Perception And Theory-of-Mind Development In Preschool Children: Comparing Visual And Auditory Modalities

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PERCEPTION AND THEORY-OF-MIND DEVELOPMENT IN PRESCHOOL CHILDREN: COMPARING VISUAL AND AUDITORY MODALITIES

by

ANITA A. HASNI

Under the Direction of Lauren B. Adamson, PhD

ABSTRACT

Research on theory of mind (ToM) has been dominated by the traditional False Belief tasks; however, recent work has established a developmental sequence for children’s mental-state understanding. Wellman and Liu (2004) formulated a ToM scale that tests four additional aspects of ToM abilities in the visual realm: Diverse Desires, Diverse Beliefs, Knowledge Access, and Real-Apparent Emotions. Our study extended the scale to include five parallel tasks assessing ToM in the auditory realm. Sixty-six typically developing preschoolers (30 female) between the ages of 3- and 5-years-old were tested using 10 ToM tasks (5 visual, 5 auditory). A 3(age) x 2(modality) x 2(gender) repeated measures ANOVA yielded significant effects for age and gender, where 4- and 5-year-olds demonstrated greater mental-state understanding than 3-year-olds and girls passed more tasks than boys. There was no effect of modality nor did any interactions emerge. Like the visual tasks in the theory-of-mind scale, the auditory tasks form a scalable set, with Diverse Desires and Diverse Beliefs occurring earlier in the scale than Knowledge Access, False Belief, and Real-Apparent Emotions. Our new scale provides researchers with five novel tasks to measure the progression of theory-of-mind development in
the auditory realm and may be extended to assess preschoolers, such as children with visual impairments and children with autism spectrum disorder, who have shown delays in mental-state understanding when tested using predominantly visual tasks.

INDEX WORDS: Theory of Mind, Auditory, Mental states, False belief, Cognition, Preschoolers
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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Arts in the College of Arts and Sciences Georgia State University 2015
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August 2015
DEDICATION

I dedicate this project to my family and friends for their unwavering love, support, and encouragement. I wish to thank my parents and my brother, in particular, for fueling the passion to seek knowledge from every corner of the world.
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1 INTRODUCTION

Understanding the mind is a key developmental achievement that enables children to reason about their social world (Wellman, 1990). In 1978, Premack and Woodruff coined the term “theory of mind” to describe how children come to represent and infer others’ mental states. Mental states (i.e., desires, emotions, beliefs, and intentions) are inner experiences that are often expressed through behavior (Wellman, Cross, & Watson, 2001).

Over the past few decades many psychologists have focused on exploring theory-of-mind development within the first five years of life (de Villers, 2007; O’Neill, Astington, & Flavell, 1996; Wellman, 1990). Their research reveals that children first learn that others have internal mental states, and then they subsequently come to understand that others’ internal mental states might differ from their own and even from reality.

Many researchers have used false-belief tasks as the gold standard for determining when a child has acquired theory-of-mind skills. False-belief tasks require that the child understands that other people may hold mistaken beliefs that differ from what the child knows to be true (Wimmer & Perner, 1983). From false-belief tasks alone, it appears that theory-of-mind abilities emerge around age four (Flavell, 2004; Hala, Hug, & Henderson, 2003). More and more research suggests that the false-belief task may not be an accurate measure of mental-state understanding and that children may be aware of people’s inner psychological states even earlier in life (Baillargeon, Scott, & He, 2010). Wellman and Liu (2004), along with several others (Bloom & German, 2000; Fabricius & Khalil, 2009; McAlister & Peterson, 2013), argue that it is misleading to consider theory-of-mind development as a single cognitive process or achievement. Rather, they propose that theory-of-mind abilities form a series of accomplishments that develop over time.
Wellman and Liu’s (2004) theory-of-mind scale charts the development of mental-state understanding in preschoolers. In their study, they presented children with a series of tasks assessing five aspects of theory-of-mind development to test the hypothesis that achievement on some tasks might precede achievement on others (e.g., ignorance before false belief; Wellman & Liu, 2004). Their results indicated that theory-of-mind abilities develop in the following sequence: Diverse Desires, Diverse Beliefs, Knowledge Access, False Belief, and finally Real-Apparent Emotions. The theory-of-mind scale provides researchers with a broader view of children’s developing mental-state understanding. It has since been adopted to examine whether the sequence of development holds true for children from different cultures (Nawaz, Hanif, & Lewis; 2014; O’Reilly & Peterson, 2014; Shahaeian, Peterson, Slaughter, & Wellman, 2011), children who are deaf (Wellman, Fang, & Peterson, 2011), children with cochlear implants (Remmel & Peters, 2008), and children diagnosed with autism spectrum disorder (Peterson, Wellman & Liu, 2005; See Discussion).

As successful as Wellman and Liu’s (2004) theory-of-mind scale is, it is worth noting that all five tasks are primarily visual. Children make sense of the world around them based on inputs from multiple modalities, not just their visual environment. Auditory input, in particular, provides important information not present to the eyes, and this information can support children’s early reasoning and communication skills (Kirk, Diefendorf, Pisoni & Robbins, 1995). Yet there have been few studies that have assessed theory-of-mind development outside of visual and tactile modalities (Brambring & Asbrock, 2010; Davis, 2001; O’Neill, Astington, & Flavell, 1996; Peterson, Wellman, & Slaughter, 2012; Rubio-Fernández & Geurts, 2013; Scott, He, Baillargeon, & Cummins, 2012). Brambring and Asbrock (2010) tested 4-10-year-old congenitally blind children from Germany and 3-6-year-old sighted children (control group).
from the Netherlands using visual, tactile, and auditory false-belief tasks. They did not find any differences in solution frequency among the false-belief tasks based on visual, tactile, or auditory experiences. Few other studies have probed how children use auditory information to reason about others’ mental states (Moll, Carpenter, & Tomasello, 2012; Williamson, Brooks, & Meltzoff, 2013).

The purpose of our study was to extend the theory-of-mind scale into the auditory realm and to investigate when and in what sequence preschoolers begin to understand mental states presented via sounds. We addressed these questions by constructing a set of five auditory theory-of-mind tasks that paralleled Wellman and Liu’s (2004) visual theory-of-mind scale tasks (See Section 2.3).

1.1 Theory of Mind

Theory of mind explores children’s developing abilities to reason about mental states and predict others’ thoughts, beliefs, and behaviors (Baron-Cohen, O’Riordan, Stone, Jones, & Plaisted, 1999; Frye & Moore, 1991). Premack and Woodruff first coined the term “theory of mind” in 1978. It is discussed in terms of a theory for two reasons: 1) mental states are not directly observable, and 2) mental-state understanding is a system of inferences that can be used to make predictions (Taylor, 1996). Although mental states are unobservable, they are commonly expressed through terms such as: want, think, know, and believe (Gelman & Au, 1996; Povinelli & Preuss, 1995). Research on children’s theory-of-mind continues to show that the ability to understand mental states is important for typical development of social, affective, and communicative relationships (Gweon, Dodell-Feder, Bedny, & Saxe, 2012; Perner, Frith, Leslie, and Leekam, 1989).

Knowledge about the mind is considered to be one of the most fundamental domains of
human understanding (Wellman and Gelman, 1992). Children who develop an understanding of beliefs come to know that mental states vary by person and that some mental states can change over time (Gelman & Au, 1996). Knowing how others think and behave transforms the way children “see other people and make sense of what they are doing” (Frye & Moore, 1991, p. 2). Leekam (1993) notes that moral, social, and communication development is also closely tied to theory of mind development.

Prior to developing knowledge about others’ mental states, children are egocentric; they see events from their own point of view and have difficulty sharing others’ perspectives (Schreibman, 2005). Piaget’s (1926) early studies found that children younger than 7- or 8-years old are unable to understand others’ internal mental states and, therefore, are unable to successfully modify messages to account for what a listener does or does not know. Since Piaget’s early work, research on this topic has shown that children begin to develop theory-of-mind abilities by at least 3 years of age, and master many skills by age five (Baron-Cohen, Lombardo, Tager-Flusberg, Cohen, 2013; Flavell, 2004; Wellman, Cross, & Watson, 2001).

Theory-of-mind abilities improve as children interact with the world around them. As Astington (2001) points out, children’s internal resources, along with social supports, influence theory-of-mind development. Children increase their mental-state vocabulary and social-cognitive skills through everyday interactions with peers and adults (Dunn, Brown, Slomkowski, Tesla, & Youngblade, 1991). In particular, early joint attention skills (Charman et al., 2000; Van Hecke et al., 2007) and language skills (Schick, de Villiers, de Villiers, & Hoffmeister, 2007; Watson, Painter, & Bornstein, 2001) have been found to facilitate later theory-of-mind development. A longitudinal study by Nelson, Adamson, and Bakeman (2008) found that toddlers (ages 18-30 months) who engaged in longer, richer, periods of joint engagement with
their caregivers had higher false belief scores by preschool (42-66 months). Richer periods of engagement included more time spent coordinating attention between a caregiver and an object, and/or more time spent incorporating symbols in the interaction.

While joint attention skills are viewed as a precursor to theory-of-mind development, language skills have been discussed as both precursors and consequences of social understanding. Language enables children to talk about others’ thoughts and desires, but it is also a means by which they learn mental states (Astington, 2001). Even before children acquire their own expressive language abilities, they are engaging in mental-state interactions with others. For example, parents who ask their child to indicate a preference for one toy over another are engaging in interactions about wants and desires. Despite having little to no language, young children are able to participate in this social interaction by picking up the object or gesturing towards it. Children seem to master the semantics of mental-state terms around the same time they master false belief tasks (Moore, Pure, & Furrow, 1990).

