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PREDICTORS OF FIGURATIVE AND PRAGMATIC LANGUAGE COMPREHENSION IN CHILDREN WITH AUTISM AND TYPICAL DEVELOPMENT

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Elisabeth M. Whyte

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The dissertation of Elisabeth M. Whyte was reviewed and approved* by the following:

Keith E. Nelson
Professor of Psychology
Dissertation adviser
Chair of Committee

Reginald Adams
Assistant Professor of Psychology

Rick Gilmore
Associate Professor of Psychology

Carol A. Miller
Associate Professor of Communication Sciences and Disorders

Melvin Mark
Professor of Psychology
Head of the Department of Psychology

*Signatures are on file in the Graduate School.

Abstract

Children with autism often have difficulties with learning various aspects of language, including vocabulary and syntax. Children with autism spectrum disorders also often have a difficult time understanding the pragmatic and figurative (nonliteral) aspects of language, as in idioms such as "it's raining cats and dogs" or "hit the sack". Learning the figurative meaning of nonliteral phrases from the context of conversations, along with learning the appropriate pragmatic use of language in context, may require a combination of cognitive and social processes, along together with fundamental semantic and syntactic skills. The current study examined figurative and pragmatic language abilities in children ages 5 to 12 with autism (ASD) compared to an age-matched typically-developing (TD) group and a language-matched TD group. The current study also examined the relationship between pragmatic and figurative language comprehension and multiple predictors: vocabulary, syntax, theory of mind, social skills, and working memory. Results suggest that idiom comprehension may not be specifically impaired in ASD beyond delays in structural language abilities such as syntax. Syntax, vocabulary (or both) were always significant contributors to performance on idioms, other figurative/nonliteral expressions, and pragmatic expressions, across three methods of analyses. Multiple regressions indicated that in addition to basic language skills, social skills contributed to understanding pragmatic expressions. For figurative/nonliteral expressions, both social skills and Theory of Mind (TOM) contributed to comprehension in addition to basic language skills. For idioms, TOM skills contributed to comprehension in addition to basic language skills. The findings overall fit particularly well with dynamic systems and neuroconstructivist theorizing on how multiple language, cognitive, and social processes work together in supporting the learning and use of nonliteral expressions in language by TD and ASD children of ages 5 to 12 years.

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Chapter 1: Development of figurative and pragmatic language

Autism is characterized by a combination of language and social difficulties. Children with autism may have a difficult time understanding the more figurative aspects of language (where the speaker's intended meaning is different from the literal meanings of the phrases or individual words that make up the phrases). Figurative language includes various types of non-literal language such as idioms, simile, metaphor, proverbs, sarcasm and indirect requests. For example, the figurative meaning of the idiom "raining cats and dogs" is that it is raining really hard outside, not that there are actual cats and dogs falling from the sky. Misunderstanding figurative language may have an impact on children's learning in classroom environments. Figurative language is commonly spoken to children in the classrooms, where even teachers of children with language impairments frequently use figurative phrases (Colston & Kuiper, 2002; Kerbel & Grunwell, 1997; Lazar, Warr-Leeper, Nicholson, & Johnson, 1989). Children who fail to understand the figurative phrases may struggle to understand the directions of their teacher (which is especially problematic for indirect requests, where the teacher may not understand why the child is failing to comply with their directions, e.g. "I want all eyes on the board!"). Pragmatic language development is another domain where children with autism often show delays compared to their typically developing peers. Pragmatic language development is defined as the ability to use language appropriately in context, such as knowing the conventions of how to answer the phone or ask people for assistance or greet people when you meet them for the first time (McTear & Conti-Ramstden, 1992).

There are often a lot of individual differences in the development of figurative language and pragmatic language in childhood, especially for children with autism or other language delays, though the nature of these individual differences is not well understood. Since there is a mismatch between the speaker's intentions and the literal meaning of the words, it is possible that developing the understanding of the figurative meaning of idiomatic phrases ("it's raining cats and dogs") or other figurative phrases ("I want all eyes on the board") from the context of conversations may require a combination of cognitive and social processes which interact dynamically during the learning process. One possible factor that may be related to developing a range of language abilities (including figurative language, pragmatic language, syntax, and vocabulary) is Theory of mind (ToM), defined as the ability to understand the thoughts, emotions, and beliefs of others (Astington & Jenkins, 1999; Happe, 1993). Some previous research also suggests that children with autism or language disorders may have delays in their figurative and pragmatic aspects of language if they also show delays in their structural language abilities including vocabulary and syntax (Norbury, 2004; Norbury, 2005). In addition, working memory abilities may be important for developing an understanding of figurative language, especially for holding in mind information relevant to interpreting unfamiliar figurative phrases.

The current study will investigate the development of figurative language while asking the following questions: Do children with autism show a delay in their figurative language abilities when compared to age-matched or language-matched typically developing children? Do children with autism show delays in their developmental trajectories compared to typically developing children? Do vocabulary, syntax, , theory of mind, social skills, and working memory each relate to figurative and pragmatic language development? What combination of abilities best predict figurative and pragmatic language development?

