 = some word identification ($n$ = 8; 2.3%), and 4 = consistent word identification ($n$ = 205; 58.4%).

**Nonverbal IQ.** We used the Differential Ability Scales-II (DAS-II; Elliott, 2007), subtest Matrices to assess Nonverbal IQ. All children were assessed using their preferred communication mode. Children were shown an incomplete matrix and asked to select the image, from a closed set of four or six that would correctly complete the matrix. A basal of at least three correct answers in a set needed to be established. Ceiling was reached by either having more than three wrong answers in a set or alternatively for Set A, five consecutive item failures, or for Set B, six consecutive item failures.

**Language measures.** We used the *Expressive One-Word Picture Vocabulary Test-4* (EOWPVT; Martin & Brownell, 2011) to measure children's expressive vocabulary ability. EOWPVT required a child to name (using either speech or sign or both, depending on child's preferred modality) a picture of increasingly unfamiliar items. We used this test because it was easily adaptable for children's preferred modality. Assessors used standard basal and ceiling rules; however, the assessors used a list of acceptable signs to score children's sign responses. A panel of deaf and hearing native signers created the list of acceptable signs through consensus (list available upon request). All items were scored as either correct or incorrect. We used the Elaborated Phrases and Sentences subtest of the *Test of Auditory Comprehension of Language-3*

(TACL; Carrow-Woolfolk, 1999) to assess children's abilities in receptive English grammar and word order at the sentence level. Assessors administered items in spoken English, voice-off English-like signing, or simultaneous communication (SimCom), depending on child's language grouping. Assessors signed the sentences in English word order but did not sign English morphemes (e.g., -ed, -s). We used the *ASL Receptive Skills Test-Revised* (Schick 2013) to measure DHH children's ability to understand ASL syntax and classifiers at the sentence level. This test was given to the sign only and bimodal group. Children watched a video of a model signing ASL sentences and selected a picture from a closed set of three, four, or six pictures.

**Theory of mind measures.** Three ToM tasks were given to each child. Administrators where trained through video modeling and were instructed to follow a script, but there were portions of the script that allowed for improvisation in order to keep children engaged in the activities. These tasks were performed in each child's preferred communication modality, sign only, spoken only, or bimodal. The ToM tasks consisted of skills related to social pretend, knowledge access, and false belief. All tests used a doll named "Mary", had similar scenarios, and control & target questions. For social pretend, children were asked to pretend to paint a plastic cup a different color from the original color of the cup. This task required two responses from the child: What color did we paint the cup? And what color the doll "Mary" would think the cup is? The knowledge access task had a nondescript box that was holding a dog. After the child was shown the concepts, the box was closed. The children were asked two control questions: what was in the box and did Mary open the box? The children were then asked the target question of: Does Mary know what is in the box? The final task was a content false belief task using a crayon box that was holding a toy car. The children were asked two control questions again: What is actually in the box? And Did Mary open the box? The targeted question was what would Mary think is in the box? The tasks were given in the order of social pretend, then knowledge access, then false-belief since this is the order believed to be the easiest to hardest for DHH population (Peterson & Wellman, 2009). Children were scored as passing a task if they answered all of the questions associated with the task correctly. If the children missed any of the questions, control or target, they were given a score of zero. For each ToM task a child could either earn a total of 1 (pass) or 0 (did not pass).

**Statistical Analysis**

These data were analyzed using first confirmatory factor analysis (CFA) and then structural equation modeling (SEM). Both CFA and SEM were fit through R software (R core team, 2013) using the *lavaan* package (Rosseel, 2012). Maximum likelihood estimation was used to handle missing data, thus assuming that data was missing at random and results were estimated without eliminating data. The construct of ToM is indicated through the three ToM items: false belief, knowledge access, and social pretend, in two time-periods, fall and spring testing. Confirmatory factor analysis is a method of factor analysis that takes unobserved or latent variables and attempts to replicate findings with observed outcomes. Confirmatory factor analysis will be used to test the theory that 1) confirm that these three tests are measuring a single construct, and 2) are consistent or invariant in measuring this construct across the two time periods. This will answer research question one. Once the CFA model is established, it will work as the measurement model for SEM. A structural model can then be added to determine the unique effects of language, age, cognition, communication modality, and parent hearing status on a student's ability to pass ToM tasks at each time-period.

SEM is considered to be a combination of CFA and multiple regression (Ullman, 2001). An SEM model will be constructed first to consider the effects of language, age, and cognition in order to answer question two. Then a model will be constructed to estimate the effects of communication mode and parental hearing status to answer question three. Finally a full model incorporating language, age, cognition, communication mode, and parental hearing status will be used to determine any direct and/or indirect effects these variables have on a child's ability to pass the ToM tasks across the school year.

# Chapter III

## Results

### Descriptive Statistics

**Independent variables.** The language and cognitive test results given in the fall are shown in Table 3. The raw scores and percentile ranks, for clinical reference, are both shown. The raw scores were used in any statistical analysis. This table shows that on average the entire group had language and cognitive skills that fell within the normal range (percentile ranks between 16$^{th}$ and 85$^{th}$ percentile).

Table 3
Descriptive Statistics of Language and Cognition Tests

| Tests | N | Mean Raw Scores | SD | Mean Percentile Rank | SD |
|---|---|---|---|---|---|
| Fall DAS | 345 | 8.6 | 4.1 | 37.1 | 26.9 |
| Fall EOWPVT | 315 | 54.6 | 19.2 | 19.3 | 21.6 |
| Fall TACL | 344 | 16.1 | 8.7 | 17.6 | 18.2 |
| Fall ASL R | 239 | 19.6 | 5.9 | 60.5* | 19.6 |

Notes:
DAS= Differential Ability Scales-II; EOWPVT= Expressive One-Word Picture Vocabulary Test-4; TACL= Test of Auditory Comprehension of Langauge-3; ASL-R= ASL Receptive Skills-Revised; *= ASL-R is percentage correct.

Table 4 shows that there was a high correlation between all of the language tests, EOWPVT, TACL, and ASL-R with a Pearson's r of 0.70 and 0.62 ($p<0.001$). Because of this high significant correlation and that, the ASL-R was only used in two of the three communication groups, only the language test of EOWPVT and TACL are used in creating the latent variable of Language in later models.

Table 4
Correlations of Standardized Tests

| Tests | Fall DAS | Fall EOWPVT | Fall TACL | Fall ASL-R |
|---|---|---|---|---|
| Fall DAS | 1<br>(n = 345) | | | |
| Fall EOWPVT | **0.32****<br>**(n = 309)** | 1<br>(n = 315) | | |
| Fall TACL | **0.31****<br>**(n = 339)** | **0.70****<br>**(n = 309)** | 1<br>(n = 344) | |
| Fall ASL-R | **0.43****<br>**(n = 234)** | **0.70****<br>**(n = 210)** | **0.62****<br>**(n=237)** | 1<br>(n = 239) |

Notes: DAS= Differential Ability Scales-II; EOWPVT= Expressive One-Word Picture Vocabulary Test-4; TACL= Test of Auditory Comprehension of Langauge-3; ASL-R= ASL Receptive Skills-Revised
**. Correlation is significant at the 0.01 level (2-tailed).

Table 5 shows the correlations of all independent variables. In structural equation modeling, these variables are considered exogenous variables. Any correlations that were of high significance ($p \leq 0.001$) were used to construct the structural model discussed below. These relationships specifically were relationships between: communication mode and parental hearing status ($t = -0.23$, $p =0.000$), communication mode and language ($t = 0.19$), parental hearing status and language ($t = 0.21$, $p < 0.001$ & $t = 0.18$, $p = 0.001$), and the three-way relationship of age (age & cognition: $t = 0.30$, $p = 0.001$; age & language: $t = 0.32$ & $0.28$, $p < 0.001$), cognition, and language (cognition & language: $t= 0.32$ & $0.31$, $p < 0.001$).

Table 5
Correlations of Exogenous Variables

| Variables | ComMode | DHHPar | FAgeMo | FDASRW | FEOPVTRW | FTACEPRW |
|---|---|---|---|---|---|---|
| ComMode | 1 (n= 351) | | | | | |
| DHHPar | **-.23**** **(n = 341)** | 1 (n = 341) | | | | |
| FAgeMo | -.11* (n = 351) | -.11* (n=341) | 1 (n = 351) | | | |
| FDASRW | .038 (n = 345) | -.041 (n = 335) | **.30**** **(n = 345)** | 1 (n = 345) | | |
| FEOPVTRW | .005 (n = 315) | **.21**** **(n = 306)** | **.32**** **(n = 315)** | **.32**** **(n = 309)** | 1 (n = 315) | |
| FTACEPRW | **.19**** **(n = 344)** | **.18**** **(n = 335)** | **.28**** **(n = 344)** | **.31**** **(n = 339)** | **.70**** **(n = 309)** | 1 (n = 344) |

Notes: ComMode= communication modality, either sign only, spoken only, or bimodal; DHHPar= at least one parent with a hearing loss, FAgeMo= The age of the children at testing in the fall, in months; FDASRW= Differential Ability Scales-II fall testing raw scores; FEOPVTRW= Expressive One-Word Picture Vocabulary Test-4 fall testing raw scores; FTACEPRW= Test of Auditory Comprehension of Langauge-3, fall testing raw scores
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 6 shows the descriptive statistics of cognition and language scores by communication mode. Again, percentile ranks are also shown for clinical reference. The only group difference was detected for the TACL scores. The Sign only group had significantly lower TACL scores compared to either Spoken Only ($t = -2.53$, $p = 0.01$, Cohen’s $d = 0.33$) or the Bimodal groups ($t = -3.41$, $p = 0.001$, Cohen’s $d = 0.44$), while the spoken only and bimodal groups did not significantly differ from each other.