Lohmann & Tomasello (2003) outline four “global hypotheses” that describe how language and theory of mind might be interrelated. The first hypothesis suggests that children come to understand false beliefs by learning mental-state terms. Knowing common mental-state terms (e.g., think, know, and believe) influences children’s abilities to learn how mental states are discussed (Astington, 2000; Bartsch & Wellman, 1995). Adults often use these terms to reference a mental state, and children who can connect the mental-state term to the relevant mental state (referent), develop an understanding about mental states.

A second hypothesis, proposed by de Villiers and de Villiers (2000), suggests that syntax helps children reason about false beliefs. Adults talking about false beliefs formulate sentences that include a full clause as the object complement (syntax complementation). Lohmann &
Tomasello (2003) provide the following example: Peter thinks Mommy’s home. This sentence can be broken down into a main clause with a mental state (Peter thinks X) and its embedded clause (that Mommy’s home). Thus, understanding the underlying rules that govern sentence structure can help children understand underlying mental states. More recently, Slade and Ruffman (2005) found supporting evidence that general language abilities (e.g., syntax, semantics), rather than a particular aspect of language, correlate with theory of mind.

The third hypothesis, supported by Harris (1996, 1999) and Tomasello (1999), suggests children begin to recognize others’ mental states through exchange and discourse. This hypothesis does not rely on semantic content or syntax to explain how language influences false belief understanding. In comparison to the first hypothesis, proponents of this idea suggest that children learn about mental states when they are part of the conversation. Children come to know that other people may know things they do not know through “linguistic interchange” (Lohmann & Tomasello, 2003). A training study by Guajardo & Watson (2002) manipulated children’s exposure to naturalistic discourse about mental states. The results indicated that greater exposure to discourse (through training) improved children’s performance on theory-of-mind understanding.

Finally, the fourth hypothesis claims that language does not play a special role, and instead, language is grouped together with other relevant data that contributes to children’s growing understanding of others’ minds (Lohmann & Tomasello, 2003). No one in particular has made this claim; however, Gopnik & Wellman (1992) describe a similar explanation in their case for a theory-theory. Theory theory (TT) postulates that children come to develop theories about the mind just as scientists develop theories, and that these theories can change with time.

Thus, there is clear evidence that language plays a role in theory-of-mind development;
however, the nature of that role remains undefined. Furthermore, these studies have explored the relationship between language and social understanding primarily through the false belief task. We will highlight some of the challenges of using this task as the singular marker of theory-of-mind understanding in the next section.

1.2 Measuring Theory of Mind

False-belief tasks have been the most commonly used measures to determine whether or not a child understands others’ mental states (de Villers & Pyers, 2002; Walker & Shore, 2011). Early work on this topic purports that children do not develop theory of mind until they are able to recognize that people’s mental states may be misinformed and misaligned with that of reality (i.e., false belief; Wellman, Cross, & Watson, 2001). Although false-belief tasks have been administered on numerous occasions, there have been some recent debates on the validity of using this single task to signify theory-of-mind development (Bloom & German, 2000; Wellman, Cross, & Watson, 2001).

On the one hand, Povinelli and Preuss (1995) argue that false-belief tasks are an excellent test of theory of mind since a child who acquires false-belief understanding must appreciate the divergence between the mind and the world. Davis (2001) also notes that successful performance on false-belief tasks demonstrates a shift from non-representational understanding to a general representational understanding of the mind. False-belief tasks require a child to recognize that mental states are internal and may be distinct from reality (Wellman, Cross, & Watson, 2001).

On the other hand, a primary argument against using false-belief tasks as the sole indicator of theory-of-mind development is that these tasks require skills that extend beyond theory-of-mind abilities. Bloom and German (2000) note that the classic Sally-Anne task (see
Baron-Cohen, Leslie, & Frith, 1985) and the contents false-belief task (see Hogrefe, Wimmer, & Perner, 1986) are too difficult in and of themselves. For the Sally-Anne task, Bloom and German (2000) argue that the child must be able to follow a narrative, remember the characters’ actions, recall where the chocolate was stored at the start of the task and where it is at the end of it, understand that the question is asking where will Sally look not where should she look, and be able to inhibit the notion that beliefs are inherently true, in order to successfully pass the task. The contents false belief task presents children with a familiar object with unexpected contents. Correctly answering this task places similar cognitive demands on the child by requiring him or her to inhibit any previous knowledge about what will be inside.

Some researchers have re-designed the approach to testing false-belief understanding by using spontaneous-response tasks. Spontaneous-response tasks, such as violation-of-expectation (VOE) and anticipatory-looking (AL) tasks, allow researchers to infer children’s understanding from behaviors he or she produces while watching a scene unfold (Baillargeon, Scott, & He, 2010). These tasks have been used with children under age two and unlike elicited-response tasks they do not require children to explicitly answer a question about others’ mental states. Scott and Baillargeon’s (2009) response account notes that elicited-response tasks require children to carry out three processes: 1) represent another’s false belief, 2) access their representation of another person’s false belief in order to answer a question, and 3) inhibit their own tendency to answer the question based on their own knowledge. In contrast, the spontaneous-response tasks only require children to represent another’s mental state. Interestingly, results using spontaneous-response tasks suggest that children are able to attribute false-beliefs to others by the second year of life when tested using spontaneous-response tasks.
1.3 Wellman and Liu’s Theory-of-Mind Scale

Despite abundant false-belief studies, many questions remain unanswered regarding the complex aspects of theory-of-mind development. To address some of these issues, Wellman and Liu (2004) conducted a thorough meta-analysis of over 40 studies relating to children’s developing theory-of-mind abilities. They began their review by identifying studies that tested different aspects of mental-state understanding (e.g., desires vs. beliefs, ignorance vs. false belief). Next, they consolidated their findings into a series of seven experimental tasks that could represent the emergence of theory-of-mind in young children.

Wellman and Liu (2004) administered seven tasks to 75 typically developing 3-, 4-, 5-year-old children and found that children performed similarly on the two tasks that probed false beliefs (Contents False Belief and Explicit False Belief) and the two that probed hidden emotions (Belief Emotion task and Real-Apparent Emotions). They had initially included these similar tasks to see whether different task formats (testing the same conceptual content) resulted in different performance. Since the results were similar, Wellman and Liu retained the Contents False Belief and Real-Apparent Emotions tasks in the final analysis. They established a five-item theory-of-mind scale based on the total proportion of children that passed each task, ranging from easiest to hardest. The results yielded the following sequence for theory-of-mind development among preschoolers: Diverse Desires, Diverse Beliefs, Knowledge Access, False Belief, and Real-Apparent Emotions.

The theory-of-mind scale includes five tasks showing the developmental progression of children’s understanding of others’ mental states. As mentioned above, the tasks are ordered according to increasing difficulty for typically developing preschoolers. The first and easiest task, Diverse Desires, requires the child to judge that two people may have different desires
about the same object. The Diverse Beliefs task probes the child’s ability to judge that two people may have different beliefs about an unknown state of affairs without knowledge of which belief is true or false. In the third task, Knowledge Access, the child is shown the contents of a box and is asked to judge the knowledge of another person who has not seen what the box contains. Not until the fourth task do we arrive at False Beliefs. As mentioned earlier, in this task, the child is first shown the false contents of a distinctive container (e.g., Band-Aid box) and then asked to judge another person’s belief about what is inside the container. Finally, the Real-Apparent Emotions task, which was deemed most difficult, tests the child’s ability to judge that a person may internally feel one emotion, but overtly display a different one.

The scale has also been adapted to understand how culture impacts theory-of-mind development (Shahaeian, Peterson, Slaughter, & Wellman, 2011; Wellman, Fang & Peterson, 2011). Shahaeian, Peterson, Slaughter, and Wellman (2011) found that 3- to 6-year-old Iranian children successfully passed Knowledge Access tasks prior to Diverse Beliefs. Wellman, Fang, Liu, Zhu, and Liu (2006) found that Chinese-speaking preschoolers also passed Knowledge Access tasks prior to Diverse Beliefs. Comparatively, Australian and American children came to understand that people hold differing beliefs (Diverse Beliefs) before understanding that people can be knowledgeable or ignorant (Knowledge Access). There was no evidence of cultural differences in the overall rates of theory-of-mind development among Iranian and Australian preschoolers; however, the authors suggest that future research should consider siblings (McAlister & Peterson, 2013), educational practices, parental attitudes, and parenting styles as variables that might influence the sequence of development. Collectivist (Iranian and Chinese) and individualistic cultures (Australia and the United States) vary in terms of what each society values, and these findings raise interesting questions about other factors that might influence the
sequence of theory-of-mind development.

1.4 Audition

Current theory-of-mind literature ignores auditory input as an important source of information. From a biological perspective, children experience auditory inputs prior to visual inputs. The human cochlea reaches adult function soon after the fifth month of gestation (Elliot & Elliot, 1964), and it is around this time that a fetus begins hearing auditory signals (via fluid-borne sounds; Northern & Downs, 1991). There is also evidence that newborns pay acute attention to human voices, which could reflect an innate understanding that voices carry emotion and intent (Eisenberg, 1975).

Audition also impacts other modes of perception, most commonly, vision. Meredith and Stein (1987) conducted a study on multisensory neurons in cats’ superior colliculi. The superior colliculus is a region in the brain responsible for integrating visual, auditory, and somatosensory inputs. For instance, when the cat hears a sound, it “knows” to orient towards the sound because of perceptual processes occurring in real time. This suggests that auditory events directly influence where the cat looks and what it sees, which in turn will impact what the cat comes to know (Smith & Katz, 1996).

Buccino and colleagues (2001) suggest that humans understand actions and intentions by mapping the auditory/visual representation of an observed action onto our motor representation of the same action. Similarly, once the actions of another individual are represented and understood in terms of one’s own actions, it is possible to predict the mental state of the other individual, leading to theory-of-mind abilities.