Theories of language development

Theories of figurative language understanding often draw on theories of understanding language in general, including vocabulary and syntax learning. There are various theories to describe how the structural aspects of language are learned, and how this learning process may be disrupted in autism and other developmental language impairments. Newer emergentist theories describe the acquiring of new language abilities as being supported by domain-general processes (arising from more basic processes), rather than domain-specific (arising from innate language modules in the brain). The emergentist perspective of language development, including contributions from dynamic systems theory and connectionism, has focused on understanding the mechanisms by which language emerges from more domain-general processes, including a focus on social interactions between a child and their environment (Elman, 2003; Evans, 2001; McClune, 2008). This set of theories view language learning as "softly assembled" with input from the environment being processed by the child's more general perception and pattern abstraction abilities (Evans, 2001; Marchman, 1997; Mclune, 2008). According to Evans (2001), emergentist theories view language acquisition as a system that emerges out of the interactions between a child and the environmental context – where the child integrates the "acoustic, linguistic, social, and environmental cues within the context of the communicative interaction".

When learning new vocabulary, syntax, or other aspects of language, dynamic systems theories suggest that "numerous social, emotional, motivational, cognitive, structural challenges and current neural network conditions must reach threshold levels of convergence to support any advance in learning" (Nelson & Arkenberg, 2008). Learning new syntactic structures in a language may require the child to engage with a person fluent in that language in communicative acts, where most of the language teaching happens indirectly (Nelson, 1989). While it is possible to identify and isolate individual components, it is also important to understand how the conditions work together in a "dynamic convergence" to lead to advances in language learning, where there will be high variability in the rates of learning for individuals due to differences in the individual components and differences in the dynamic convergence during episodes of learning (Nelson, Craven, Xuan, & Arkenberg, 2004; Nelson & Arkenberg, 2008).

Connectionist models have been used to examine language development. Elman et al. (1996) argue that while genetics and biology play a large role in the early development of the brain, it doesn't mean that the cells "know what kind of information they will have to compute". Early differences in sensory exposure will have an impact on the development of brain systems, with brain regions having more plasticity in the early years of life (Elman et al., 1996). Neuroconstructivist theories describe how more general domain-relevant mechanisms may become domain-specific over the course of development (Karmiloff-Smith, 1998). That is, the processing mechanisms may not start out dedicated to language, but may become dedicated to language over time. Thus, while adults appear to have more modular domain-specific language mechanisms in adulthood, the systems responsible for the development of language may be less modular. The implication of this theory is that for developmental disorders, such as specific language impairment (SLI) and autism, it is unlikely for a particular domain to be impaired without subtle impairments in other domains that are developing at the same time across childhood (Karmiloff-Smith, 1998). Neuroconstructivist views of development suggest that for some children, their “abnormal phenotypes stem from brains that have developed differently throughout prenatal and postnatal development. They are not normal brains with parts intact and parts missing; they are brains that have developed differently from the outset” (Oliver, Johnson, Karmiloff-Smith & Pennington, 2000). Thus, it is likely that problems with learning language will also lead to problems with other cognitive or social domains (or vice versa), even if those deficits are sufficiently subtle as to not meet clinical disorder criteria. Children with structural language impairments or delays, thus, can be expected to sometimes exhibit difficulties with passing theory of mind tasks or with pragmatics and figurative aspects of language (Berman & Ravid, 2010; Karmiloff-Smith, 1998; Farrar et al. 2009). In addition, Nelson, Welsh, Vance Trup, and Greenberg (2011) found that four year old children living in poverty who showed delays in language also displayed lower skills in areas such as emergent literacy skills and emotion recognition.

There are multiple approaches to examining differences in performance between individuals with ASD and typically developing children. One approach is a group matching approach to examine mean performance differences between the ASD group and a control group matched on any number of characteristics (ie. age, gender, nonverbal IQ, verbal IQ, vocabulary, syntax, etc). The matching designs, common in autism research, are used to examine dissociations between intellectual functioning and performance on any number of outcomes (language, social, perceptual, etc). "The aim of matching is to rule out noncentral explanations of group differences" (Jarrold & Brock, 2004). The choice of matching variables, however, needs to be theory-driven, as improperly matched groups runs a risk of leading to biased conclusions about the nature of symptoms in autism (Gernsbacher & Pripas-Kapit, 2012; Jarrold & Brok, 2004; Thomas et al., 2009). For examining possible deficits in figurative language, it could be important to include syntax as a matching variable between groups, rather than the typical method of matching on verbal or nonverbal intelligence alone (Gernsbacher & Pripas-Kapit, 2012).

Another approach to examining differences in development for individuals with autism compared to their typically developing peers is the trajectory approach, which allows for examining differences in the rate of growth of figurative language abilities across development, even for cross-sectional samples (Thomas et al., 2009). It is possible to look at age trajectories for a group of children with autism compared to children of the same chronological age range to see if the children with autism have a different developmental trajectory. It is also possible to use age-equivalence scores from standardized tests (including vocabulary, syntax, or nonverbal intelligence) to examine the rate of development in a behavior as a function of various possible predictors (Thomas et al., 2009; Annaz et al., 2009). While the traditional group matching process only tells us that there is a difference between the two groups, the trajectory approach provides information about the types of delay. For example, is there a delay in the onset of the behavior for the children with autism relative to a control group? Is there a delay in the rate of development for children with autism with increasing age or performance on the predictor variable? Or, is there both a delay in onset and rate of development? Using a combination of both group matching and trajectory approaches can tell us important information about group level differences as well as the processes that may be related to the development of the variables of interest.