Table 6
Language & Cognition Scores Based on Communication Mode

| | DAS | | | EOWPVT | | | TACL | | |
|---|---|---|---|---|---|---|---|---|---|
| | Raw Score | | Percentile | Raw Score | | Percentile | Raw Score | | Percentile |
| Modes | N | M (SD) | M (SD) | N | M (SD) | M (SD) | N | M (SD) | M (SD) |
| Spoken only | 106 | 8.7 (4.5) | 38.1 (27.4) | 100 | 55.2 (17.7) | 18.8 (20.4) | 104 | 16.9 (8.5) | 18.2 (18.8) |
| Sign Only | 133 | 8.4 (3.5) | 35.0 (25.6) | 113 | 54.2 (22) | 19.8 (23.8) | 133 | **14.1*** **(**8.5) | 13.0 (14.7) |
| BiModal | 106 | 8.8 (4.4) | 38.8 (28.1) | 102 | 54.4 (17.3) | 19.4 (20.6) | 107 | 17.9 (8.7) | 21.6 (19.9) |

Notes: DAS= Differential Ability Scales-II; EOWPVT= Expressive One-Word Picture Vocabulary Test-4; TACL= Test of Auditory Comprehension of Langauge-3
*= F(341,2)= 6.51, p=0.002; Sign Only vs Spoken Only: t=-2.5, p=0.01, Cohen's d= 0.33; Sign Only vs Bimodal: t= -3.41, p= 0.001, Cohen's d= 0.44

Table 7 shows the descriptive statistics of language and cognition scores based on parent hearing status. Between the two groups, the children with at least one DHH parent tended to have higher scores. The cognition scores of these two groups did not significantly differ but both language scores (EOWPVT and TACL) were significantly higher for the children with at least one DHH parent compared to the children that had hearing parents. The mean raw score for the EOWPVT was 61.2 (SD = 20.95, $F_{(1,304)} = 13.65$, $p < 0.001$, Cohen's d = 0.44) and the mean raw score for the TACL was 18.67 (SD = 8.7, $F_{(1, 333)} = 10.85$, $p = 0.001$, Cohen's d = 0.396). This corresponds to other studies that have found similar benefits of having at least one parent with hearing loss (Courtin, 2000; Schick et al., 2007).

Table 7
Language & Cognition Scores Based on Parent Hearing Status

| | DAS | | | EOWPVT | | | TACL | | |
|---|---|---|---|---|---|---|---|---|---|
| | Raw Score | | Percentile | Raw Score | | Percentile | Raw Score | | Percentile |
| Modes | N | M (SD) | M (SD) | N | M (SD) | M (SD) | N | M ( SD) | M (SD) |
| No DHH | 241 | 8.7 (4.3) | 36 (27.4) | 222 | 52.2 (18.1) | 16.3 (19.2) | 239 | 15.2 (8.6) | 16.4 (18) |
| DHH | 94 | 8.4 (3.3) | 40.3 (25.1) | 84 | **61.2*** **(**21) | 27.8 (25.1) | 96 | **18.7*** **(**8.7) | 20.7 (19) |

Notes: DAS= Differential Ability Scales-II; EOWPVT= Expressive One-Word Picture Vocabulary Test-4; TACL= Test of Auditory Comprehension of Langauge-3; ASL-R= ASL Receptive Skills-Revised
*= EOWPVT: $F_{(1, 304)}$= 13.65, p<0.001, Cohen's d= 0.44
TACL: $F_{(1, 333)}$= 10.85, p= 0.001, Cohen's d= 0.396

**Dependent variables.** Table 8 shows the passing rate of the ToM tasks in the fall and spring for the entire group. The ToM tasks have been ordered from hardest to easiest based on these percentages, so that false belief appears to be the hardest task followed by social pretend and then knowledge access. Between fall and spring, the percentage of students that passed the test increased for each test. A paired sample t-test reveals that the growth from fall to spring for false belief (p < 0.001) and knowledge access (p < 0.001) were significant. The growth for social pretend was not found to be statistically significant.

Table 8
ToM Percentage Passing Rates

| ToM Task | Fall | Spring |
|---|---|---|
| False Belief | 14.0% (n = 340) | **25.4%***** (n = 313) |
| Social Pretend | 17.4% (n = 343) | 19.1% (n = 313) |
| Knowledge Access | 34.8% (n = 341) | **45.0%***** (n = 313) |

Notes:
***= False Belief: t (306) = -5.78, p < 0.001; Knowledge Access: t(340)= 5.78, p < 0.001

Table 9 shows the outcome of ToM passing for both fall and spring based on a child's communication mode. The mean can be viewed as the percentage of children that passed the test since each test is considered a dichotomous variable. Only Knowledge Access showed a significantly different passing rate between the groups. An independent t-test showed that the sign only group had fewer students that passed knowledge access in the fall, 24% compared to 42% in the Spoken only group ($t= -2.9$, $p = 0.004$) and 43% in the Bimodal group ($t = -3.09$, $p = 0.002$). Similarly, in the spring 37% passed compared to 60% of the spoken only group ($t = -3.37$, $p = 0.001$) and 58% of the Bimodal group ($t = -3.14$, $p=0.002$). The spoken only and bimodal groups did not significantly differ on any test or at any time point. All three groups followed the same general pattern of knowledge access being the easiest task followed by social pretend and then false belief being the hardest during fall testing. All groups had fewer percentage of students pass social pretend in the spring compared to false belief (Spoken only had 20% pass social pretend while 32% passed false belief etc.).

Table 9
ToM Passing Rate Based on Communication Mode

| Groups / Time | False Belief | | Social Pretend | | Knowledge Access | |
|---|---|---|---|---|---|---|
| | N | M (SD) | N | M (SD) | N | M (SD) |
| Spoken Only | | | | | | |
| Fall | 104 | 0.15 (0.36) | 104 | 0.17 (0.38) | 104 | 0.42 (0.5) |
| Spring | 90 | 0.32 (0.47) | 90 | 0.2 (0.4) | 90 | 0.6 (0.49) |
| Sign Only | | | | | | |
| Fall | 130 | 0.14 (0.35) | 133 | 0.2 (0.4) | 131 | **0.24*** (0.43) |
| Spring | 119 | 0.27 (0.45) | 119 | 0.19 (0.4) | 119 | **0.37 *** (0.49) |
| Bimodal | | | | | | |
| Fall | 106 | 0.14 (0.35) | 106 | 0.16 (0.37) | 106 | 0.43 (0.5) |
| Spring | 104 | 0.27 (0.45) | 104 | 0.25 (0.44) | 104 | 0.58 (0.5) |

Notes:
*= Fall Knowledge Access: $F(2,338)= 6.14$, $p=0.002$; Sign only vs Spoken Only: $t= -2.90$, $p=0.004$, Sign only vs Bimodal: $t= -3.09$, $p= 0.002$

Spring Knowledge Access: $F(2, 310)= 7.32$, $p= 0.001$, Sign only vs Spoken Only: $t= -3.37$, $p=0.001$, Sign only vs Bimodal: $t= -3.14$, $p= 0.002$

Finally, Table 10 shows the passing rate of the ToM tasks based on parental hearing status. There were no significant differences between passing rates for any task at any time point although a similar switch of the order in tasks in the spring was seen where social pretend had the fewest children passing (21% of children with no DHH parents and 24% of children with at least one DHH parent). Although not significantly statistic, a greater percentage of children with at least one DHH parent passed the tasks at each time point.

Table 10
ToM Passing Rate Based on Parental Hearing Status

| | False Belief | | Social Pretend | | Knowledge Access | |
|---|---|---|---|---|---|---|
| Groups<br>Time | N | M (SD) | N | M (SD) | N | M (SD) |
| No DHH | | | | | | |
| Fall | 237 | 0.12 (0.33) | 236 | 0.17 (0.38) | 238 | 0.34 (0.48) |
| Spring | 219 | 0.25 (0.44) | 219 | 0.21 (0.41) | 219 | 0.5 (0.5) |
| DHH | | | | | | |
| Fall | 95 | 0.2 (0.4) | 97 | 0.2 (0.4) | 97 | 0.41 (0.50) |
| Spring | 84 | 0.33 (0.47) | 84 | 0.24 (0.43) | 84 | 0.51 (0.50) |

Notes: No DHH = No parents with hearing loss; DHH = one or more parents with hearing loss

**CFA Models**

In order to explore the change in ToM skills over time a confirmatory factor analysis (CFA) model was developed. The theory guiding our CFA model is that the three tasks of false belief, knowledge access, and social pretend are indicators of the latent variable of ToM. We expect that false belief will be the most difficult task. We expect that the measurement properties for these tasks will be equivalent over time (i.e., that ToM might change, but the validity of the items does not). In order to test this hypothesis of invariance over time, the process of CFA requires an unconditional model and then restrictions to be sequentially tested (Vandenberg & Lance, 2000). If the sequence of restricted models are not significantly different, then the restricted models can be used in describing the data with a longitudinally consistent (and parsimonious) structure in subsequent structural equation models.