Some recent studies have probed non-visual aspects of theory-of-mind development. For example, Williamson, Brooks, and Meltzoff (2013) tested 2- and 3-year-olds to determine when
children come to understand others’ auditory perceptions. The study presented children with four clear plastic tubes each filled with one of the following contents: glitter, beads, bells, or feathers. When shaken, the tubes containing beads or bells produced a loud sound, while the tubes containing glitter or feathers produced a very soft sound. Once children were familiarized with the objects, the experimenter briefly stepped out of the room to retrieve a baby doll sleeping in a bassinet. Children were then instructed to either wake up the baby or allow her to continue sleeping by selecting the appropriate object in a paired-comparison test (e.g., glitter versus beads). They found that children as young as 2 years old were able to choose the appropriate object (loud or soft) based on the goal of the task (wake versus don’t wake the baby). This suggests that children have an early understanding of how sounds impact others’ perceptions and behaviors.

Another study, by Moll, Carpenter, and Tomasello (2012), tested 2- and 3-year-old children on their understanding of another person’s auditory experience. During the task, each child heard two sounds. The first sound was played in the presence of an adult and the child, while the second sound was played only in the presence of the child. When both sounds were later replayed, the adult reacted with surprise at hearing two sounds as opposed to one. The results indicated that children as young as two years old were able to direct an adult’s attention to the second sound (not heard by the adult) more often than not. These findings provide evidence that children demonstrate theory-of-mind abilities before 4 years of age and that they are able to extend their understanding beyond the visual realm.

Brambring and Asbrock (2010) administered a series of altered false belief tasks to congenitally blind children between 4- and 10-years-old to determine whether reported delays in social understanding were linked to task demands. They presented children with nine false belief
tasks that were primarily visual, primarily auditory, or primarily tactile. The primarily auditory tasks included one unexpected outcomes task—previously learned (children were presented with the first part of a well-known children’s song, asked what they should hear next, and then presented with an unexpected continuation of another well-known song), one unexpected outcome—newly learned (children pressed a series of buttons following an auditory sequence, asked what they should hear next, and then presented with an unexpected sound that broke the sequence), and one change-of-locations task (children were presented with stories in which person A went away and person B changed locations, and were then asked to report where person A would look for person B). Prior to Brambring and Asbrock’s (2010) study, research with this population suggested that blind children do not understand false beliefs till 8 years, 5 months (approximately 4 years later than sighted children). Their battery of false belief tasks led to evidence that false belief understanding emerges around 6 years, 8 months, and that congenitally blind children were able to reason about mental states in other modalities.

Although there is some evidence that children can think about mental states in the auditory realm, there is also reason to think that they may perform differently on auditory tasks. Auditory and visual modalities have different characteristics. For example, visual inputs allow children to follow postural and eye orientations, which may make it easier to understand others’ visual experiences, while auditory inputs do not provide any such observable behavioral markers. Vision is also considered to be a more active sense than audition because it is closely linked with action (Moll, Carpenter, & Tomasello, 2012) and provides viewers with quick, reliable information about objects in their environment (i.e., “what” and “where”). Auditory inputs, on the other hand, do not provide listeners with any information as to what is producing the sound or where it is coming from. Children do not learn that an object’s acoustic properties are
uncovered by listening, not looking, until around 3 years old (Pillow, 1993). Williamson, Brooks, & Meltzoff (2013) also note that, for humans, ears are not located as prominently as eyes are on the face (e.g., eyes are in the front, ears are on the side and often obscured by hair). Thus, they suggest that mental-state understanding via auditory information is comparatively harder for children (Moll, Carpenter, & Tomasello, 2012).

In sum, theory-of-mind development has been well documented, and researchers have found that, with age, children’s understanding improves from a simple awareness of beliefs and desires to a more complex understanding of others’ knowledge and ignorance, false beliefs, and hidden emotions. Some preliminary evidence suggests that preschoolers have an early understanding of knowledge and ignorance based on audition; however, to date, there is little research available on how children develop an understanding of others’ experiences with sound. Our study extends the current theory-of-mind scale to include five parallel auditory tasks that assess children’s ability to reason about mental states in the auditory realm.

1.5 The Present Study

Our goals were to 1) assess whether or not preschool children are able to reason about mental-state representations in the auditory realm, 2) identify when children come to understand others’ mental-state representations of auditory experiences, and 3) determine whether this understanding in the auditory realm develops at the same time and in the same sequence as the visual theory-of-mind scale. To test theory-of-mind abilities related to audition, we crafted five tasks that paralleled those in Wellman and Liu’s (2014) theory-of-mind scale but which focused on auditory input more so than visual or multimodal input. The five new auditory tasks probe the same aspects of mental-state understanding -- desires, beliefs, knowledge and ignorance, false beliefs, and real versus apparent emotions -- assessed by Wellman and Liu’s (2004) theory-
of-mind scale.

We compared preschoolers’ (3-, 4-, and 5-year olds) performance on all five aspects of theory-of-mind development across two modalities (visual and auditory). In line with previous research, we expected that children would pass more tasks with increasing age. We did not expect any differences in performance between boys and girls. For purposes of replication, we anticipated that performance on the visual tasks would be similar to what Wellman and Liu (2004) reported for their theory-of-mind scale. We also predicted that children would perform similarly on the newly designed auditory tasks and the visual tasks; however, this prediction was based on the limited availability of studies focusing on audition.

There are a few possibilities related to how children will perform on the auditory tasks. One possibility is that children will find the auditory tasks easier than the visual ones since their experience with auditory input begins in the womb. Another possibility, as Moll, Carpenter and Tomasello (2012) point out, is that the auditory tasks will be more difficult than the visual tasks since auditory experiences do not provide any observable behavioral markers. It is also possible, as we predict, that the auditory and visual tasks are equally challenging, regardless of modality. By the time children are in preschool, our capacity to integrate sensory inputs and view the world as a whole could eliminate any differences between performance on visual and on auditory tasks that probe the same underlying construct.

In terms of the sequence of performance, we hypothesized that children would pass the auditory tasks in the same sequence as the visual tasks since the auditory tasks were comparable to other tasks utilized in published research. Overall, we hypothesized that children would come to understand others’ mental states of auditory experiences in the same sequence as the theory-of-mind scale: Diverse Desires, Diverse Beliefs, Knowledge Access, False Beliefs, and Real-
Apparent Emotions.

Furthermore, we predicted that the auditory tasks would be scalable. We utilized Guttman scaling (Guttman, 1944) to confirm whether or not the auditory tasks formed a scalable set. The Guttman scale represents strict and ideal response patterns based on increasing difficulty of the tasks. Thus, if the tasks represent a scale, knowing a child’s Guttman score would reveal how they performed on all easier items in the scale. If a child fits the Guttman scale, then passing a particular item along the scale would indicate that he or she successfully passed all easier items as well.

2 METHOD

2.1 Participants

Sixty-six typically developing children (36 boys and 30 girls) participated in this study: 22 3-year-olds (range = 35 months to 46 months; $M_{age} = 37.7, SD = 2.0$), 22 4-year-olds (range = 47 months to 59 months; $M_{age} = 52.6, SD = 3.9$) and 22 5-year-olds (range = 60 months to 69 months; $M_{age} = 63.2, SD = 3.2$). Children were recruited from the Georgia State University Developmental Psychology child subject pool. Families were identified via website and community postings, bulk mailings, recruitment from other research studies and word of mouth. Once a child met the criteria for age and typical development, parents were contacted by phone or email, provided a brief description of the project, and invited to participate. The sample consisted of 74% European American, 20% African American, 2% Asian American, and 5% biracial children. An additional three children participated in the study, but were excluded from the final sample due to experimenter error.
2.2 Design

We used a 3 x 2 x 2 repeated measures design to test our hypotheses. The between-subjects factors were age (3-, 4-, or 5-years-olds) and gender. The within-subjects factor was modality, defined as auditory or visual.

Each child was randomly assigned to participate in one of four presentation orders. The orders were generated based on the following constraints: 1) all orders began with a Diverse Desires task, 2) all orders ended with a Real-Apparent Emotions task, and 3) the auditory and visual tasks assessing a given aspect of theory of mind (e.g., Knowledge Access) were not presented directly one after another. As per Wellman and Liu’s (2004) recommendation, we began each administration with Diverse Desires (auditory or visual) to ease the child into the tasks, and ended with a Real-Apparent Emotions task (auditory or visual), which was deemed the hardest task according to the theory-of-mind scale. Thus, each child received a total of 10 tasks beginning with a Diverse Desires task, and ending with a Real-Apparent Emotions task. The four presentation orders are shown in Table 1. Of the 66 children, 18 received Order A, 15 received Order B, 15 received Order C, and 18 received Order D.
Table 1. Order of Presentation for the Theory-of-Mind Tasks

<table>
<thead>
<tr>
<th>Order</th>
<th>DD-V</th>
<th>RAE-V</th>
<th>FB-A</th>
<th>KA-A</th>
<th>DB-V</th>
<th>DD-A</th>
<th>FB-V</th>
<th>DB-A</th>
<th>KA-V</th>
<th>RAE-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>DD-V</td>
<td>RAE-V</td>
<td>FB-A</td>
<td>KA-A</td>
<td>DB-V</td>
<td>DD-A</td>
<td>FB-V</td>
<td>DB-A</td>
<td>KA-V</td>
<td>RAE-A</td>
</tr>
<tr>
<td>B</td>
<td>DD-V</td>
<td>DB-V</td>
<td>KA-V</td>
<td>DD-A</td>
<td>FB-V</td>
<td>RAE-A</td>
<td>KA-A</td>
<td>FB-A</td>
<td>DB-A</td>
<td>RAE-V</td>
</tr>
<tr>
<td>C</td>
<td>DD-A</td>
<td>FB-V</td>
<td>RAE-V</td>
<td>KA-V</td>
<td>DB-A</td>
<td>FB-A</td>
<td>KA-A</td>
<td>DB-V</td>
<td>DD-V</td>
<td>RAE-A</td>
</tr>
<tr>
<td>D</td>
<td>DD-A</td>
<td>KA-V</td>
<td>FB-A</td>
<td>RAE-A</td>
<td>DD-V</td>
<td>DB-A</td>
<td>FB-V</td>
<td>KA-A</td>
<td>DB-V</td>
<td>RAE-V</td>
</tr>
</tbody>
</table>

*Note.* The 10 tasks are abbreviated above as: Diverse Desires (DD), Diverse Beliefs (DB), Knowledge Access (KA), False Belief (FB), Real-Apparent Emotion (RAE). Visual tasks are denoted by -V; auditory tasks are denoted by -A.
2.3 Tasks

We adopted five tasks from the theory-of-mind scale established by Wellman and Liu (2004) and constructed five tasks that aimed to explore comparable mental-state understanding in the auditory realm. Table 2 contains a brief description of the five aspects of mental-state understanding that were assessed. Visual tasks were those described in Wellman and Liu’s (2004) theory-of-mind scale; auditory tasks were designed to parallel the visual tasks, but they utilized sounds as the target stimuli. Figure 1 provides a representation of the sounds and stimuli utilized in the 10 tasks. Tasks were administered in a structured format, and the child was prompted to respond to two types of questions: target questions and contrast/control questions.