Figurative language development

For typically developing children, figurative language understanding develops slowly across childhood and into adolescence. The timing and course of development for understanding figurative language varies by the type of figurative language. Some children as young as 3 to 5 are able to comply with some forms of indirect requests (Ledbetter & Dent, 1988). Some children ages at 5 and 6 are able to demonstrate an emerging knowledge of metaphor and simile, and some children age 6 are starting to be able to understand the meaning of idiomatic phrases (Ackerman, 1982; Winner, Rosenstiel, & Gardner, 1976). However, older children (ages 8 through 12) show even greater levels of understanding, and are more likely to generate the correct meaning of most types of figurative phrases (Ackerman, 1982; Johnson, 1991).

Levorato and Cacciari (1995) suggest that for understanding idiomatic language, children go through phases of development, starting with giving literal definitions, and then increasingly more figurative definitions as they get older. In this "phase transition model", the literal to figurative transition begins to happen around age seven during typical development (Levorato & Cacciari, 1995). Several studies have found that the number of correct idiom interpretations increases with age through childhood and adolescence. For example, Ackerman (1982) presented idiomatic phrases to 72 children (ages 6 to 10 years), as well as 24 adults. Ackerman (1982) found that children as young as six were able to interpret a small percentage of idioms, and that the percentage of idioms correctly interpreted increased significantly with age, with the 10 year old children still not performing at adult levels. Idioms were presented in three different paragraph contexts, where the figurative paragraphs provided context that supported the figurative idiomatic interpretation, the literal contexts were biased more towards the literal meaning of the words, and the neutral context provided a more ambiguous interpretation. When idioms were presented in a figurative story context, children age 10 were able to produce the correct meaning 79 percent of the time, while children age six only produced the figurative meaning 30 percent of the time. In addition, children at age 6 did not produce an idiomatic interpretation for idioms presented in literal or neutral contexts, whereas fifth graders produced the correct figurative meaning 60 percent of the time in a neutral context, and 41 percent of the time in a literal context (Ackerman, 1982).

Spector (1996) examined idiom comprehension using 12 idioms which were presented in a humor context, in the form of jokes or riddles (for example: “why did snoopy want to quit the comic strip? He was *working for peanuts*.”) A total of 90 elementary school children, 8 to 11 years old, were asked to detect the idioms (“working for peanuts”) and then explain what the idiom meant. Older children were better able to detect and explain the meaning of idioms compared to younger children, showing a developmental trajectory with increased understanding of figurative phrases with age from 8 to 11 years. However, even the 10 and 11 year old children in fifth grade were only performing at 59% correct on the explanation task (even if they were able to detect over 80% of the idioms). Children in third grade, average age 8, understood the meaning of some of the idiom phrases, correctly explaining the figurative meaning of 34% of the phrases, which was significantly lower than the scores of the fourth and fifth grade children, ages 9 through 11 years.

Metaphor comprehension also increases with age during the elementary school period. Johnson (1991) measured developmental changes in metaphor comprehension for 125 children ages 7 to 12 years. Eleven metaphors such as “my sister was a butterfly” were read aloud and the children were asked to say what they thought each phrase meant. Results suggested that older children performed better than younger children on the metaphor task. In addition, children with higher scores on a story-retelling task performed better on the metaphor task, suggesting that language ability was related to metaphor comprehension.

Winner et al. (1976) measured metaphor performance for 180 children with two tasks, one was an explanation task (where the children were asked to state the meaning of the metaphor phrase), and the other was a multiple choice task (where they were asked to choose from four possible answers). Children ages 6 to 14 were read metaphors such as “the prison guard was a hard rock” and were either asked to state the meaning or choose the best meaning in the multiple choice condition. Results suggested that children went through various stages of the types of answers that they produced, where the oldest children (ages 12 to 14) gave more advanced metaphoric answers than younger children in both tasks. The youngest children (ages 6 & 7) gave more answers which were related to the literal meaning of the sentences than older children. Children of all ages were able to produce at least some metaphoric responses, with the number and complexity of the metaphoric meanings increasing with age.

Simile is a specific type of figurative language with the form 'X is like Y'. Malgady (1977) measured the understanding of simile in 60 children ages 5 through 12 years. Simile phrases included items such as "the thunder is like bowling" from poems written for children (Malgady, 1977). Experimenters read the phrases to the younger children, and the older children read the items and wrote the responses. Children in kindergarten were able to produce some figurative responses to the simile phrases, and similar to other types of figurative language, the number and complexity of figurative responses increased with age. In addition, performance on the simile task was correlated with language ability, where children with higher language abilities performed better on the simile task.

Indirect requests include phrases ("the chair is in the way", or "I don't have a pencil") usually state a need while implying that the speaker wants the listener to meet that need, where children without an understanding of the correct way to respond to the ambiguous request may not respond in an expected way (Ledbetter & Dent, 1988; Wilkinson, Wilkinson, Spinelli, & Chiang, 1984). Indirect requests also include phrases that start with "can you...?" such as "can you pass the salt?" that may lead very young children to answer yes or no, rather than to actually perform the action (Ledbetter & Dent, 1988). Wilkinson et al. (1984) examined the production of indirect requests by 57 children ages 5 to 8 years old. Children were read a story script where the experimenter stopped at certain parts of the story and asked questions such as "show me a good way for Tony to ask the teacher for help", which were used to elicit opportunities for children to produce indirect requests (Wilkinson et al., 1984). Children at all of the ages produced indirect requests, but older children made significantly more indirect requests during the production task (Wilkinson et al., 1984). Ledbetter & Dent (1988) examined compliance with direct and indirect requests in children ages 3 to 5. For both direct and indirect requests, 5 year olds had more appropriate responses than 3 year olds. For children at all ages, direct requests elicited more correct responses than indirect requests, but even children at 3 years old produced the correct response for at least some indirect requests (Ledbetter & Dent, 1988).