The unconditional model created our latent variables of ToM at time 1 (fall testing) and ToM at time 2 (spring testing); see Figure 1. The fit for this model, its ability to estimate the results that are similar to the observed results, were within or close to be expected for a good model fit (see Table 11). A good model fit will have a Comparative Fit Index (CFI) that is greater than 0.95 and a Root Means Square Error Approximation (RMSEA) of less than 0.05 (Schreiber, Nora, Stage, Barlow, & King, 2006; Hu & Bentler, 1999). The unconditional model showed a CFI of 0.98 and an RMSEA of 0.06. The estimates of this first unconditional model can be found in Table 12 in comparison to the estimates of the final CFA model (discussed below).

The first restricted model fixed the loadings such that measured variables (ToM tasks) adequately predicted the same latent variable at each time point. This is called the Loading Model. The model fit results of the Loading Model can be found in Table 11. This model also showed good fit with a CFI of 0.98 and the RMSEA at 0.05. Finally, a second restricted model where the thresholds or ability needed in order to pass a test was the same across time. This is called the Scalar model. This model also showed good fit with a CFI of 0.98 and RMSE of 0.04 (see Table 11). A chi square test was run to see if these models differed significantly in their ability to estimate the observed results. Seen in Table 11, there was no significant difference in using the unconditional model compared to the other two models. The remaining analysis used the scalar model as the measurement model when creating SEM as this was not significantly different from the unconditional model ($p = 0.4$), but also had the best model fit (CFI = 0.98, RMSEA = 0.04).

Figure 1: Unconditional CFA Model

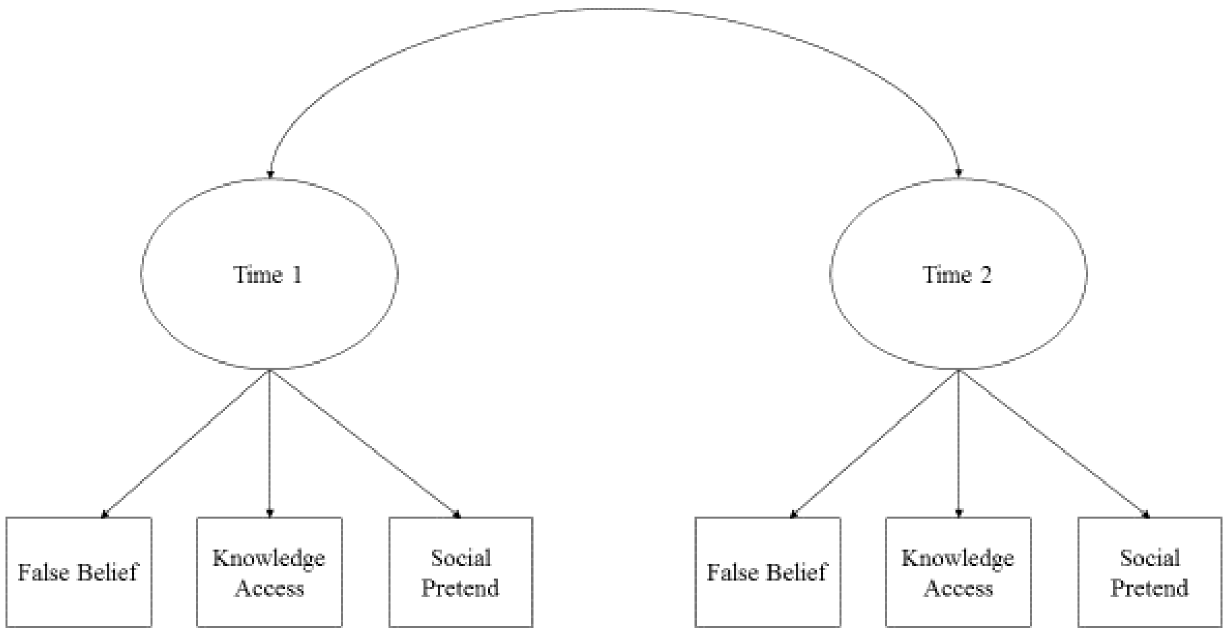


Figure 1: Time 1 is fall testing of false belief, knowledge access, and social pretend and time 2 is the spring testing of the same tasks. Double arched arrow signifies correlation. The circle represents a construct while the squares are the actual measurements. The arrow going from the circle to the square signifies the square measurement is the indicator for the latent variable (construct) in CFA.

Table 11
Model Fit Statistics and Chi Square Tests for CFA models

| Models | $\chi^2$ | Df | CFI | RMSEA | p |
|---|---|---|---|---|---|
| Unconditional Model | 12.24 | 8 | 0.97 | 0.06 | |
| Loading Model | 16.09 | 10 | 0.98 | 0.05 | 0.27 |
| Scalar Model | 16.56 | 12 | 0.98 | 0.04 | 0.40 |

The unstandardized loadings of the scalar model show that false belief (Time 1= 0.75 and Time 2= 0.9) and knowledge access (Time 1= 0.70 and Time 2= 0.83) have excellent relationship to the latent variable ToM at both times (See Figure 2 & Table 12). In the following figures: circles represent latent constructs while rectangles represent observed tests. Straight arrows represent regressions (or the measurement relation between a factor and a test). Two-way arrows show a correlation relationship. The $R^2$ value also shows these two tasks to explain a large portion of the variance seen in the data. Social Pretend does not show a high correlation (0.30 and 0.36) or prediction of invariance ($R^2$= 0.09 and 0.13). The thresholds from the Scalar model show a pattern of easier to more difficult tasks with the knowledge access task being the easiest (the smallest number, 0.38). Followed by social pretend (0.95) and false belief (1.03) being the most difficult task. These thresholds can be found in Table 12. These thresholds also mirror what was found in the descriptive statistics listed previously. Figure 2 shows a visual of the Scalar model including the correlation between time 1 and time 2 (0.92). A latent effect size can be calculated from the mean of Time 2 divided by the square root of the variance of time 1. The latent effect size for the Scalar model is 0.65, over half a deviation difference in abilities from time 1 to time 2.

Figure 2: Scalar CFA Model (fully standardized estimates)

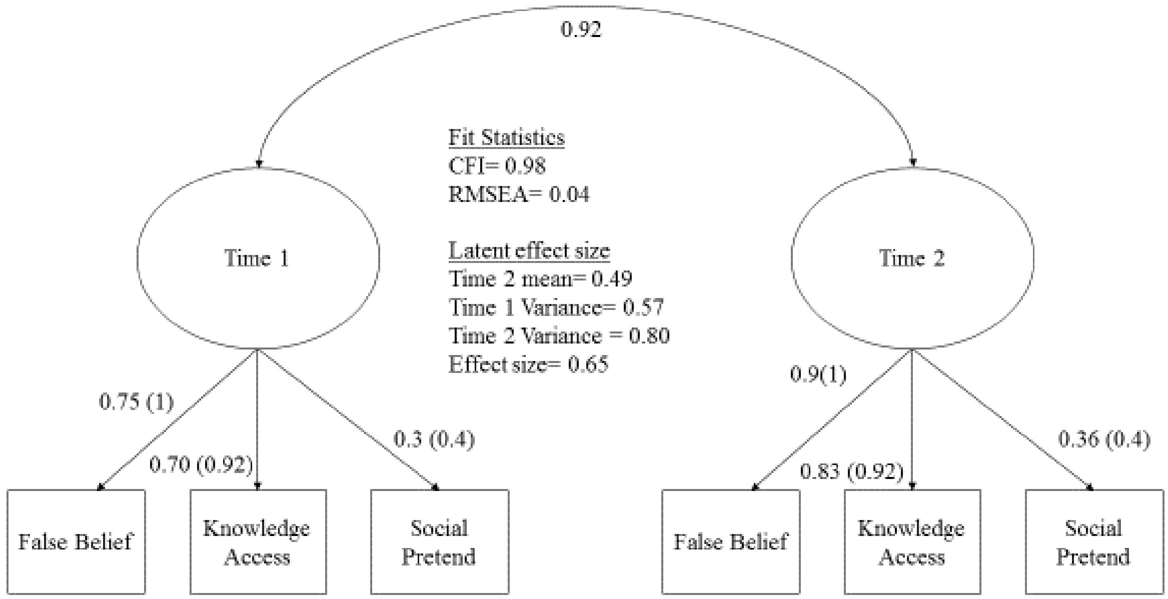


Figure 2: Fall testing of false belief, knowledge access, and social pretend make up the latent variable of time 1 and spring testing of the tasks create time 2. Loading numbers are the unstandardized results from the scalar model. These numbers show very good fit for false belief and knowledge access at both time points. Numbers in parentheses are the standardized values. There is a strong correlation between performances at time 1 compared to time 2.