Each task began by either introducing a protagonist in the form of a toy figurine (e.g., Polly) or an object with a hidden item inside (e.g., an opaque box containing pennies). After the child was oriented to the situation, he or she was asked the control question(s) about reality/own mental state and the target question(s) about a protagonist’s mental state. The child was allowed to respond verbally or indicate an answer by gesturing (most commonly with a point). For a detailed description of each task see Appendix A.

Both the auditory and visual versions of each task utilized the same toy figurine. Pictures were clipart images evenly spaced and printed on 8.5 x 11 sheets of paper and included: 1) cookie and carrot, 2) bushes and a garage, and 3) an emotion scale with simple black and white happy, sad, and neutral faces. The sounds included: 1) piano, 2) drums, 3) “ambiguous” sheep sound, 4) cat meowing, and 5) an emotion scale with sound clips of a child laughing, child crying, and child saying “hmm”. The objects included: 1) two nondescript wooden boxes, 2) a toy dog, 3) pennies, 4) a Band-Aid box (clearly identifiable), 5) a toy pig, and 6) a small stuffed animal dog containing the audio clip of a cat meowing.
To preserve the parallels between the auditory and visual tasks, we presented children with structured scenarios using the same protagonist and similar stimuli. The Diverse Desires task introduced the child to Mr. Jones. For the visual task, the child was told it was snack time and Mr. Jones would like to choose a snack to eat; for the auditory task, he or she was told it was music time and Mr. Jones would like to choose an instrument to hear. The child was prompted to indicate his or her preference for a snack (carrot or cookie) or an instrument (piano or drums). The experimenter then informed the child that it was a good choice, and proceeded to reveal Mr. Jones’ desire (opposite to the child’s desire). The target question required the child to indicate which one snack/instrument Mr. Jones would choose. A child who was able to inhibit his or her own desire and respond with Mr. Jones’ desire was scored as successfully passing the task.

In the visual Diverse Beliefs task, the child was told that Linda wanted to find her cat, and that her cat might be hiding in the bushes or in the garage. The child was then asked where he or she thought the cat was hiding. After hearing the child’s response, the experimenter informed the child that it was a good idea, and revealed where Linda believed the cat was hiding (opposite to the child’s belief). The target question asked the child to indicate where Linda would look for her cat. For the auditory Diverse Beliefs task, the child was told that Linda wanted to identify a particular sound. The experimenter played the clip, told the child the sound might be a cow or a sheep, and prompted the child for his or her thoughts on whether they heard a cow or a sheep. After hearing the child’s response, the experimenter informed the child that it was a good idea and told the child what Linda believed she heard (opposite to the child’s belief). The target question asked the child to indicate what Linda believed she was hearing.

The Knowledge Access tasks presented the child with nondescript boxes containing small hidden objects. Each child was initially asked what he or she thought was in the box. The child
could provide any answer or indicate that he or she did not know. For the visual task, the experimenter opened a box to reveal a small toy dog; for the auditory task, the experimenter rattled a sealed box filled with pennies. After the child correctly answered the control question of what was inside, the experimenter introduced Polly. The child was told that Polly had never seen/heard what was inside the box. The target questions then asked the child whether Polly knew what was in the box and if Polly had seen/heard what was inside.

The False Belief task presented each child with what appeared to be a familiar object paired with a mismatched reality. In the visual task, the child was presented with a clearly identifiable Band-Aid box and asked what he or she thought was inside; similarly, for the auditory task, we presented the child with a toy dog and asked what sound the toy should make. Once the child correctly identified the true character of what they should see/hear, the experimenter presented the mismatched reality. The Band-Aid box was opened to reveal a toy pig inside, while the toy dog actually produced a cat sound. The child was then introduced to Peter who had never seen inside the box (visual) or heard the sound the toy produces (auditory). The target questions asked the child what Peter thought was in the box/what sound Peter thought the toy should make (a dog sound or a cat sound), as well as whether or not Peter saw inside the box or heard the sound.

The final task assessed hidden emotions and was presented in the form of a story. Prior to telling the story, each child was trained on an emotional scale using pictures (a sheet of paper with three faces drawn on it–happy, neutral/okay and sad) for the visual task and sound clips (a child laughing, child crying, and child saying “hmm”) for the auditory task to ensure knowledge of the emotional expressions. The child was told to expect questions regarding how Matt really felt inside and how he looked on his face/sounded in his voice. The experimenter also told the
child how Matt really felt inside might be the same as how he looks on his face/sounds in his voice or it might be different. The visual task story was as follows:

   This story is about Matt. Matt’s aunt just got back from a trip. She promised that she would buy Matt a toy car, but, she got Matt a book instead. Matt doesn’t like books. What Matt really wants is a toy car, but Matt has to hide how he feels, because if his aunt knows his real feelings, she’ll never buy him anything again.

Similarly, the auditory task was as follows:

   This story is about Matt. Matt’s aunt is on the phone. She promised that she would take Matt to visit the zoo today, but when she called she told Matt that she is taking him to the mall instead. Matt doesn’t like going to the mall. What Matt really wants to do is go to the zoo, but Matt has to hide how he feels, because if his aunt knows his real feelings, she would never take him anywhere again.

After reading the story aloud, the experimenter proceeded to ask two control questions and two target questions. The control questions were administered to check for comprehension and asked what Matt’s aunt offered him and what she would do if she knew how Matt really felt. If the child answered these two questions correctly, the experimenter followed up with target questions about how Matt really felt inside—happy, sad, or okay, and how Matt tried to look on his face/sound in his voice—happy, sad, or okay.

The experimenter scored each child’s response during the administration. Responses were scored using a binary system (pass/fail) for both the control and target questions. If the child passed the control and target questions he or she received a score of 1; however, if the child passed only one or neither of the question types, he or she received a score of 0. Any alternative answers were also scored as zeroes. For example, one child answered that the ambiguous sound
in the auditory Diverse Beliefs task was a horse, despite being provided with answer choices of cow and sheep. We calculated an overall composite score (out of 10) based on the child’s individual responses to each task. We also computed separate sub-scores for the total number of auditory (out of 5) and visual (out of 5) tasks passed.

Table 2. Theory-of-Mind Tasks

<table>
<thead>
<tr>
<th>Task</th>
<th>Premise (Children’s ability to…)</th>
</tr>
</thead>
</table>
| Diverse Desires (DD)        | Understand that people might have different desires than their own, and this will guide their behavior  
                            | Auditory: Piano versus drums sound clips                                                         |
| Diverse Beliefs (DB)        | Understand that people might have different beliefs about the same object, and the child does not know which belief is true or false  
                            | Auditory: Ambiguous sound (Is it a cow or sheep?)                                               |
| Knowledge Access (KA)       | Attribute knowledge and ignorance to a person                                                    
                            | Auditory: Sealed, opaque box filled with pennies                                                   |
| False Belief (FB)           | Understand that two people can have different or conflicting beliefs about the same event       
                            | Auditory: Toy dog producing a cat sound                                                          |
| Real-Apparent Emotions (RAE)| Understand that a person can feel one emotion internally but display a different emotion        
                            | Auditory: Narrative plus auditory emotion scale- child laughing, crying, or neutral “hmm”       |
Figure 1. Images representing the stimuli used to test the five aspects of theory-of-mind development.

Objects and text presented on the left of each protagonist are used in the visual tasks, while objects and text presented on the right are used in the auditory tasks.
2.4 Procedures

Parents and children were invited to participate in one session in the Learning and Development Laboratory at Georgia State University. Sessions were approximately one hour and involved several brief experiments in addition to the theory-of-mind tasks. These experiments varied based on the child’s age, as well as the current studies being administered in the laboratory. A quarter of the time (~15 minutes) was allocated for the theory-of-mind tasks, but there was no set order for when the 10 tasks were presented relative to other studies.

Each child was tested individually in a quiet room and was seated at a small table across from the experimenter. A parent was allowed to remain in the room throughout the administration; the parent was seated behind the child so as to minimize distractions. The session was video-recorded from two mounted cameras providing separate angles for reviewing purposes. One camera angle focused on the child and the stimuli being manipulated while the other provided a profile view of the experimenter, child, and stimuli. Stimuli were kept out of sight until the child was introduced to a given task.

Parents completed a general consent form and brief demographic questionnaire prior to testing. We maintained confidentiality by assigning each participant an identification number and storing the video records in a locked cabinet housed in a locked room.