Pexman and Glenwright (2007) examined children's knowledge of irony (saying "that was a terrible play" after someone scores a goal, or saying "that was a great play" after someone misses). A total of 70 children ages 6 to 10 were asked to say how nice or mean they thought someone was being, and were also asked to rate the speaker on whether or not the speaker was teasing the person. Understanding of irony increased slowly with age, with older children being better at making correct judgments about the speaker's intentions when they make ironic remarks.

In summary, the understanding of figurative language of various types increases with age across a protracted period in childhood. Indirect requests are understood by some children as young as three years old (Ledbetter & Dent, 1988). Children, ages 10 through 12, still do not typically perform at adult-levels for comprehension on metaphors, similes, or idioms (Ackerman, 1982; Winner, et al. 1976).

Idiom item differences: Context matters. Idioms are a fairly broad class of figurative phrases that include many conventional expressions such as "feeling under the weather", meaning that you feel sick or don't feel very good. Idioms may vary on several different dimensions that influence how difficult they may be to learn or understand. These item-level factors influencing idiom comprehension include familiarity, transparency, and the role of context (while these factors originated from the adult literature, they have all been examined in studies with children). Familiarity refers to how frequent the idiom is, and how much an idiom is recognized (Titone & Connine, 1994). Transparency (also called decompositionality) relates to how easy (or hard) it is to guess the meaning of idioms from their individual words; where the idiomatic meaning of transparent (high decompositionality) idioms are closer to the individual words, and opaque (low decompositionality) idioms are very hard to guess from the meaning of the individual words (Levorato & Cacciari, 1999; Nippold & Duthie, 2003). Whether or not the items are presented in isolation, in a context that supports the figurative meaning, or in a context that supports the literal meaning of the phrase also matters for idiom performance, especially for young children (Ackerman, 1982). In addition, these factors may interact with each other to affect performance on tasks designed to measure idiom comprehension, and thus are often related to the selection of stimuli used in figurative language tasks.

Transparency (or decompositionality) relates to how easy or difficult it is to use the individual words of the idiom to understand the phrase. Idioms with higher semantic analyzability, based on the individual words in the idiom, are more transparent. For example, individual words from the idiom "saved my skin" may contribute to the idiom's meaning of helping someone out of a difficult situation or saving them from harm. However, for the idiom "hit the sack", the individual words don't contribute very much to the meaning of going to sleep or going to bed. Levorato & Cacciari (1999) suggests that idioms may be considered part of lexical and semantic understanding processes in general, rather than being a special case of language development. Learning the meanings of idiomatic phrases could be similar to the process of how children learn multiple meanings for the same word, where children have to learn how to decide which meaning of a word is intended by the speaker based on the context it is presented in (Levorato & Cacciari, 1995). An important finding supporting the role of semantic analyzability in figuring out the meaning of idioms is that transparent idioms are understood more easily than idioms which are more opaque. For opaque idioms, the listener is less able to use the individual words to construct the meaning, thus scoring lower on opaque idioms in various tasks (Levorato & Cacciari, 1995; Levorato & Cacciari, 1999). Hamblin and Gibbs (1999) suggest that while idioms with higher semantic analyzability (which are more decompositional) are easier to comprehend, even seemingly non-decompositional idioms show an influence of the meaning of the verb in the interpretation of the phrase. Thus, idioms should be thought of as dynamic language stimuli, rather than as fixed-meaning "dead metaphors" (Gibbs, 1992).

Nippold & Rudzinski (1993) also suggest that children try to analyze the meaning of the idioms from the individual words when learning idioms (which works better for transparent than opaque idioms), leading performance to be increased for transparent idioms. Nippold & Duthie (2003) examined idiom comprehension in 40 children (ages 11 and 12), and 40 adults (mean age of 27). Idioms were presented in the context of short paragraphs, and children were asked to choose one of four possible meanings. Half of the 20 idioms were transparent idioms, and half were opaque idioms. Subjects were also asked to describe a mental image that they thought of when they heard the idiom (ie. "what do you see, hear, or feel in your mind?" when you hear the idiom phrase) (Nippold & Duthie, 2003). Children and adults scored higher on a comprehension task for transparent compared to opaque idioms. In addition, in the mental imagery task, the children and adults described more figurative mental images for the transparent idioms than the opaque idioms. More figurative mental images were likely described for transparent idioms because the meaning of the words more closely matched the figurative meaning (Nippold &

Duthie, 2003). However, some studies with children have not found significant effects in the expected direction for decompositionality, so it is still an open question as to how much children use the individual words from the idiom phrase to help them understand the figurative meaning during development (Norbury, 2004; Whyte, Nelson, & Khan, 2011). Under certain conditions, idioms when presented in a story context may actually have higher scores for opaque (low decompositional) idioms than transparent (high decompositional) idioms for some children (Cain, Oakhill, & Lemmon, 2005; Norbury, 2004).

The frequency with which you hear certain idiom phrases may also influence your comprehension of the phrases. Children usually produce more correct responses for idioms where they have had more previous exposure to the phrase in their environment, where higher familiarity idioms are comprehended better than lower familiarity idioms. For example, Qualls, O'Brien, Blood, and Hammer (2003) examined idiom performance in 95 adolescents (mean age of 13 years) and found that adolescents had higher accuracy for high and moderate familiarity compared to low familiarity items. In addition, the amount of context provided had an interaction with familiarity, where familiarity had a stronger effect for idioms presented in isolation than when presented in a story context. For idioms presented in isolation, low familiarity idioms had an accuracy of 48%, and high familiarity items had an accuracy of 70%. For idioms presented in the story context, low familiarity idioms had an accuracy of 70%, which only increased to 75% for high familiarity idioms.