Table 12
Loadings, Thresholds, and Variance of Unconditional & Scalar Models

| Unconditional Model Estimates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fall (Time 1) | | | | Spring (Time 2) | | | |
| Tasks | Loadings | z-value (p) | Thresholds | $R^2$ | Loadings | z-value (p) | Thresholds | $R^2$ |
| FB | 1.00 | | 1.06 | 0.6 | 1.00 | | 0.57 | 0.77 |
| KA | 0.92 | 7.05 (<0.001) | 0.36 | 0.51 | 0.94 | 9.96 (<0.001) | -0.01 | 0.68 |
| SP | 0.25 | 1.88 (0.06) | 0.92 | 0.04 | 0.49 | 4.63 (<0.001) | 0.79 | 0.18 |
| **Scalar Model Estimates** | | | | | | | | |
| | Fall (Time 1) | | | | Spring (Time 2) | | | |
| Tasks | Loadings | z-value (p) | Thresholds | $R^2$ | Loadings | z-value (p) | Thresholds | $R^2$ |
| FB | 1.00 | | 1.03 | 0.57 | 1.00 | | 1.03 | 0.80 |
| KA | 0.92 | 13.43 (<0.001) | 0.38 | 0.48 | 0.92 | 13.43 (<0.001) | 0.38 | 0.68 |
| SP | 0.4 | 4.976 (<0.001) | 0.95 | 0.09 | 0.4 | 4.98 (<0.001) | 0.95 | 0.13 |

Notes: FB = False belief, KA = Knowledge Access SP= Social Pretend

**Structural Equation Modeling**

Structural equation models were used to investigate the relationships of ToM abilities and possible influences such as language, age, cognition, modality choices, and parental hearing status. ToM abilities were defined by the results established in the scalar model. All of the prediction relationships discussed are an extension of the CFA scalar model.

As established in the descriptive statistics, the three language tests EOWPVT, TACL, and ASL-R were all significantly and strongly correlated to one another. Since all children were given the EOWPVT and the TACL regardless of modality, these two tests were used to construct a latent variable of Language (hence in Figure 3, the arrows point from Language to the measurements of EOWPVT and TACL). Age and cognitive scores predicted the construct of Language and in turn, age and cognitive scores co-vary. In Figure 3 age and cognition have arrows pointing to Language to show they are predicting Language, not constructing the variable. By establishing these relationships and then allowing language, age, and cognition to predict the ToM abilities at time 1 and time 2 we create a model in which the direct and indirect effects of these three variables can be seen on ToM.  See Figure 3 for the SEM model of language, age, and cognition.  Table 13 shows the results of Language predicting ToM abilities at time 1 and time 2 when controlling for age and cognition, also known as SEM Model 1.

Figure 3 SEM Model 1

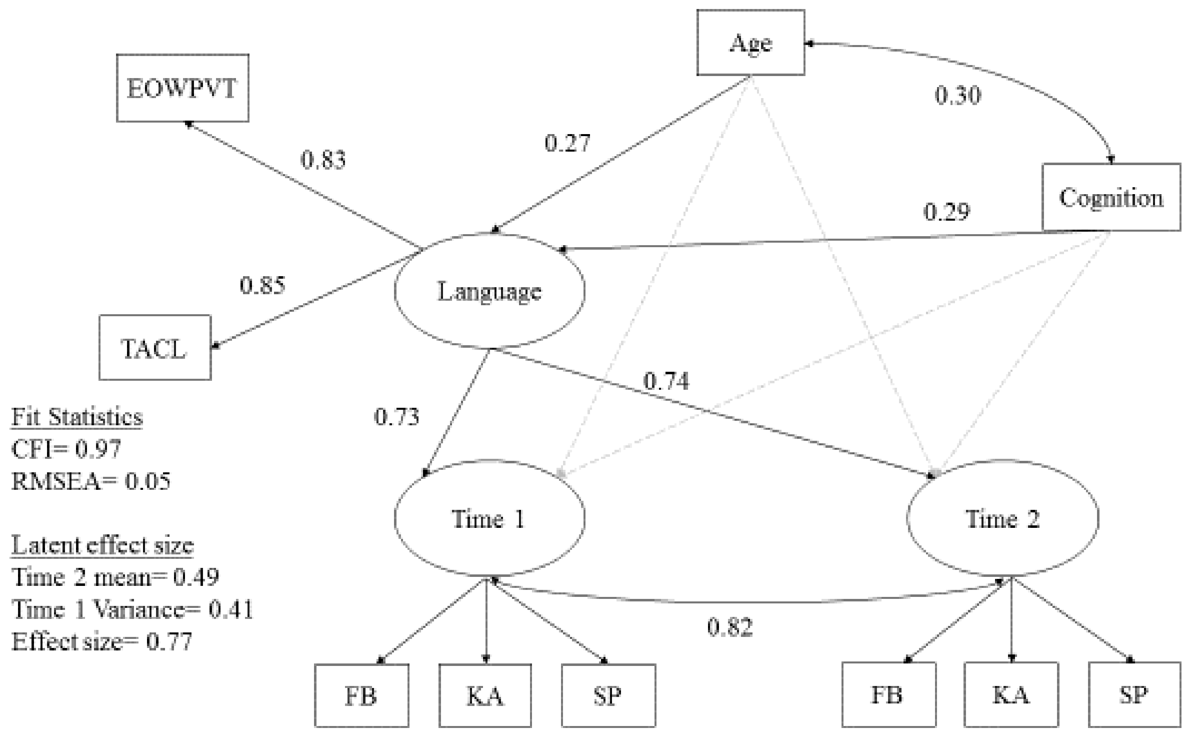


Figure 3: Language, age, and cognition make up the structural model and help predict the outcomes of the CFA Scalar model time 1 and time 2 latent variables. Language is a latent variable constructed from EOWPVT and the TACL. Age and cognition significantly predict language but not time 1 or time 2. Only language predicts time 1 and time 2 when controlling for age and cognition.

Table 13
SEM Model 1 Estimates

| | Fall (Time 1) | | | | Spring (Time 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | Regression | SE | z-value | p | Regression | SE | z-value | p |
| **Language** | **0.73** | **0.004** | **8.40** | **0.00*** | **0.74** | **0.005** | **8.74** | **0.00*** |
| Age | 0.03 | 0.004 | 0.39 | 0.7 | -0.10 | 0.005 | -0.15 | 0.88 |
| Cognition | 0.07 | 0.01 | 0.96 | 0.35 | 0.001 | 0.02 | 0.01 | 0.99 |

| Covariance | Estimates | SE | z-value | p |
|---|---|---|---|---|
| Age & Cognition | 0.30 | 2.25 | 6.72 | 0.00 |

This model, like the CFA models, also show good fit (CFI= 0.97, RMSEA= 0.05). The SEM Model 1 shows that the construct of Language best predicts outcomes of ToM at time 1 (0.72, p = 0.000) and time 2 (0.741, p= 0.000) and that age and cognition do not uniquely influence ToM development. Only through language do age and cognition have an influence on ToM. The direct effects of age and cognition on ToM was highly nonsignificant at both time points. The latent effect size for this model was 0.77, even greater than the original CFA Scalar model.

The influence of parental hearing status and communication modality were explored in SEM Model 2. As stated previously it is much more likely that a child who has deaf parents will use sign only than the other two modalities. The spoken language group and bimodal group were compared to the sign language group in the data. When looking at the descriptive statistics the sign only group significantly varied from these other two groups, while there was no significant difference between the bimodal and spoken only groups. This model had the poorest model fit with a CFI of 0.9 and an RMSEA of 0.07 (see Figure 4). This model showed a significant negative covariance of having at least one deaf parent and being in spoken language group compared to the sign language group. For time 1 both having at least one parent with hearing loss (0.46, p = 0.006) and being in the spoken language group (0.40, p= 0.02) significantly predicted ToM abilities at time 1, but only the spoken language group (0.34, p = 0.03) predicted abilities at time 2 with the parental hearing status approaching significance (0.31, p = 0.06). The latent effect size for this model was much smaller at 0.53 standard deviations.