2.5 Inter-observer Agreement

The principal investigator, who was also responsible for administering the sessions, initially scored each child’s responses. Inter-observer agreement was assessed for both modalities using Cohen’s kappa (Cohen, 1960), and agreement was defined as both coders awarding one point for successfully passing a task or zero points for failing a task. To assess agreement, two observers independently coded the 5 visual and 5 auditory tasks for 15 (23%)
children. Sessions were randomly selected from the corpus with the constraint that each age group was represented equally.

We tallied the frequency of agreements and disagreements using two, 2x2 contingency (kappa) tables for the visual and auditory tasks (see Bakeman & Quera, 2011). Of the 75 judgments per modality; 34 were pass and 38 were fail; in 3 cases, the second observer called a fail what the first observer called a pass, and in no cases did the second observer call a pass what the first observer called a fail. Based on the subset of videos coded, kappas for performance on each task were .92 for the auditory and visual tasks, which yielded 95% agreement between the observers.

3 RESULTS

Each of the five aspects of theory-of-mind development was assessed using an auditory and visual task (see Figure 1). Children were tested on all 10 tasks and were given a total score of number of tasks correct ranging from 0 to 10. On average, children passed approximately half of all tasks ($M_{score} = 4.89, SD = 2.42$).

3.1 Children’s Performance Across Modalities

Our first goal was to develop a set of five auditory tasks that paralleled the tasks used to establish Wellman & Liu’s (2004) theory-of-mind scale. These novel tasks would help us address our first research question of whether or not children are able to reason about mental-state representations in the auditory realm. Since both sets of tasks assessed the same aspects of mental-state understanding, we anticipated that children would perform similarly on the auditory and visual theory-of-mind scale tasks. Our results indicated that children were able to pass a comparable number of auditory ($M_{score} = 2.39, SD = 1.26$) and visual tasks ($M_{score} = 2.50, SD = 1.34$). Table 3 shows the total number and percent of children who passed each
auditory and visual task, as well as results from Wellman and Liu’s (2004) study. The findings revealed considerable differences in the proportion of children who passed the visual tasks in both samples, with fewer preschoolers from our sample passing each task compared to Wellman and Liu’s (2004) sample.

To determine whether children’s performance was influenced by modality, age, or gender, we conducted a repeated measures analysis of variance with age and gender as the between-subjects factors and modality as the repeated measures factor. We expected to find a significant main effect of age, but no effect of gender or modality. The results confirmed a significant main effect of age, along with a main effect of gender. There was no significant effect of modality on performance, nor did we find any significant interactions among the variables.

As expected, children passed significantly more tasks with increasing age, $F(2, 60) = 21.34, p < .001, \eta_p^2 = .416$ (See Table 4). We found that 5-year-olds performed significantly better than 3-year-olds ($p < .001$), and 4-year-olds performed significantly better than 3-year-olds ($p < .001$); however, there was no significant difference in performance between 4- and 5-year-old children (Bonferroni’s post-hoc analyses). On average, 3-year-olds passed less than half of all tasks ($M_{score} = 3.0, SD = 1.6$), 4-year-olds passed approximately half of the tasks ($M_{score} = 5.6, SD = 2.4$), and 5-year-olds passed more than half of all 10 tasks ($M_{score} = 6.7, SD = 1.8$).
Table 3. Numbers (and Percentages) of Children who Passed the ToM Tasks

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(N = 66)</td>
<td>(N = 66)</td>
<td>(N = 75)</td>
</tr>
<tr>
<td>Diverse Desires</td>
<td>48 (72.7)</td>
<td>52 (78.8)</td>
<td>71 (95)</td>
</tr>
<tr>
<td>Diverse Beliefs</td>
<td>52 (78.8)</td>
<td>54 (81.8)</td>
<td>63 (84)</td>
</tr>
<tr>
<td>Knowledge Access</td>
<td>32 (48.5)</td>
<td>32 (48.5)</td>
<td>55 (73)</td>
</tr>
<tr>
<td>False Belief-Contents</td>
<td>18 (27.3)</td>
<td>18 (27.3)</td>
<td>44 (59)</td>
</tr>
<tr>
<td>Real-Apparent Emotion</td>
<td>8 (12.1)</td>
<td>8 (12.1)</td>
<td>24 (32)</td>
</tr>
</tbody>
</table>

*Note.* The table shows the total number (and percentage) of children correct on each task, ordered from the easiest to the hardest, as per the theory-of-mind scale. Wellman and Liu’s (2004) results include data from 75, 3-, 4-, and 5-year-olds.
Table 4. Numbers (and Percentages) of Children who Passed the ToM Tasks by Age

<table>
<thead>
<tr>
<th></th>
<th>Visual Tasks</th>
<th>Auditory Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3yo</td>
<td>4yo</td>
</tr>
<tr>
<td>Diverse Desires</td>
<td>13 (59.1%)</td>
<td>17 (77.3%)</td>
</tr>
<tr>
<td>Diverse Beliefs</td>
<td>14 (63.6%)</td>
<td>19 (86.4%)</td>
</tr>
<tr>
<td>Knowledge Access</td>
<td>2 (9.1%)</td>
<td>11 (50.0%)</td>
</tr>
<tr>
<td>False Belief-Contents</td>
<td>1 (4.5%)</td>
<td>9 (40.9%)</td>
</tr>
<tr>
<td>Real-Apparent Emotion</td>
<td>0 (0.0%)</td>
<td>4 (18.2%)</td>
</tr>
<tr>
<td>Mean # of tasks correct (SD)</td>
<td>1.41 (.91)</td>
<td>2.73 (1.24)</td>
</tr>
</tbody>
</table>

*Note. n = 22 per age group; (SD) represents Standard Deviation values*
Contrary to our predictions, we found a significant effect of gender on overall performance \( F(1, 60) = 4.12, p < .047, \eta^2_p = .064 \). When we compared the total number of correct responses, girls \( (M_{score} = 5.5, SD = 2.1) \) performed significantly better than boys \( (M_{score} = 4.4, SD = 2.6) \), \( F(1, 44) = 6.46, p < .015, \eta^2_p = .128 \). There was no significant interaction between gender and modality, but looking at the mean number of tasks children passed, we found that girls \( (M_{score} = 2.9, SD = 1.2) \) performed significantly better than boys \( (M_{score} = 2.2, SD = 1.4) \) on the visual tasks, \( t(64) = -2.10, p = .04; d = .53 \), but not on the auditory tasks, \( t(64) = -1.42, p = .16; d = .35 \).

Given our focus on the effect of modality on children’s performance for theory-of-mind tasks, we inspected the patterns of performance on each task as a function of modality even though we did not find a main effect for modality. As shown in Figure 2, there were no clear differences in performance related to modality on any individual task. The results displayed in Table 4 also show minimal to no differences in the number of children who passed each task across modalities. For example, more 4-year-olds passed the visual False Beliefs task (40.9%) compared to the auditory False Belief task (22.7%); however, this was a difference of just four (out of 22) children. All 3-year-old children failed to pass the visual Real-Apparent Emotions task, but only one passed the parallel auditory task. Five-year-olds demonstrated a similar understanding across all tasks and both modalities. Additionally, there was no effect of task order on children’s performance.
Figure 2. Total proportion of children correct by modality of task and age.

The 10 tasks are abbreviated above as: Diverse Desires (DD), Diverse Beliefs (DB), Knowledge Access (KA), False Belief (FB), Real-Apparent Emotion (RAE).
3.2 Scaling Theory-of-Mind Development

Our second goal was two-fold: 1) we wanted to identify when children come to understand others’ mental-state representations of auditory experiences, and 2) we were interested in knowing whether theory-of-mind abilities develop at the same time and progress in the same sequence as Wellman & Liu’s (2004) theory-of-mind scale.

To address the first part of our goal, we computed how many children passed the auditory tasks in each age group (see Table 4). We found that our youngest participants (3-year-olds) were able to reason about some mental states in the auditory realm particularly for the Diverse Desires and Diverse Beliefs tasks. Four- and five-year-olds performed better than 3-year-olds on the auditory tasks, but there was greater variability in 4- and 5-year-olds ability to reason about False Belief and Real-Apparent Emotions.

To address the second part of our goal, we identified which children fit the strict Guttman patterns of the theory-of-mind scale (Diverse Desires, Diverse Beliefs, Knowledge Access, False Belief, and Real-Apparent Emotions) for the visual and auditory tasks. We hypothesized that children would pass the auditory tasks in the same sequence as the theory-of-mind scale since the auditory tasks were comparable to other tasks utilized in Wellman and Liu’s (2004) scale. The patterns for the visual and auditory tasks were analyzed separately, and patterns ranged from passing none of the tasks (- - - - -), to passing one (+ - - - -), two (+ + - - -), three (+ + + - -), four (+ + + + -), or all five tasks (+ + + + +). A child who did not fit any of the patterns demonstrated an alternative pattern where he or she passed a later task along the scale, but failed even one easier item. Alternative patterns were categorized as “other”.

Table 5 contains the six ideal Guttman response patterns for a five-item scale (top) and frequency counts related to children’s performance on the visual and auditory tasks (bottom). As
shown in the table, 50 of the 66 (75.8%) children in our sample fit one of the six ideal theory-of-mind scale patterns for the visual tasks. Of the 16 (24.2%) children who demonstrated an alternative pattern, 7 (10.6%) children showed only a reversal in understanding at the Diverse Desires and Diverse Beliefs stage. Wellman and Liu (2004) reported that 60 of their 75 (80%) preschool participants fit the strict Guttman patterns, while 15 (20%) children were categorized as “other” (based on the results they reported, it was not possible to determine which alternate patterns occurred most often in their sample). Children tended to pass more items in succession with increasing age; the relationship between age (in months) and Guttman scale score for the visual tasks was high, \( r(66) = .60, p < .01 \). Wellman & Liu (2004) also reported a high correlation between age and scale scores, \( r(75) = .64, p < .001 \).