Familiarity also has an effect on idiom comprehension for children with language disorders. Qualls, Lantz, Pietrzyk, Blood, and Hammer (2004) examined idiom comprehension in 22 adolescents (mean age = 14 years) who had language disorders, and low reading ability, and a control group of 21 typically developing children. Qualls et al. (2004) found that children with language disorders performed worse on idioms that were low familiarity versus high familiarity. In addition, the language disordered adolescents performed worse overall compared to typically developing children when they were presented in the context of short stories.

The linguistic context that idioms are presented in can be important for aiding comprehension. Levorato & Cacciari (1999) found that younger children benefitted more from context than older children, and suggest that the learning of figurative phrases is a gradual process that develops over time. Vosniadou (1987) suggests that both linguistic and contextual information are used to understand the meaning of metaphors, especially in young children. Vosniadou (1987) suggests that there are several limitations that impact the learning of metaphor and simile in childhood, including the understanding the meaning of the words (ie. the simile “The boy moved like a snake” requires the vocabulary and knowledge of snake-like features to attribute to the boy, so rich in-depth interpretations should be helpful). In addition, children need the capacity for the types of information processing necessary to build those associations (for example, memory ability and knowledge of strategies for using the context to interpret the figurative phrases).

Cain et al. (2005) suggest that knowledge of specific idiomatic phrases are built up slowly over time. While low familiarity items are less likely to be fully lexicalized or memorized by the individual when compared to high familiarity idioms, the low familiarity still likely have some previous exposure outside of the experiment that would impact how they are comprehended. So, presenting novel phrases (ie. phrases which are idiomatic but not found in the speaker’s language) both in and out of context may help with understanding how context is used to help interpret phrases where there has been no previous exposure outside the experiment. Cain et al. (2005) examined idiom performance in typically developing children ages 9 and 10 and found that subjects had more correct responses for transparent than opaque idioms presented out of context. Transparent idioms also showed a large increase in performance when they were presented in a story context which supported an idiomatic interpretation. In addition, children understood real idioms better understood than novel expressions when presented in or out of context. Performance was higher for the novel expressions when they were presented in context than out of context, but the real idioms showed an even larger increase in performance when they were presented in context.

While younger children may benefit more from context than older children, even adults may still use context for aiding in interpreting idiomatic phrases. Ackerman (1982) found that children ages 6 to 10 and adult college students were able to produce more idiomatic interpretations when the idioms were presented in a figurative context than in a neutral or literal context. Adults only produced 44 percent idiomatic responses when idioms were presented in a literal context, 83 percent idiomatic explanations for neutral contexts, and 100 percent idiomatic responses in a figurative context. The children ages 6, 8, and 10 were also able to produce more idiomatic interpretations in the figurative context than the neutral or literal contexts.

Figurative language development in autism. Previous research with children with autism or developmental language disorders suggest that these groups likely have difficulties with understanding various aspects of figurative language (Bernstein, 1987; Dennis, Lazenby, & Lockyer, 2001; Happe, 1993; Kerbel & Grunwell, 1998a; Kerbel & Grunwell, 1998b; Lyons & Fitzgerald, 2004; Norbury, 2004). For example, research has found that children with autism or language impairments often fall behind their typically developing peers on measures of metaphor understanding (Happe, 1993; Happe, 1995; Highnam, Wegmann, & Woods, 1999; Jones & Stone 1989). Children with autism and language impairments also have difficulty understanding and producing the correct figurative interpretation of idioms, compared to their age-matched peers (Kerbel & Grunwell, 1998b). For children with autism, delays in the structural aspects of language (syntax and vocabulary) have been implicated as one possible source of the delays in figurative abilities, where some children with autism may not show impairments in figurative language if they do not also show impairments in their vocabulary and syntax abilities (Norbury, 2004; Gernsbacher & Pripas-Kapit 2012).

Nikolaenko (2004) examined metaphor and idiom understanding in eight children ages 10 to 15 years with Asperger's syndrome and 55 typically developing children ages 7 to 15 years. In the idiom and metaphor task, children were asked to pair together cards that matched each other based on choosing the figurative meaning that matched the idiom or metaphor. The children with autism showed deficits compared to the typical controls in both types of figurative language, where they made fewer correct figurative responses in the metaphor and idiom task. Nikolaenko (2004) suggests that problems with figurative language understanding may be related to problems with associative thinking, since the children with autism also had difficulties on a task which measured associative thinking, where they were asked to name words beginning with a certain letter. However, this study had a very small sample of children with autism, who were not matched to the typical children on any variables.

Dennis et al. (2001) examined performance on various language tasks, including metaphor performance, in eight high-functioning children with autism compared to age-matched typically developing children. Figurative language was measured by a multiple choice task that presented metaphors with a supportive figurative context. While the autism and control groups had similar scores on vocabulary and lexical ambiguity tasks, the autistic group showed worse performance on the metaphor task and several other tasks that required the intentional or pragmatic use of language. Dennis et al. (2001) suggest that difficulty with understanding metaphorical language for children with autism likely relates to problems with understanding the intentionality of the figurative phrases. Even for children with autism who have normal vocabulary understanding, the more social aspects of communication can be more difficult to learn.