Figure 4 SEM Model 2

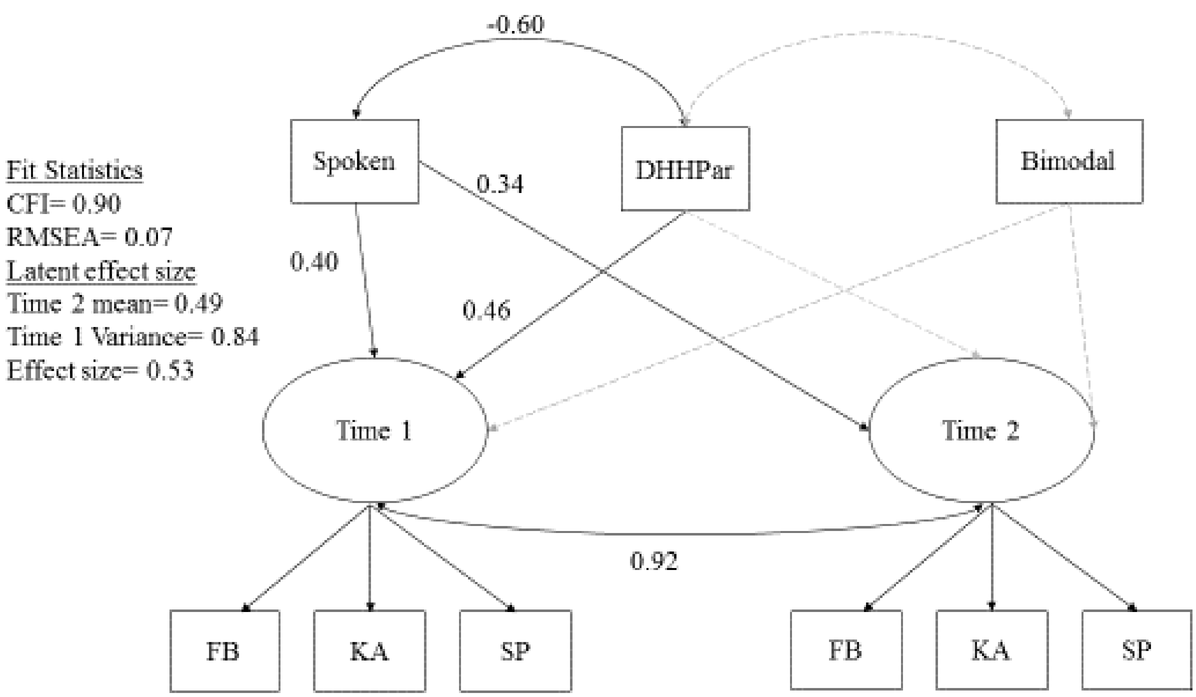


Figure 4: This model uses communication mode, spoken group vs sign group and bimodal group vs sign group to predict ToM along with DHHPar. The spoken language group predicts ToM at both time points and DHHPar predicts Time 1 and almost reaches significance at time 2. Model fit (CFI= 0.898, RMSEA= 0.072) is not as strong for this model.

Table 14
SEM Model 2 Estimates

| | Fall (Time 1) | | | | Spring (Time 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | Regressions | SE | z-value | p | Regressions | SE | z-value | p |
| **DHHPar** | **0.46** | **0.13** | **2.73** | **0.01*** | 0.31 | 0.15 | 1.9 | 0.06 |
| **Spoken** | **0.40** | **0.13** | **2.31** | **0.02*** | **0.34** | **0.14** | **2.13** | **0.034*** |
| Bimodal | 0.15 | 0.08 | 1.45 | 0.15 | 0.12 | 0.08 | 1.3 | 0.19 |

| Covariance | Estimates | SE | z-value | p |
|---|---|---|---|---|
| DHHPar and Spoken | -0.60 | 0.08 | -7.85 | 0.000* |
| DHHPar and Bimodal | -0.09 | 0.09 | -0.9 | 0.37 |

Finally, to answer research question four, SEM Model 3 was constructed combining the variables from questions two and three (see Figure 5). Due to the correlations established earlier, all other independent variables (age, cognition, communication modality, and parental hearing status) were used to also predict the construct of Language while also predicting ToM at the two time points. Table 15 shows the results of this model and Figure 5 highlights the significant relationships established in this model. All gray pathways signify a nonsignificant correlation or covariance.

Figure 5 SEM Model 3

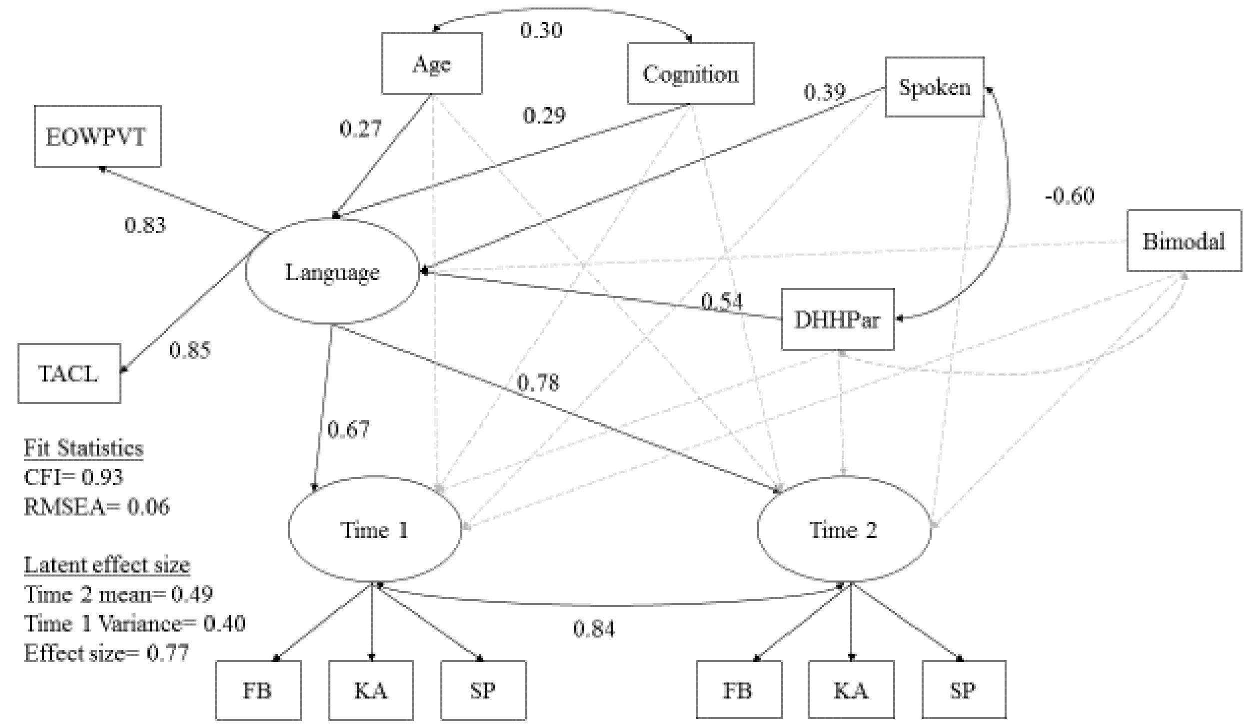


Figure 5: All variables used in Models 1 and 2 are used to predict ToM skills at time 1 and time 2 using the scalar model. Only language significantly predicts ToM (time 1= 0.674, Time 2= 0.78) while age, cognition, DHHPar, and the spoken group compared to the sign group, can significantly predict language abilities.

Table 15
SEM Model 3 Estimates

| | Fall (Time 1) | | | | Spring (Time 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | Regression | SE | z-value | p | Regression | SE | z-value | p |
| **Language** | **0.67** | **0.005** | **6.13** | **0.000*** | **0.78** | **0.006** | **7.05** | **0.000*** |
| Age | 0.04 | 0.004 | 0.57 | 0.57 | -0.02 | 0.005 | -0.30 | 0.76 |
| Cognition | 0.09 | 0.01 | 1.10 | 0.27 | -0.01 | 0.02 | -0.15 | 0.88 |
| DHHPar | 0.09 | 0.13 | 0.49 | 0.62 | -0.11 | 0.15 | -0.66 | 0.51 |
| Spoken | 0.14 | 0.12 | 0.87 | 0.39 | 0.04 | 0.14 | 0.27 | 0.79 |
| Bimodal | 0.05 | 0.07 | 0.56 | 0.57 | -0.01 | 0.07 | -0.06 | 0.95 |

| Covariance | Estimate | SE | z-value | p |
|---|---|---|---|---|
| Age & Cognition | 0.30 | 2.25 | 6.72 | 0.000 |
| DHHPar & Spoken | -0.60 | 0.08 | -7.85 | 0.000 |
| DHHPar & Bimodal | -0.09 | 0.09 | -0.9 | 0.37 |

With all variables accounted for in the SEM, the model fit was again closer to adequate (CFI= 0.93 and RMSEA=0.06) compared to Model 2. As seen in Table 15, when all other variables are controlled by their influence on language, the language abilities of a child are the most significant and only predictor that influences a child's ability to pass ToM tasks at either time point (time 1 = 0.67, p = 0.000; time 2 = 0.78, p = 0.000). Finally, with language again included into our model the latent effect size returns to 0.77.