Our analyses resulted in similar findings for the auditory tasks. We fit children’s responses to the Guttman patterns defined by Wellman & Liu’s (2004) theory-of-mind scale and found that 44 of the 66 (66.7%) children fit the scale (see Table 5). Of the 22 (32.3%) children who fit an alternative pattern (passed a later task along the scale but failed even one easier item), 6 (9.1%) children showed a reversal in understanding only at the Diverse Desires and Diverse Beliefs stage. We also found a strong relationship between age (in months) and Guttman scale score for the auditory tasks (summing the items passed out of five), \( r(66) = .50, p < .01 \).
Table 5. Patterns for the Visual and Auditory ToM Guttman Scales and Number of Children who Fit the Patterns

<table>
<thead>
<tr>
<th></th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverse Desires</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Diverse Beliefs</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Knowledge Access</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>False Belief-Contents</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Real-Apparent Emotion</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

**Visual**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-olds</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>6</td>
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<tr>
<td>4-year-olds</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>5-year-olds</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4</td>
<td>4</td>
<td>15</td>
<td>13</td>
<td>9</td>
<td>5</td>
<td>16</td>
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</tbody>
</table>

**Auditory**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-year-olds</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>4-year-olds</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>5-year-olds</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4</td>
<td>5</td>
<td>10</td>
<td>13</td>
<td>10</td>
<td>2</td>
<td>22</td>
</tr>
</tbody>
</table>

**Note.** A minus sign indicates that the child failed the task; a plus sign indicates the child passed. Any child who did not exhibit one of the six patterns (P) presented above was categorized as “Other”. N = 66, 22 in each age group.
We analyzed children’s performance at the individual-level to determine how many fit the scale in one modality but not another. Our results yielded: 13 of the 66 (19.7%) children fit the scale for the visual tasks but not auditory, 6 of the 66 (9.1%) children fit the scale for the auditory tasks but not visual, and 9 of the 66 (13.6%) children did not fit either the visual or auditory Guttman scales.

We computed the coefficient of reproducibility (Rep) using Green’s method of estimation to determine if our results formed a scalable set. The coefficient of reproducibility from the scalogram analysis was .95 for our visual tasks (after removing two children who did not pass any tasks) and .92 for our auditory tasks (after removing two children who did not pass any tasks). Values greater than .90 indicate scalable items, thus both auditory and visual tasks formed a scalable set.

Green’s index of consistency (I) estimates the Rep that would be expected by chance if the tasks were mutually independent. Green’s index of consistency was .47 for the visual tasks and .29 for the auditory tasks (values greater than .50 are considered significant). Thus, the scales did not form a scalable set when compared to chance; however Green (1956) notes that the index of consistency is more conservative than the coefficient of reproducibility. Wellman & Liu (2004) report Green’s index of consistency for the visual tasks was .56.

3.3 Task-Level Analyses

Wellman and Liu (2004) also conducted a series of pairwise comparisons to determine whether particular tasks were easier than others. We conducted the same analyses for both auditory and visual tasks, particularly since we found some children passed Diverse Beliefs prior to Diverse Desires. Our results confirmed three significant pairwise comparisons across modalities. First, Diverse Beliefs was significantly easier than False Beliefs in both the auditory
Second, Knowledge Access was significantly easier than False Belief in both the auditory (McNemar’s $\chi^2 (1) = 8.65, p < .003$) and visual realms (McNemar’s $\chi^2 (1) = 8.45, p < .004$). Finally, the False Beliefs task was significantly easier than the Real-Apparent Emotions task in both the auditory (McNemar’s $\chi^2 (1) = 5.04, p < .025$) and visual (McNemar’s $\chi^2 (1) = 5.06, p < .024$) realms. However, the earliest two tasks did not appear in a sequence; Diverse Desires did not prove to be easier than Diverse Beliefs in either the auditory or visual modality, McNemar’s $\chi^2 (1) = .45, p = \text{ns}$ and $\chi^2 (1) = .01, p = \text{ns}$, respectively.

As shown in the Guttman scales, a child often reached a particular task that was too difficult and failed all subsequently harder tasks. We were interested in examining whether they were unable to pass the task because of poor comprehension of the control questions or because the entire task was too difficult. The Diverse Desires and Diverse Beliefs tasks require the child to state his or her own desire/belief, and then identify the protagonist’s contrasting mental state. Thus, only three of the five aspects of theory-of-mind development were of interest because Diverse Desires and Diverse Beliefs did not have control questions that a child could fail.

Of the children who did not pass the target questions for the Knowledge Access task, 22 (65%) passed the control questions for the visual task and 25 (74%) passed the control questions for the auditory task. Even more children demonstrated comprehension for the visual and auditory False Belief control questions, 45 (94%) and 41 (85%), respectively. The Real-Apparent Emotions tasks required children to answer two control questions and two target questions (see Appendix A). Of the children who did not successfully pass this task, 6 (10%) children were able to answer both control questions for the visual task, and 7 (12%) children were able to answer both control questions on the auditory tasks. Furthermore, 15 (26%)
additional children were able to correctly answer that Matt’s aunt bought him a book in the visual task, and 17 (29%) were able to correctly answer that Matt’s aunt said she would take him to the mall, but all of these children failed to answer the second control question of what Matt’s aunt would do if she knew how Matt really felt. Children largely misunderstood this control question and prematurely answered with an emotion (happy, sad, or okay).

Children who failed either the Knowledge Access or False Belief task because of the target question still demonstrated an understanding of the task and the concealed object/sound, but their ability to extend that knowledge to the protagonist was lacking. Although few children passed the Real-Apparent Emotions task overall, a vast majority who failed did so because they could not answer how Matt’s emotions could impact his aunt’s behavior. However, most children were able to answer the first control question related to what Matt’s aunt did (bought him a book; said she was taking him to the mall), but not what Matt’s aunt would do, in the future, if she knew how he really felt (she would never buy him anything ever again; she would never take him anywhere ever again). Thus, children were able to comprehend the Knowledge Access, False Belief, and part of the Real-Apparent Emotions tasks, and it is valuable to assess performance on these control questions because they provide more information about children’s emerging understanding.

4 DISCUSSION

The current study was the first to investigate preschoolers’ mental-state abilities in the auditory realm using a set of auditory tasks that paralleled Wellman and Liu’s (2004) theory-of-mind scale. In line with previous research (Calero, Salles, Semelman, & Sigman, 2013; Wellman & Liu, 2004), children’s capacity to understand various aspects of theory of mind (i.e., desires, beliefs, and emotions) increased with age, and we found evidence of this progression
using the auditory tasks as well. Children as young as 3 years old were able to reason about some aspects of others’ auditory representations of thoughts, behaviors, and emotions, and, in line with other studies of mental-state understanding (Davis, 2001; Flavell, Flavell, Green, & Moses, 1990; Gelman & Au, 1996), they made significant strides in theory-of-mind development in the auditory realm during the preschool years.

Overall, children passed a comparable number of tasks across visual and auditory modalities. We also found that performance on three of the five aspects of theory-of-mind development (Diverse Desires, False Belief, and Real-Apparent Emotion) was equivalent across modalities. Given that modality did not significantly affect performance, we would expect that a child who was able to reason about others’ mental states for the visual properties of objects would also be able to reason about others’ mental states for its auditory properties. Auditory and visual tasks were matched to assess the same aspects of theory-of-mind development, thus equivalent performance across modalities shows mastery of the underlying construct.

Our results indicated that girls had a higher total score correct than boys. Although, Wellman and Liu (2004) did not find a significant effect of gender on children’s performance, our findings are consistent with other studies in the literature. For example, Charman, Ruffman, and Clements (2002) found that girls had a significant, but weak, advantage in their performance on false belief tasks. Similarly, Nelson, Adamson, and Bakeman (2008) found preschool-aged girls passed significantly more false belief tasks than boys.

Guttman scalogram analysis of the visual tasks revealed a slightly different pattern for our sample compared to Wellman & Liu’s (2004) sample. We administered the same visual tasks presented in the theory-of-mind scale; however, some children demonstrated a reversal in passing the Diverse Beliefs task prior to the Diverse Desires task. Thus, these children no longer
fit the scale, and were classified as fitting an alternative pattern. Approximately one-fourth of participants did not fit the visual Guttman patterns.

A majority of children passed the auditory tasks in the same sequence as the visual tasks; however, one in three children did not fit the auditory patterns. This was particularly evident amongst 3-year-olds. As mentioned before, there are several explanations for this reversal (i.e., genuine understanding of beliefs prior to desires, order of the tasks being presented, individual differences, cultural differences, etc.). Pairwise comparisons also confirmed that Diverse Desires was not significantly easier than Diverse Beliefs in either modality. Reversals in the sequence have also been found when comparing theory-of-mind abilities across cultures; however the reversal occurs between the stages of Diverse Beliefs and Knowledge Access (Shahaeian, Peterson, Slaughter, Wellman, 2011).

Our findings are comparable in many regards to what Wellman & Liu (2004) report, but some differences did emerge. Children in both samples showed a greater ability to reason about mental states with increasing age, and demonstrated theory-of-mind abilities prior to four years of age. Considerably more children in Wellman & Liu’s sample passed each task, but this difference was most likely due to differences in sample characteristics. Our 3-year-olds averaged 6 months younger than their sample of children. There was no major difference in the mean age of 4-year-old participants; however, our mean age for 5-year-olds was 5 years, 3 months compared to 5 years, 7 months for Wellman & Liu (2004). It is also worth noting that our oldest participant was 5 years, 9 months, whereas they assessed children until the age of 6 years, 6 months.