Gold, Faust, and Goldstein (2010) used event related potentials (ERPs) to examine how linguistic information processes (as measured by N400 waveforms) may help explain the poor behavioral performance of adults with Asperger's syndrome (n= 17) on metaphor tasks compared to a control group of typical adults (n= 16). Adults with Asperger's syndrome had larger N400 waveforms than the controls for metaphoric stimuli. Gold et al. (2010) suggests that this reflects difficulties that the adults with Asperger’s syndrome have with integrating the semantic information when presented with metaphoric word pairs (more effortful processing and lower performance).

MacKay and Shaw (2004) examined various aspects of figurative language in 19 children, ages 8 to 11 years, with autism and 21 children with typical development, ages 9 and 10. The autism and control group were matched at a group level for chronological age and vocabulary age-equivalence scores. The six types of figurative language used by MacKay and Shaw (2004) were: indirect requests, irony, hyperbole ("millions of dishes"), rhetorical questions ("how could you?"), metonymy ("green corner! work more quietly, please”), and understatements (“it's a bit sore”). Children with autism performed worse than the typically developing children on measures of understanding the meaning and intent for all six types of figurative phrases.

Ozonoff & Miller (1996) examined humor, inference, and indirect request comprehension in adults with and without autism. These types of figurative language phrases were still difficult even for autistic adults to understand. Ozonoff & Miller (1996) suggest that the figurative language deficit likely comes from difficulty with using the social and linguistic context for understanding the meaning of figurative phrases. For indirect requests with autistic adults, they were more likely to have "over learned responses", where it was more difficult for them to use the context of the story to inhibit some responses when a more literal interpretation for "Can you..." questions would be more appropriate than a non-literal response (Ozonoff & Miller, 1996). However, it is also possible that the adults may have had more general language deficits, since they also performed more poorly on the literal language control questions in the study (such as direct requests).

Pragmatic language development in autism

In addition to delays in figurative language, previous research suggests that children with autism also have delays in their pragmatic language development. Pragmatic language development involves the dynamic use of language in social situations (McTear & Condi-Ramsden, 1992, p. 69). Performance on pragmatic language tasks seem to be lower for children with autism than typically developing children, and children with autism usually display a weakness with "processing contextual information and inferring meaning" (Louska & Moilanen, 2009). Deficits in pragmatic language abilities are seen in autistic children as the inability to use language appropriately in the context of social conversations (Volden, Coolican, Garon, White, & Bryson, 2009). Pragmatic language is a broad area of language development, and the contexts can vary as widely as answering a phone, greeting someone you just met, knowing how to ask for help or directions, how to begin or end conversations with a friend, et cetera. Pragmatic language may develop more slowly in individuals with autism, where their use of language in a social context may not always be appropriate. Some research suggests that basic vocabulary skills alone may be insufficient for understanding pragmatic aspects of language, and that pragmatic language difficulties may be influenced by social skill deficits (Louska & Moilanen, 2009).

Lam and Yeung (2012) examined pragmatic language difficulties using an observational scale for video tapes of 31 children and adolescents, ages 8 to 15 years, with autism. A group of 26 typical controls were individually matched to the autism group on verbal and nonverbal IQ (scores on the WISC-R and Raven’s progressive matrices). Children with autism showed more difficulties with all but two of the 19 items on the Pragmatic Language Scale (the autism group scored 18.4 overall on the scale, whereas the typical controls scored 3.95 out of 38 points). For example, the group with autism had more instances of "out-of-synchrony communicative behavior" and "awkward expression of ideas" (Lam and Yeung, 2012).

Philofsky et al. (2007) examined pragmatic language abilities for a total of 60 children with autism, William's syndrome, or typical development (ages 5 to 12) using parental report on the Children's Communication Checklist (CCC). Children with autism and children with William's syndrome showed parent-reported pragmatic language deficits, though the deficits were more severe for children with autism (medium effect size). The children with autism also showed deficits in other domains compared to the children with William's syndrome, including the social relations and nonverbal communication subscales of the CCC.

Young, Diehl, Morris, Hyman, & Bennetto (2005) examined pragmatic language abilities (using the test of pragmatic language, TOPL) for 17 children with autism who scored in the average range for verbal IQ, along with expressive and receptive language abilities using the Clinical Evaluation of Language Fundamentals (CELF-3), which includes a variety of subtests measuring both semantic/vocabulary and syntactic language abilities. The group with autism was matched to 17 typical controls on age, language abilities, and nonverbal IQ. Children with autism performed worse than the typically developing children on the TOPL, where the mean score for the children with autism was about 1.5 standard deviations lower than the mean for the typical control group on this measure of pragmatics.

Predictors of figurative and pragmatic language development

The development of figurative and pragmatic language is a slow process across childhood and adolescence that likely draws on multiple cognitive, linguistic, and social skills, rather than developing in isolation. Levorato (1993) suggests that "the acquisition of idioms by children is far from a simple matter of passively learning conventional expressions, but is, on the contrary, a process involving complex linguistic and cognitive skills" (p. 119). Figurative language understanding is complex and may be related to other types of linguistic abilities including to the child's vocabulary, syntax, and reading abilities (Johnson, 1991; Malgady, 1977). Understanding figurative and pragmatic language may also draw on other abilities, including theory of mind (the ability to understand the thoughts, beliefs, and emotions of others) and working memory (the ability to store information in mind for further information processing).