In order to complete a model that represents these findings, all of the nonsignificant variables are removed from the time 1 and 2 regression equations. This final model has all other independent variables predicting language and language being the only predictor for ToM at different time points. This final model shows a similar, but better, model fit as compared to Model 3 (see Figure 6, CFI= 0.94 and RMSEA= 0.05). In the Final SEM model (Figure 6), the main effect of language is seen to be more equal across time (0.79 at time 1 and 0.73 at time 2). The final latent effect size seen in this model is 0.8 considered to be a very large effect size close to one standard deviation difference from time 1 to time 2 when accounting for the influence of language and its relationship to other independent variables.

Figure 6 Final SEM Model

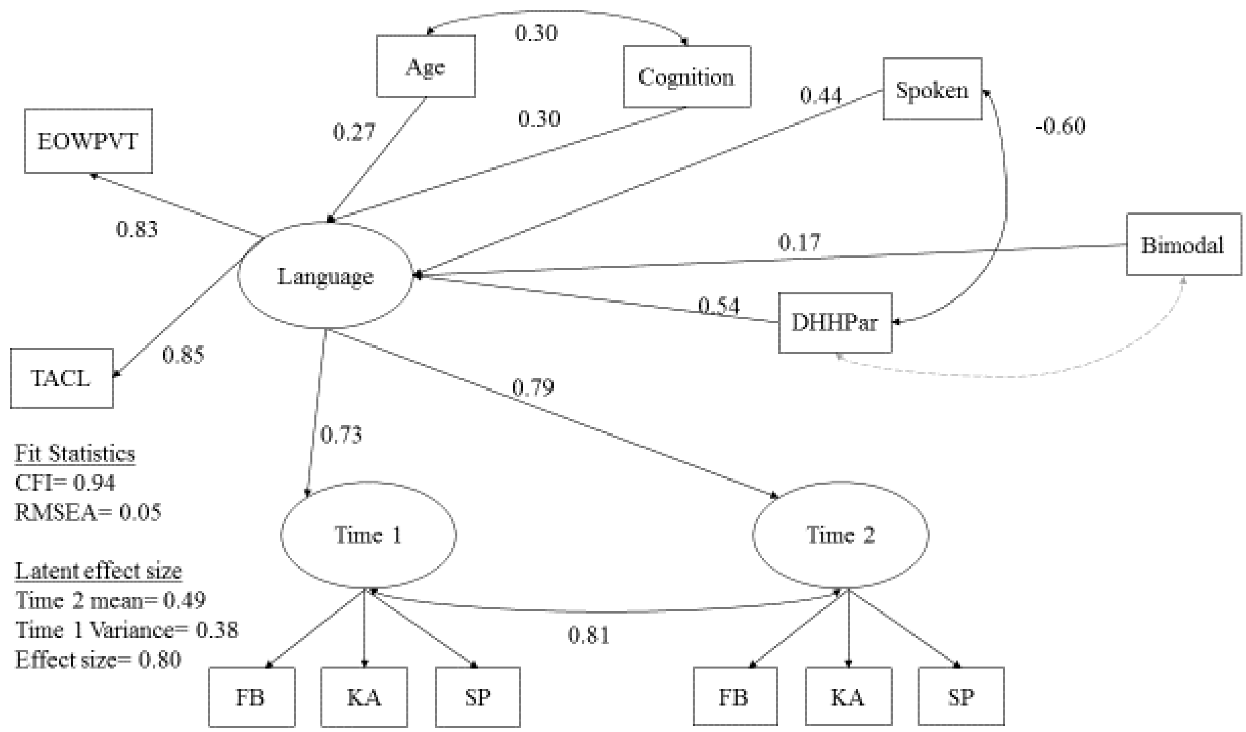


Figure 6: The final model removes all variables from the time 1 and time 2 regressions that did not reach significance. This model demonstrates languages influence on ToM and the influences of age, cognition, DHH parents, and communication modality on language abilities. The correlation between the Bimodal group and parent hearing status is gray because it is nonsignificant (p= 0.37).

Table 16
SEM Final Model Estimates

| | Fall (Time 1) | | | | Spring (Time 2) | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | Regression | SE | z-value | p | Regression | SE | z-value | p |
| **Language** | **0.79** | **0.004** | **8.50** | **0.000*** | **0.73** | **0.005** | **8.93** | **0.000*** |

| Covariance | Estimates | SE | z-value | p |
|---|---|---|---|---|
| Age & Cognition | 0.30 | 2.25 | 6.72 | 0.000 |
| DHHPar & Spoken | -0.60 | 0.08 | -7.85 | 0.000 |
| DHHPar & Bimodal | -0.09 | 0.09 | -0.90 | 0.37 |

# Chapter IV

## Discussion

This study represents a large and diverse sample of children with hearing loss in the United States, tested in multiple dimensions of ToM at age levels that would be at a typical age to pass these tasks. The results allow for an exploration of the comparison and influence of parental hearing status, auditory access, and language on ToM skills. Even without directly comparing to a hearing population, as a group, the DHH population appears to be delayed with some ToM skills at the beginning of elementary school. Only 45% students passed Knowledge Access, 25% passed False Belief, and 19.1% passed Social Pretend. Other studies that explored these three ToM tasks. Stanzione (2014) used younger DHH students (2;9 – 5;2) and Peterson and Wellman (2009) had older groups of DHH students (See Table A1 in Appendix). These three studies show there is wide variety in ToM performance both in DHH and in hearing populations. Without doing statistical comparisons, the results of this current study more closely resembled Peterson and Wellman by age level. The age ranges of  Peterson and Wellman's study was 5;10 – 13;6 which overlaps more with the current study's age range of 4;9 – 10;1. However, there are two major differences to the Peterson and Wellman group. There appears to be a reversal in social pretend being more difficult than knowledge access in our study, which matches Peterson and Wellman's hearing group, not the DHH group. In addition, the percentage of students passing false belief tasks during the spring testing was much closer in age and performance to the hearing group shown in Peterson and Wellman. In the present study, 25% of the children with a mean age of 7;3 passed false belief, while Peterson and Wellman's hearing group had a passing rate of 28% and a mean age of 4;5. This still demonstrates a delay in ToM performance for the DHH group, but not as extreme as we might think.

This brings us to the factors that may influence ToM performance especially in the DHH population. First, this study suggests that the three tests: social pretend, knowledge access, and false belief make up one single construct of ToM. Based on the CFA Scalar model, they do make up a single construct, but social pretend is not as strong as the other two tasks (Table 12, 0.3 & 0.36). The thresholds confirm the order of these tasks to be, from easiest to hardest: knowledge access, social pretend, and then false belief. There is a large, nearly perfect correlation between performance at time one and performance at time 2 (Figure 2, 0.92). Other published studies have not explored using CFA as a way to confirm the order and relevance of these three tasks to ToM (see Stanzione 2014 for unpublished results using CFA and these tasks).

This study explored language generally while controlling for age, cognition, parental hearing status, and communication modality. Unique to this study, communication modality was not only categorizing students by modality, but also considering their access to auditory language in that classification. Many other studies only consider the outward modality use (spoken or sign) without considering how much access a child has to utilize spoken language (Courtin, 2000). By doing this, we created a third group, children who used sign language, but also had enough auditory access to utilize spoken language as well. This group did not differ significantly from the spoken only group based on language or ToM skills

**SEM Models**

By using a large collection of data, we were able to use a more in depth statistical analysis for this population. The SEM models created in this study show the complexities, relationships, and correlations between many factors that ultimately influence ToM development in this population. The SEM Models 1 & 2 focused on the unique variances of language, age, and cognition (Model 1), and communication modality and parental hearing status (Model 2). While not including language, Model 2 looks like there is a significant direct effect of communication modality or access to amplification as well as parental hearing status on ToM development. Yet, only when language, age, and cognition are also factored into Model 3 do we see language has the largest and only direct effect on ToM abilities. Communication modality, parental hearing status, age, and cognition all significantly influence language abilities. These variables have an indirect influence on ToM abilities, but do not appear to directly affect ToM beyond their influence on language.

ToM and the diversity of the DHH population warrant studies with larger sample sizes in order to represent what is the “norm” of the whole population. SEM models are sometimes recommended to be used only when studies have a ratio of 10 participants to each estimated parameter (Schreiber et al., 2006) while more recent investigation points out sample size can depend on multiple factors and there may be allowances for smaller groups (Wolf, Harrington, Clark, & Miller, 2013). SEM models help to explain and describe the complex factors and variations that are seen in the DHH population (e.g. language abilities, modalities, language exposure, therapy interventions, age of identification, degree and stability of hearing loss, amplification etc.). Studies with larger and more representative samples of the entire deaf population will continue to give us more important and relevant information that can be used in clinical practice.

In the last 15 years, the DHH population has changed and grown with several important changes both culturally and technologically. Newborn hearing screenings now make it possible to identify children with hearing loss and connect families to services earlier. This use of early intervention has shown to make a significant difference in the linguistic development of DHH children (Lederberg, Schick, & Spencer, 2013). Therefore, although the majority of children are born to hearing families, in most cases these hearing families now have support to help raise their child. Amplification technology such as digital hearing aids and cochlear implants have also made improvements and children that would not have been able to have amplification in the past now have options. Finally, with better internet access and a variety of platforms moving to visual conferencing, families that were once isolated and unable to gain therapy support or audiological services to their child now have the option of tele-health services. The DHH population needs to be continuously studied because these technological advances will continue to change the access to services and ability to gain amplification.