Using Green’s coefficient of reproducibility (Rep) summary statistic we found that the visual tasks in both studies were highly scalable as were the newly crafted auditory tasks.
Wellman & Liu (2004) also computed Green’s index of consistency ($I$) to determine whether their visual tasks would be scalable if the tasks were treated as mutually independent and compared to chance. Green (1956) notes that the chance reproducibility criterion of $I = .50$ gives “roughly comparable results” to other indices that have been used and that it was established for those who simply want to indicate a dichotomy of scales versus nonscales. Wellman and Liu (2004) report $I = .56$; however, neither the visual ($I = .47$) nor auditory tasks ($I = .26$) in our study met criterion. Our findings for the scalability of the visual tasks using Green’s index of consistency were largely the same as Wellman & Liu’s (2004) findings. On the other hand, Green’s index of consistency yielded a nonscale for the auditory tasks. It is possible that the greater number of deviations from the theory-of-mind scale (children categorized as “other”) for the auditory tasks impacted the index value. Since theory-of-mind abilities are not mutually exclusive skills, the coefficient of reproducibility is a better measure than the index of consistency for determining whether the tasks represent a scalable set. We therefore confirm that the visual tasks are a scalable set, and based on the Guttman scalogram analysis and Green’s coefficient of reproducibility, conclude that the auditory tasks also form a scalable set.

The addition of these five new scalable auditory tasks enables researchers to probe the underlying constructs of theory-of-mind from another modality. Sounds are private (Maclachlan, 1989), just like internal mental states. Investigations using these auditory tasks could provide valuable information about the dual-role language plays in the development of mental-state understanding. Language acquisition is also an auditory experience that begins early in life. There is evidence that children’s use of mental-state words at 2.5 years is correlated with their performance on false belief tasks at 4.5 years of age (Brooks & Meltzoff, 2015). Language abilities are just as crucial to developing mental-state understanding (Astington, 2001).
Thus, looking at the relationship between language development and auditory tasks could provide more information about how children come to understand others’ mental states. This relationship may also help explain how gender influences performance on theory-of-mind tasks. For example, girls may acquire vocabulary for mental states earlier, if mothers spend more time talking about emotions with girls than boys (Dunn, Bretherton, & Munn, 1987). It is also possible that differences in performance among preschool boys and girls are related to greater amounts of time spent in symbol-infused joint engagement during toddlerhood (Nelson, Adamson, & Bakeman, 2008) and to higher verbal abilities for girls in preschool (Maccoby, 1966). The tasks demand children to follow linguistically complex stories, and differences in language skills, as well as differences in experience with talking about emotion, could translate to differences in performance. Our study did not capture any data on children’s verbal or language abilities; however, future work should incorporate a language measure to determine how verbal skills may influence performance on auditory tasks.

Moreover, the auditory tasks formed a scalable set according to the Guttman scalogram and Green’s coefficient of reproducibility, thus the tasks can be extended to other populations. It would be beneficial to administer these tasks on individuals who are visually impaired or have sensory difficulties (e.g., children with autism spectrum disorder). Research with both of these populations have shown delays or differences in sequence in theory-of-mind understanding, but perhaps assessing children using a variety of auditory tasks will reveal different patterns of mental-state understanding.

Children with congenital blindness (without any additional impairments) have shown substantial delays, up to four years, in their ability to pass false belief tasks (Brambring & Asbrock, 2010; Peterson, Peterson, & Webb, 2000); It is possible that their responses were
limited by the format of the tasks and do not reflect their actual understanding of mental states. For example, blind children are limited in their ability to observe emotions through facial expressions and gestures (McAlpine & Moore, 1995). Thus, asking them to reason about someone’s real versus apparent emotions would be difficult since this is not the way they experience the world. Pérez-Pereira and Conti-Ramsden (2005) note that finding adequate and reliable tasks for blind children, that are equivalent to tasks for sighted children, is difficult. Perhaps probing their knowledge about mental states through auditory tasks could reveal an earlier understanding of others’ thoughts, beliefs, and emotions.

Children with autism spectrum disorder consistently show a deficit in performance on implicit and explicit theory-of-mind tasks (Holroyd & Baron-Cohen, 1993; Peterson, Wellman, & Liu, 2005; Sodian, Schuwerk, & Kristen, 2015), and they demonstrate a substantial disadvantage when having to predict others’ behaviors (Baron-Cohen, Leslie, and Frith, 1985). Most longitudinal studies show a consistent deficit or delay in performance, but Steele, Joseph, and Tager-Flusberg (2003) administered 10 theory-of-mind tasks to children with autism spectrum disorder between the ages of 4 to 14 years (initial visit) and found significant improvements in performance one year later. They suggest that using 10 tasks enabled them to assess a range of theory-of-mind abilities including desires, contents false belief, knowledge perception, lies and jokes, and moral judgments. Similarly, the auditory tasks developed for our study provide more and varied tasks that could potentially tap into a broader range of mental-state understanding.

The primary aim of this study was to expand the theory-of-mind scale to explore how the modality in which desires, beliefs, access to knowledge, and emotions are presented might influence theory-of-mind development in typically developing preschoolers. Our largest
contribution is the addition of five new auditory tasks that parallel the theory-of-mind scale and prove to be scalable. The findings add to the growing body of research that utilize multiple tasks to assess theory-of-mind (rather than relying on the false belief tasks alone) and to the literature demonstrating mental-state understanding prior to age four.

As noted by Wellman & Liu (2004), the theory-of-mind scale confirms that mental-state abilities develop in a progression. The auditory tasks we utilized move beyond the confines of predominantly visual false-belief tasks and provide additional evidence that theory-of-mind development begins prior to four years of age. In sum, our results support the idea that preschool-aged children demonstrate a developmental progression in their ability to reason about others’ mental state representations, and that they can do so across a variety of theory-of-mind tasks in the visual and auditory realms.
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APPENDIX

Appendix A. Theory-of-Mind Tasks Manual

**General Procedures:** The Theory-of-Mind Scale tasks always begin with a Diverse Desires task and end with a Real-Apparent Emotion task. The remaining eight tasks are randomized. All of the stories and prompts are located on a set of numbered cards. Be sure to present sounds and objects to the child in the order described on the story cards. Placement of the characters relative to the objects is key for certain tasks (e.g., Diverse Desires-Visual).

**Tasks:** 10 (DD-V, DB-V, KA-V, FB-V, RAE-V, DD-A, DB-A, KA-A, FB-A, RAE-A)

**Props:**
- Story cards (Set of 10)
- Characters (small figurines)
  - Mr. Jones
  - Linda
  - Polly
  - Peter
  - Matt
- Objects
  - 8.5 x 11 laminated sheet of paper with a color drawing of a carrot on one half and cookie on the other
  - 8.5 x 11 laminated sheet of paper with a color drawing of bushes on one half and a garage on the other
  - Small nondescript rectangular container that can be opened/shut
  - Toy dog to fit in the small nondescript rectangular container
  - Small nondescript box with pennies inside (should be sealed shut)
  - Standard Band-Aid box with Band-Aid image on front
  - Toy pig to fit inside the Band-Aid box
  - Stuffed animal toy dog with small audio recorder inside
  - 8.5 x 11 laminated sheet of paper with emotion scale (three simple faces, bare-bones smiley-type black and white faces of just circular outline plus simple eyes and line-like mouths). One happy, one sad, and one neutral (in the middle)
- Sound clips:
  - Piano
  - Drums
  - Ambiguous animal sound
  - Cat meowing
  - Child laughing
  - Child crying
  - Child neutral (child says “hmm”)

**Set-up:** Be sure that all sounds clips have been loaded onto the media player and the volume is set to 100%. Keep all props out-of-sight.
Administration guidelines and story cards: The theory-of-mind scale tasks have a set of 10 accompanying story cards. Each story card contains information regarding the props, set-up, questions, and scoring guidelines necessary to administer the task. Below are some guidelines to follow when administering each task:

<table>
<thead>
<tr>
<th>Task</th>
<th>Total # of times to ask the question</th>
<th>When faced with non-compliance, should you return to the task later?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverse Desires</td>
<td>2x</td>
<td>Yes, only once more</td>
</tr>
<tr>
<td>Diverse Beliefs</td>
<td>2x</td>
<td>Yes, only once more</td>
</tr>
<tr>
<td>Knowledge Access</td>
<td>2x</td>
<td>Yes, unless you have already opened/shaken the box</td>
</tr>
<tr>
<td>False Belief</td>
<td>Follow prompts on script</td>
<td>Yes, unless you have already opened the box/played the sound</td>
</tr>
<tr>
<td>Real-Apparent Emotion</td>
<td>2x</td>
<td>No</td>
</tr>
</tbody>
</table>

The story cards are as follows:

**Diverse Desires**

- **Visual** -

**Props:** Small figurine of man. 8.5x11 paper with drawings of carrot on one half and cookie on the other.

**Story:** Here’s Mr. Jones *(place figurine next to picture, midway between two items).* It is snack time, so Mr. Jones wants a snack to eat. Here are two different snacks: a carrot *(point)* and a cookie *(point)*.

**Contrast Question:** Which snack would you like best? Would you like a carrot *(point)* or a cookie *(point)* best?

- **If carrot:** Well, that’s a good choice, **BUT** Mr. Jones really likes cookies *(don’t point)*. He doesn’t like carrots. What he likes best are cookies.

- **If cookie:** Well, that’s a good choice, **BUT** Mr. Jones really likes carrots *(don’t point)*. He doesn’t like cookies. What he likes best are carrots.

**Question:** So, now it’s time to eat. Mr. Jones can only choose one snack, just one. Which snack will Mr. Jones *(point to Mr. Jones)* choose? A carrot or a cookie?

**Scoring:** Child passes if they answer the target question opposite from his/her answer to the own-desire question.
Diverse Desires - Auditory -

Props: Small figurine of man. Sound clips of piano and drums.

Story: Here's Mr. Jones (place figurine on the table). It is music time, so Mr. Jones wants to choose an instrument to hear. Here are two different instruments: the piano (play clip) and the drums (play clip).