The role of vocabulary and syntax. While many studies find deficits in figurative and pragmatic language abilities in children and adults with autism, questions still remain about the specificity of those deficits in relation to the children's structural language comprehension abilities, namely syntax and vocabulary. Research on in children with specific language impairments suggest that difficulties with figurative language are not unique to autism spectrum disorder, but are instead most likely related to impairments in language comprehension more generally (Gernsbarcher & Pripas-Kapit, 2012; Highnam et al., 1999; Norbury, 2004; Qualls et al., 2004). Deficits in at least some aspects of pragmatic language are also found in children with other types of disorders which impact their language development, such as Williams Syndrome (Asada, Tomiwa, Okada, and Itakura, 2010; Philofsky et al., 2007).

Gernsbacher & Pripas-Kapit (2012) criticized studies related to figurative language impairments with autism, saying that the many of studies which have found deficits in figurative language for children with autism have not used control groups matched properly on language development (ie. only matching on age or nonverbal IQ). Gernsbacher & Pripas-Kapit (2012) also argue that vocabulary, the most commonly used language variable for matching groups, is a poor matching variable to control for structural language abilities when attempting to examine potential deficits in figurative language. It is possible that children with autism could perform well on measures of vocabulary but still have some impairments in syntax which could explain poor performance in other areas of language development (figurative and pragmatics), as well.

For example, the Landa and Goldberg (2005) study showed that while the autistic and control groups were matched for verbal IQ (based on the WISC or WAIS), the autism group scored significantly poorer on both the basic grammar and figurative language measures, which leaves open the possibility that poor grammar/syntax abilities could have explained the differences in figurative performance. In addition, Eigsti and Bennetto (2009) found that children with autism showed impairments in some aspects of grammaticality judgments compared to typical controls matched on age and vocabulary abilities, further suggesting that matching on vocabulary may not account for all aspects of structural language difficulties in children with autism.

Basic structural language abilities relate to pragmatic language for children with autism. Volden et al. (2009) examined performance on pragmatic language (using the TOPL) in 37 children with autism. Expressive and receptive structural language abilities (measured by the

CELF-3, which contains a variety of subtests measuring structural language abilities) predicted a large portion of the variance in pragmatic language ability (70%). Volden et al. (2009) still recommends that pragmatic language should be measured in addition to structural language abilities for examining the communicative abilities for children with autism, since both structural and pragmatic abilities predicted social behavior in the children.

In addition, difficulties with figurative language appear in other groups of children with developmental disorders impacting their language development. For example, Highnam et al. (1999) examined metaphor performance in 8 to 12 year olds with language disorders and an age-matched typically developing control group. The language disordered group performed worse on two metaphor tasks, which involved describing the pairs of pictures and the pairs of words depicting metaphors. This deficit in metaphor comprehension remains in language disordered adolescents, as well. Jones and Stone (1989) examined the comprehension of 24 metaphors in adolescents, age 16 to 18 years, who were either typically developing or diagnosed with a language disorder. Metaphors such as “a butterfly is a flying rainbow” (meaning colorful) were presented in the context of short stories (Jones & Stone, 1989). Half of the items were presented with multiple choice answers, and half were presented in a definition task which required verbal explanations of the meanings. The language disordered group performed worse in both the multiple choice and definition tasks than the typical language group (Jones & Stone, 1989).

Idiom comprehension is also impaired in adolescents with language-based learning disabilities. Qualls et al. (2004) examined idiom comprehension in middle-school students (mean age 13.8 years) with language-based learning disabilities and a typical control group (mean age 13.3 years) which was matched with the language disordered group on reading ability, age, and gender. When idioms were presented in a story context, the adolescents with language disabilities performed worse than typically developing adolescents. However, for familiar idioms when presented in a verification task (when the participants were asked to respond yes or no when presented with an idiom and possible meaning), there were no differences between the groups.

Evidence suggests that children with autistic social symptoms who have high language comprehension abilities may not have a specific impairment in understanding idioms (Norbury 2004) or metaphors (Norbury, 2005). Norbury (2004) examined idiom comprehension in children with autism (with or without language impairments), children with specific language impairments (without autistic social symptoms), and a typically developing control group. The ages of the 132 children ranged from 8 to 15. In addition to having a battery of various standardized tests measuring language abilities, children also completed a measure examining comprehension of 10 idioms (with previous ratings of low familiarity) without any context or in the context of a short story paragraph. Results for the groups showed that children with language impairment (with or without a diagnosis of autism) scored poorly for idioms in context compared to children with autism (without impairments in structural language abilities) or children with typical development. The group of children with autism without significant impairments in their language abilities scored similarly to the typical control group for idiom comprehension. This suggests that language abilities (especially syntax measures indexing sentence processing abilities) overall are a better predictor of figurative language comprehension than the presence of autistic social impairments. In addition, a regression model including age, nonverbal ability, memory for factual story components, sentence processing, and word knowledge accounted for approximately 60% in the variance for predicting idiom comprehension (Norbury, 2004).

Evidence also suggests that vocabulary and syntax abilities are better predictors of metaphor comprehension than autistic social symptoms, as measured by the Autism Screening Questionnaire (Norbury, 2005). Norbury (2005) examined metaphor comprehension in a total of 134 children, divided between several groups: children with a specific language impairment (no autistic symptoms), children with autism (with a structural language impairment), children with autism (without structural language impairments) and typically developing children, ages 8 to 15 years. Results found that the autistic social symptom questionnaire was not correlated with metaphor comprehension abilities. Children with a structural language impairment (with or without a diagnosis of autism) scored lower than children with autism without a structural language impairment or controls ($\eta^2 = .177$).