**Clinical Applications.**

ToM is an ability that is often not explicitly targeted in speech and language therapy and education, especially at early elementary school levels. This study confirms that as a group, children with hearing loss are delayed in their ability to see other people's perspectives and specifically understanding knowledge access, social pretend and false belief. Less than 45% of the students were able to pass any of the tasks at either time point. This study shows how important language ability is for developing ToM skills. Speech language pathologists and teachers of the deaf can focus more on language development and tasks that are similar to these kinds of thought experiments (Lohmann & Tomasello, 2003). Not only do these tasks often have higher levels of language, but cognitively also stimulate and encourage the child to think critically about another person's perspective. A six-week intervention study by Wellman and Peterson (2013a) showed that elementary DHH students were able to make significant improvements on ToM tasks by using a visuals and explicitly teaching how to talk about different false-belief tasks. Since this current study shows that language is a major predictor of theory of mind, it gives more credence for language intervention studies that could help in improving ToM abilities.

## Study Limitations

There are some limitations of the current study. First, the task for social pretend was more difficult to obtain reliable results at either time point. Anecdotally, administrators felt that when administering the task there was confusion and misunderstanding. Results may reflect this misunderstanding unrelated to the act of social pretense that was being targeted. This task did not have a high value for loading in either time 1 or time 2 and there was no significant growth across time unlike the other two tasks. Also, as the descriptive statistics showed, there was a strange statistically nonsignificant reversal between social pretend and false belief during spring testing which would not be expected based on previous research. Because our models ultimately contained good fit, the variable of social pretend was not dropped from analysis.

There was not a direct statistical comparison to these three communication groups and hearing, same age peers. Based on these results and that language is a more robust indicator of ToM performance, a group of language-matched hearing peers would make for a good comparison group for future studies.

## Future Research

Many other factors or variables were not included in the models for this study. Factors such as cochlear implant use, age of identification, or more complex or specific language abilities (e.g. understanding complements) as well as environmental factors (classroom modality, geographic location, sibling interactions, or more direct measurement of parental language abilities) could all be explored in the future and may show an influence on ToM development for this population. This project also studies language as a broad general construct. Future models could explore if there are specific parts of language that influence these TOM skills such as syntax or semantics or more advanced language skills such as understanding object complements (de Villiers & Pyers, 2002). As pointed out by the meta-analysis completed by Milligan et al. (2007), specific verses general language factors have had mixed results in the literature as it pertains to false-belief, and no studies have investigated the impact of specific language on the other TOM tasks used in this study.

**Conclusions**

This study represents one of the only studies to use CFA and SEM in order to describe the influence and factors of ToM development in any population. Because of the complexities and unobservable nature of ToM, more studies should utilize CFA to confirm tasks that adequately represent this variable as well as exploring personal and environmental factors that influence ToM development. Through this large study, we find that for DHH population language, controlling for age, cognition, parental hearing status, and auditory access/communication mode, helps to predict ToM skills in early elementary school students across a school year. Without using SEM, parental hearing status and even communication mode could seem to play a direct effect on TOM, which for this population these factors do play an important role in predicting language development. Ultimately, the general language abilities of a child help us to significantly predict ToM abilities for the DHH population.

## References


Astington, J. W., & Jenkins, J. M. (1999). A longitudinal study of the relation between language and theory-of-mind development. *Developmental Psychology*, *35*(5), 1311 -1320. Retrieved from https://colorado.idm.oclc.org/login?url=https://search-proquest-com.colorado.idm.oclc.org/docview/224541670?accountid=14503

Bartsch, K., & Wellman, H. (1989). Young children's attribution of action to beliefs and desires. *Child Development 60*(4), 946-964. doi: 10.2307/1131035

Bello, A., Capirci, O., & Volterra, V. (2004). Lexical production in children with Williams's syndrome: Spontaneous use of gesture in a naming task. *Neuropsychologia*, *42*(2), 201-213. doi:10.1016/S0028-3932(03)00172-6

Brown, T. A., & Moore, M. T. (2012). Confirmatory factor analysis. In R.H. Hoyle (Ed), *Handbook of structural equation modeling*, (p.p. 361-379). New York: Guilford Press.

Carrow-Woolfolk, E. (1999). *CASL: Comprehensive Assessment of Spoken Language*. Circle Pines, MN: American Guidance Services.

Ching, T. Y. C., Crow, K; Martin, V., Day, J., Mahler, N., Youn, S., …Orsini. J. (2010). Language development and everyday functioning of children with hearing loss assessed at 3 years of age. *International Journal of Speech-Language Pathology 12* (2), 124 – 131. doi: 10.3109/17549500903577022

Courtin, C. (2000). The impact of sign language on the cognitive development of deaf children: The case of theories of mind. *Journal of Deaf Studies and Deaf Education*, *5*(3), 266 - 276. Retrieved from https://doi-org.colorado.idm.oclc.org/10.1093/deafed/5.3.266

Custer, W. L. (1996). A comparison of young children's understanding of contradictory representations in pretense, memory, and belief. *Child Development*, *67*(2), 678-688. doi: 10.2307/1131840

de Villiers, J. G., & Pyers, J. E. (2002). Complements to cognition: A longitudinal study of the relationship between complex syntax and false-belief-understanding. *Cognitive Development*, *17*(1), 1037-1060. Retrieved from https://doi.org/10.1016/S0885-2014(02)00073-4

Devine, R. T. & Hughes, C. (2013). Silent films and strange stories: Theory of mind, gender, and social experiences in middle childhood. *Child Development*, *84* (3), 989 – 1003. doi: 10.1111/cdev.12017

Dunn, L., & Dunn, L. (1981). *Peabody Picture Vocabulary Test-Revised.* Circle Pines, MN: American Guidance Service.

Elliott, C.D. (2007) Differential Ability Scales, 2nd Edition: Introductory and technical handbook. San Antonio, TX: The Psychological Corporation.

Fabricius, W. V., & Khalil, S. L. (2003) False beliefs or false positives? *Journal of Cognition and Development*, *4,* 239 – 262. doi: 10.1207/S15327647JCD0403_01

Flavell, J. H., Flavell, E. R., Green, F. L., & Moses, L. J. (1990). Young children's understanding of fact beliefs versus value beliefs. *Child Development*, *61,* 915 – 928. doi: 10.1111/j.1467-8624.1990.tb02831.x

Friedman, O., Griffin, R., Brownell, H., & Winner, E. (2003) Problems with the seeing = knowing rule. *Developmental Science*, *6*(5), 505 – 513. doi: 10.1111/1467-7687.00308

Gardner, M (1990). *Expressive One-Word Picture Vocabulary Test*. Austin, TX: Pro-Ed.

Gopnik, A., & Slaughter, V. (1991). Young children's understanding of changes in their mental states. *Child Development*, *62*(1), 98-110. doi: 10.2307/1130707

Guttman, L. (1944). A basis for scaling qualitative data. *American Sociological Review*, *9*(2), 139-150. doi: 10.2307/2086306

Haskins, J. (1949). Kindergarten phonetically balanced word lists (PBK). St. Louis, MO: Auditec.

Hickling, A. K., Wellman, H. M., & Gottfried, G. M. (1997). Preschoolers' understanding of others' mental attitudes towards pretend happenings. *British Journal of Developmental Psychology*, *15*(3), 339-354. doi: 10.1111/j.2044-835X.1997.tb00525.x

Hogrefe, G. J., Wimmer, H., & Perner, J. (1986) Ignorance versus false belief: A developmental lag in attribution of epistemic states. *Child Development*, *57* (3), 567 – 582. doi: 10.1111/j.1467-8624.1986.tb00228.x

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1-55. doi: 10.1080/10705519909540118

Jackson, A. L. (2001). Language facility and theory of mind development in deaf children. *Journal of Deaf studies and Deaf education*, *6*(3), 161-176. doi: 10.1093/deafed/6.3.161

Jenkins, J. M., & Astington, J. W. (2000). Theory of mind and social behavior: Causal models tested in a longitudinal study. *Merrill-Palmer Quarterly 46* (2), 203-220. Retrieved from https://colorado.idm.oclc.org/login?url=https://search-proquest-com.colorado.idm.oclc.org/docview/230125751?accountid=14503

Kim, Y-S. G. (2016) Direct and mediated effects of language and cognitive skills on comprehension of oral narrative texts (listening comprehension) for children. *Journal of Experimental Child Psychology 141*, 101 – 120. Retrieved from http://dx.doi.org/10.1016/j.jecp.2015.08.003

Lecciso, F., Petrocchi, S., & Marchetti, A. (2013). Hearing mothers and oral deaf children: an atypical relational context for theory of mind. *European Journal of Psychology of Education*, *28*(3), 903-922. doi: 10.1007/s10212-012-0146-1

Lederberg, A. R., Schick, B., & Spencer, P. E. (2013) Language and literacy development of deaf and hard of hearing children: Successes and challenges. *Developmental Psychology 49* (1), 15 – 30. doi: 10.1037/a0029558

Lohmann, H. & Tomasello, M. (2003). The role of language in the development of false belief understanding: A training study. *Child Development 74* (4), 1130 – 1144. doi: 10.1111/1467-8624.00597

Lundy, J. (2002) Age and language skills of deaf children in relation to theory of mind development. *Journal of Deaf Studies and Deaf Education 7*(1), 41 – 56. doi: 10.1093/deafed/7.1.41

Martin, N. A., & Brownell, R. (2011). *Expressive One-Word Picture Vocabulary Test-4 (EOWPVT)(4th ed.)*. Novato, CA: Academic Therapy Publications.