Contrast Question: Which instrument would you like best? Would you like to hear the piano (play clip) or the drums (play clip) best?

If piano: Well, that's a good choice, BUT Mr. Jones really likes the drums (don't play clip). He doesn't like the piano. What he likes listening to are the drums.

If drums: Well, that's a good choice, BUT Mr. Jones really likes the piano (don't play clip). He doesn't like the drums. What he likes listening to best is the piano.

Question: So, now it's music time. Mr. Jones can only choose one instrument, just one. Which instrument will Mr. Jones (point to Mr. Jones) choose? The piano or the drums?

piano drums

Scoring: Child passes if they answer the target question opposite from his/her answer to the own-desire question.

Diverse Beliefs - Visual -

Props: Small figurine of girl. 8.5x11 paper with drawings of bush on one half and garage on the other.

Story: Here's Linda (place figurine next to picture, midway between two items). Linda wants to find her cat. Her cat might be hiding in the bushes (point) or it might be hiding in the garage (point).

Contrast Question: Where do you think the cat is? In the bushes (point) or in the garage (point)?

If bushes: Well, that's a good idea, BUT Linda thinks her cat is in the garage (don't point). She thinks her cat is in the garage.

If garage: Well, that's a good idea, BUT Linda thinks her cat is in the bushes (don't point). She thinks her cat is in the bushes.

Question: So, where will Linda (point to Linda) look for her cat? In the bushes or in the garage?

bushes garage

Scoring: Child passes if they answer the target question opposite from his/her answer to the own-belief question.
Diverse Beliefs

Props: Small figurine of girl. Ambiguous sound clip.

Story: Here’s Linda (place figurine on table). Linda wants to find out what this sound is (play clip). The sound might be a cow or a sheep.

Contrast Question: What do you think the sound is? A cow (play clip) or a sheep (play clip)?

___ If cow: Well, that’s a good idea, BUT Linda thinks it is a sheep (don’t play clip). She thinks it sounds like a sheep.

___ If sheep: Well, that’s a good idea, BUT Linda thinks it is a cow (don’t play clip). She thinks it sounds like a cow.

Question: So, what does Linda (point to Linda) think the sound is? A cow or a sheep?

___ cow  ___ sheep

Scoring: Child passes if they answer the target question opposite from his/her answer to the own-belief question.

Knowledge Access

Props: Small figurine of a girl, small nondescript rectangular box, toy dog to fit inside of the box

Story: Here’s a box (keep lid closed). What do you think is inside the box?
(Child can give any answer: ________________).

Let’s see. There’s really a dog inside! (Open lid to reveal dog). (Close lid again to restrict view after a pause).

Okay, what is in the box? ____________
(If the child makes an error; open the box again to show the child what is inside; only repeat once).

Polly has never ever seen inside this box. (Take Polly out). Now, here comes Polly.

Questions: So, does Polly know what is in the box?

___ yes  ___ no

Did Polly see inside this box?

___ yes  ___ no

Scoring: Child passes if they answer the target question “no” and the memory question “no”
Knowledge Access

Props: Small figurine of a girl, small nondescript box with money (pennies) inside

Story: Here’s a box (keep box closed). What do you think is inside the box?
(Child can give any answer: ________________).

Let’s listen. There are really pennies inside!
(Do NOT open the box to reveal the pennies).

Okay, what is in the box? ____________
(If the child makes an error, shake the box again to remind them, and ask once again).

Polly has never ever heard what’s inside this box. (Take Polly out). Now, here comes Polly.

Questions: So, does Polly know what is in the box?
_____ yes  _____ no

Did Polly see inside this box?
_____ yes  _____ no

Scoring: Child passes if they answer the target question “no” and the memory question “no”

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Contents False Belief

Props: Small figurine of a boy, Band-aid box with picture of a Band-aid on front, toy pig to fit in box

Story: Here is a Band-aid box (keep lid closed). What do you think is inside the Band-aid box?
(Prompt the child if they do not answer: “Does it look like there would be Band-Aids inside? What kind of box is this? What should be in here? Should there be Band-Aids in here or books in here?”)

Let’s see. There’s really a pig inside! (Open lid to reveal pig).
(Close lid again to restrict view after a pause).

Okay, what is in the Band-aid box? ____________
(If the child makes an error, show contents inside the box; repeat only once).

Peter has never ever seen inside this box. (Take Peter out). Now, here comes Peter.

Questions: So, what does Peter think is in the box? Band-aids or a Pig?
_____ Band-aids  _____ pig

Did Peter see inside this box?
_____ yes  _____ no

Scoring: Child passes if they answer the target question “Band aids” and the memory question “no”
Contents False Belief

Props: Small figurine of a boy, stuffed animal toy dog, small audio recorder with cat meowing clip

Story: Here is a toy. What sound do you think this toy will make?
(Prompt child to say dog sound if necessary).

Let’s listen. (Squeeze the toy dog). That’s really a cat meowing!

Okay, what sound does the toy make? __________
(If the child makes an error, play the sound again; repeat only once).

Peter has never heard the sound the toy makes (Take Peter out). Now, here comes Peter.

Questions: So, what sound does Peter think the toy will make? A dog sound or a cat sound?

_______ dog ___ cat

Did Peter hear the sound the toy makes?

____ yes ______ no

Scoring: Child passes if they answer the target question “Dog” and the memory question “no”

Real-Apparent Emotion

Props: Small figurine of a boy (back of head only!), emotion scale containing three b&w smiley faces

Story: Now, I’m going to tell you a story about Matt. (Take out emotion scale) In this story, Matt might feel happy (point). He might feel sad (point). Or he might not feel happy or sad, just okay (point).

Can you point to the face that is: Happy? Sad? Okay? (Re-train once if necessary)

Okay, now about the story: After I’ve finished the story, I’m going to ask you about how Matt really feels, inside (pat own chest). AND how he looks on his face (pat own cheek). How he really feels inside (pat own chest) may be the same as how he looks on his face (pat own cheek), or it may be different.

Are you ready to hear the story? Okay, pay attention. This story is about Matt (show back of figurine). Matt’s aunt just got back from a trip. She promised that she would buy Matt a toy car. But, she got Matt a book instead. Matt doesn’t like books. What Matt really wants is a toy car. But Matt has to hide how he feels, because if his aunt knows his real feelings, she’ll never buy him anything again.
**Real-Apparent Emotion**  

**Questions:** So, what did Matt’s aunt buy for him?  
(Correct answer: book. If the child gets the answer wrong, repeat the story once more)

What will Matt’s aunt do, if she knows how Matt really feels?  
(Correct answer: she will never buy anything for Matt anymore. If the child gets the answer wrong, repeat the story once more).

So, how did Matt really feel (pat own chest), when his aunt gave him the book—Happy, Sad, or Okay?  
(Note: the examiner should not show any feelings)

___ Happy  ___ Sad  ___ Okay

How did Matt try to look on his face (pat own face), when his aunt gave him the book—Happy, Sad, or Okay?  
(Note: the examiner should not show any feelings)

___ Happy  ___ Sad  ___ Okay

**Scoring:** Child passes if they answer the really-feel question more negatively than the looks-on-his-face question

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**Real-Apparent Emotion**  

**Props:** Small figurine of a boy (back of head only!), emotion scale with three sound clips (child laughing, crying, neutral)

**Story:** Now, I’m going to tell you a story about Matt. (Prepare to play the emotion scale) In this story, Matt might feel happy (play child laughing). He might feel sad (play child crying). Or he might not feel happy or sad, just okay (play child saying “hmm”).

Play each sound clip one at a time. Is this: Happy? Sad? Okay?  
(Re-train once if necessary)

Okay, now about the story: After I’ve finished the story, I’m going to ask you about how Matt really feels, inside (pat own chest), AND how he sounds in his voice (touch own ear). How he really feels inside (pat own chest) may be the same as how he sounds in his voice (touch own ear), or it may be different.

“This story is about Matt (show back of figurine). “Matt’s aunt is on the phone. She promised that she would take Matt to visit the zoo today. But, when she called she told Matt that she is taking him to the mall instead. Matt doesn’t like going to the mall. What Matt really wants to do is go to the zoo. But Matt has to hide how he feels, because if his aunt knows his real feelings, she would never take him anywhere again.”
Real-Apparent Emotion cont...  - Auditory -

**Questions:** So, where did Matt’s aunt say she was taking him?
(Correct answer: the mall. If the child gets the answer wrong, tell the story again)

What will Matt’s aunt do, if she knows how Matt really feels?
(Correct answer: she will never take Matt anywhere again. If the child gets the answer wrong, tell the story again).

So, how did Matt really feel (pat own chest), when his aunt called to tell him where they were going (play each sound clip) — Happy, Sad, or Okay?
(Note: the examiner should not show any feelings)

____ Happy _______ Sad ________ Okay

How did Matt try to sound in his voice (touch own ear), when he was talking to his aunt—
Happy, Sad, or Okay?
(Note: the examiner should not show any feelings)

____ Happy _______ Sad ________ Okay

**Scoring:** Child passes if they answer the *really-feel* question *more negatively* than the *sounds-in-his-voice* question

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**Scoring:** Correct answers vary by task. See story cards to determine how to score each task. The child must correctly answer any control questions in addition to the target questions to pass the task. The experimenter should be sure to distinguish between an incorrect answer and no response. Children can also use gestures to indicate their response. A correct answer awards the child a score of 1, while an incorrect answer awards them 0 points. Scores range from 0 to 10.

**General Notes:** In general, the experimenter should wait to administer a task until the child demonstrates some level of engagement (e.g., eye contact, paying attention to the props). It is important to maintain a neutral tone of voice throughout administration. The experimenter should be careful not to prompt any particular response to curb question bias. For the auditory tasks, be sure the child does not hear the sound prior to presentation.