Milligan, K., Astington, J. W., & Dack, L. A. (2007). Language and theory of mind: meta-analysis of the relation between language ability and false-belief understanding. *Child Development*, *78*(2), 622-646. doi: 10.1111/j.1467-8624.2007.01018.x

Moeller, M. P., & Schick, B. (2006). Relations between maternal input and theory of mind understanding in deaf children. *Child Development*, *77*(3), 751-766. doi: 10.1111/j.1467-8624.2006.00901.x

Moog, J.S., & Geers A.E. (1990) *Early Speech Perception Test for Profoundly Hearing Impaired Children*. St. Louis, MO: Central Institute for the Deaf.

Netten, A.P., Rieffe, C., Soede, W., Dirks, E., Korver, A.M.H., Konings, S…Frijns, J.H.M (2017) Can you hear what I think? Theory of mind in young children with moderate hearing loss. *Ear & Hearing*, *38* (5), 588 – 597. doi: 10.1097/AUD.0000000000000427

Peterson, C.C (2004) Theory-of-mind development in oral deaf children with cochlear implants or conventional hearing aids. *Journal of Child Psychology and Psychiatry 45*(6), 1096 – 1106. doi: 10.1111/j.1469-7610.2004.t01-1-00302.x

Peterson, C. C., & Siegal, M. (1995). Deafness, conversation and theory of mind. *Journal of Child Psychology and Psychiatry*, *36*(3), 459-474.

Peterson, C. C., & Wellman, H. M. (2009). From fancy to reason: Scaling deaf and hearing children's understanding of theory-of-mind and pretense. *British Journal of Developmental Psychology*, *27*(2), 297-310. doi: 10.1348/026151008X299728

Peterson, C. C., Wellman, H. M., & Liu, D. (2005). Steps in Theory of Mind development for children with deafness or autism. *Child Development*, *76*(2), 502-517. doi: 10.1111/j.1467-8624.2005.00859.x

R Core Team (2018). R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org

Remmel, E. & Peters, K. (2009) Theory of mind and language in children with cochlear implants. *Journal of Deaf Studies and Deaf Education, 14*(2), 218-235. doi:10.1093/deafed/enn036

Rosseel, Y (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48(2), 1-36. URL http://www.jstatsoft.org/v48/i02/

Scarborough, H. S. (1990). Index of Productive Syntax. *Applied Psycholinguistics*, *11*(1), 1-22. doi:10.1017/S0142716400008262

Schick, B. (2013) *ASL Receptive Language Test-Revised*. Boulder, CO: University of Colorado.

Schick, B., De Villiers, P., De Villiers, J., & Hoffmeister, R. (2007). Language and theory of mind: A study of deaf children. *Child Development*, *78*(2), 376-396. doi: 10.1111/j.1467-8624.2007.01004.x

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research*, *99*(6), 323-338. doi: 10.3200/JOER.99.6.323-338

Schwebel, D. C., Rosen, C. S., & Singer, J. L. (1999). Preschoolers' pretend play and theory of mind: The role of jointly constructed pretence. *British Journal of Developmental Psychology*, *17*(3), 333-348. doi: 10.1348/026151099165320

Shahaeian, A. Peterson, C. C., Slaughter, V., &Wellman, H. M. (2011) Culture and the sequence of steps in theory of mind development. *Developmental Psychology* (*47* (5), 1239 – 1247. doi: 10.1037/a0023899

Slade, L., & Ruffman, T. (2005). How language does (and does not) relate to theory of mind: A longitudinal study of syntax, semantics, working memory and false belief. *British Journal of Developmental Psychology*, *23*(1), 117-141. doi: 10.1348/026151004X21332

Snyder, S., & Sheehan, R. (1992). The Rasch measurement model: An introduction. *Journal of Early Intervention*, *16*(1), 87-95. doi: 10.1177/105381519201600108

Stanzione, C. (2014). The development of theory of mind in deaf, hard of hearing, and hearing preschool children. (Unpublished dissertation) Georgia State University, Atlanta, Georgia

Stanzione, C., & Schick, B. (2014). Environmental language factors in theory of mind development: Evidence from children who are deaf/hard-of-hearing or who have specific language impairment. *Topics in Language Disorders*, *34*(4), 296-312. doi:10.1097/TLD.0000000000000038

Tomasuolo, E., Valeri, G., Di Renzo, A., Pasqualetti, P., & Volterra, V. (2012). Deaf children attending different school environments: Sign language abilities and theory of mind. *Journal of Deaf Studies and Deaf Education, 18*(1), 12-29. doi: 10.1093/deafed/ens035

Ullman, J. B. (2001). Structural equation modeling. In B. G. Tabachnick & L. S. Fidell (Eds.), *Using multivariate statistics* (4th ed.). Needham Heights, MA: Allyn & Bacon.

Vandenberg, R. J., & Lance, C. E. (2000). A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. *Organizational Research Methods, 3*(1), 4-69. Doi 10.1177/109442810031002

Vellante, M., Baron-Cohen, S., Melis, M., Marrone, M., Petretto, D. R., Masala, C., & Preti, A (2013). The "Reading the mind in the eyes" test: Systematic review of psychometric properties and a validation study In Italy. *Cognitive Neuropsychiatry, 18* (4), 326 – 354, doi: 10.1080/13546805.2012.721728.

Wang, Z. & Wang, L. (2015). The mind and heart of the social child: Developing the empathy and theory of mind scale. *Child Development Research, 2015,* 1 – 8. doi: 10.1155/2015/171304

Wang, Z, Wang, X.C., & Chui, W. Y. (2017) Young children's understanding of teaching and learning and their theory of mind development: A causal analysis from a cross-cultural perspective. *Frontiers in Psychology 8:725*. doi: 10.3389/fpsyg.2017.00725

Wellman, H. M., Fang, F., & Peterson, C. C. (2011). Sequential progressions in a theory-of-mind scale: Longitudinal perspectives. *Child Development*, *82*(3), 780-792. doi: 10.1111/j.1467-8624.2011.01583.x

Wellman, H. M., Fang, F., Liu, D., Zhu, L., & Liu, G. (2006) Scaling of theory-of-mind understandings in Chinese children. *Psychological Science, 17* (12): 1075 – 1081. doi: 10.1111/j.1467-9280.2006.01830.x

Wellman, H. M., & Liu, D. (2004). Scaling of theory of mind tasks. *Child Development*, *75*(2), 523-541. doi: 10.1111/j.1467-8624.2004.00691.x

Wellman, H. M., & Peterson, C. C. (2013a). Deafness, thought bubbles, and theory-of-mind development. *Developmental Psychology, 49*(12), 2357. doi: 10.1037/a0032419

Wellman, H. M., & Peterson, C. C. (2013b). Theory of mind, development, and deafness. In S. Baron-Cohen, M. Lombardo, & H. Tager-Flusberg (Eds.), *Understanding other minds: Perspectives from developmental social neuroscience* (pp. 51-71). doi: 10.1093/acprof:oso/9780199692972.003.0004

Wolf, E.J., Harrington, K.M., Clark, S.L., & Miller, M.W. (2013) Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and Psychological Measurement 73* (6), 913 – 934. doi: 10.1177/0013164413495237.

Wiig, E. H., Secord, W., & Semel, E. M. (2004). *Clinical Evaluation of Language Fundamentals Preschool*. San Antonio, TX: Psychological Corporation.

## Appendix

Table A1

Comparison of Passing Rates of DHH and Hearing Children

| | Mean Age (Range) | Social Pretend | Knowledge Access | False Belief |
|---|---|---|---|---|
| Current Study | | | | |
| Fall (n=351) | 6;8 (4;9 – 9;8) | 17% | 35% | 14% |
| Spring (n=332) | 7;3 (5;4 – 10; 1) | 19% | 45% | 25% |
| Peterson & Wellman (2009) | | | | |
| Deaf (n=33) | 9;8 (5;10 -13;6) | 54% | 36% | 27% |
| Hearing (n= 60) | 4;5 (2;8 – 5;9) | 60% | 80% | 28% |
| Stanzione (2014) | | | | |
| Deaf (n=72) | 4;2 ( 2;9- 5;2) | 33% | 17% | 6% |
| Hearing (n=109) | 4;2 (2;9- 5;2) | 32% | 32% | 6% |