Combined, this suggests that children with autism are likely to perform poorly on tasks involving figurative language abilities when compared to their age-matched peers only when syntax abilities are not controlled for. If vocabulary is an area of potential strength for children with autism, the use of syntax as a matching variable may be more appropriate for examining impairments in figurative language. However, since very few studies have been designed to specifically control for syntax abilities, it may be possible for some children with ASD that some aspects of figurative or pragmatic language may show impairments beyond their syntax impairments. Previous research examining figurative language development for children with autism have often (but not always) used group matching techniques, which collapse across various ages and IQ levels (verbal and/or nonverbal) in the children and give only one mean score representing the entire disordered sample to compare to one mean for any comparison group of typically-developing children. The developmental trajectory approach, on the other hand, can provide more information about how a behavior (such as figurative or pragmatic language) develops in relation to multiple possible predictors, including age, vocabulary, and syntax (Thomas, 2009; Annaz et al., 2009). While the traditional group matching process only tells us that there is a difference between the two groups, the trajectory approach tells us about the types of delay in figurative language in relation to vocabulary and syntax, including information about possible delays in the onset or rates of development. In addition, further aspects of social skills and theory of mind may also be important for supporting the figurative and pragmatic aspects of language and should be examined along with structural aspects of language determine their relative contributions.

The role of Theory of Mind. Another possible predictor of figurative language performance is Theory of Mind (ToM). In young children, false belief tasks are often used to measure ToM (Wimmer & Perner, 1983), the child is able to demonstrate if they have an understanding that another person can have a belief about an object's location which is false, such as knowing that their mom would look for candy where she left it, and not where it was moved to (when she was out of the room). In a meta-analysis looking across a number of studies using false belief tasks with typically developing children, Wellman, Cross, & Watson (2001) found that children are usually able to pass first-order false belief tasks by age 4. These types of first-order false belief tasks are the most common measurement of ToM and individual differences in first-order false belief performance usually describe ToM in terms of how old a child is when he or she passes or fails the task.

Leslie (1987) gives an account of how children develop the ability for metarepresentation ("representations of representations"), relating both to the development of pretend play and ToM. In addition, Perner (1991) builds on this idea of describing metarepresentations as "The ability to represent that something (another organism) is representing something," (p. 7). Perner (1991) suggests that children around age 4 years shift from a “mentalistic theory of behavior” to a “representational theory of mind”. Children develop metarepresentations after they develop primary and secondary representations. This representational ToM is demonstrated by passing first-order false belief tasks.

However, mentalizing abilities in general are unlikely to be something that stops developing at age 4, when typically developing children are usually able to pass first-order false belief tasks. The ability to understand the thoughts, emotions, and feelings of others (the broader definition of ToM and mentalizing abilities) develops across childhood in a more gradual way, with older children able to pass more advanced ToM tasks at older ages. Additional advanced ToM tasks have been developed to try and capture further development of ToM (Happé, 1994; Sullivan, Zatchik, & Tager-Flusberg, 1994). These advanced ToM measures include second-order false belief tasks and other tasks designed to be used to measure ToM in older children and even adults.

Second-order false belief tasks present slightly longer stories to the children. During these tasks, children are asked to make more advanced attributions (ie. “Does John know that Mary knows where the ice-cream man is now?”). These tasks require children to make inferences about a second person’s knowledge (“she *thinks* that he *thinks*”), whereas first-order tasks measure the knowledge of the first person’s beliefs (Sullivan et al., 1994). Most typically developing children are able to pass second-order false belief tasks by the time they are five or six years old (Sullivan et al., 1994; Perner & Wimmer, 1985). Much second-order false belief research is still somewhat categorical (ie. scores indicate whether they passed or failed).

The Strange Stories task was designed by Happé (1994) to measure Theory of Mind understanding in individuals who passed first-order false belief tasks. These short stories contain approximately three to five sentences, where the story is read out loud to the child, and then the child is asked two questions, asking if what the person said was true, and then asking why the person says it. The stories include: lies, misunderstanding, forgetting, persuasion, et cetera (Happé, 1994; O'Hare, Bremner, Nash, Happé, Pettigrew, 2009). For typically developing children, performance on this advanced theory of mind task increases with age from 5 to 12 years of age (O'Hare et al., 2009). Versions of the Strange Story task have also been used with adults (Spek, Scholte, & Van Berckelaer-Onnes, 2010). This makes the measure a useful continuous measure examining how children from about age 5 and up, along with adolescents and adults understand various mental states from the context of short stories.

Baron-Cohen et al. (2001a) designed the "reading the mind in the eyes" (RMTE) task to provide a measure of ToM that could be used to examine individual differences in mentalizing abilities of adults. Another version of this task was developed by Baron-Cohen et al. (2001b) to examine mentalizing abilities in children and adolescents. The RMTE task uses pictures of the eye regions of faces and asks the adult to choose one of four words/phrases which matches what is being expressed by the eyes. This is a task with lower verbal demands than the complex stories used for second-order false belief tasks and "strange stories" task, and also allows for a wide range of possible scores (ie. between 0 and 28 for the child version and between 0 and 36 for the adult version).

Garfield, Peterson, & Perry (2001) draw on Vygotsky's social learning theory in describing a framework where ToM (rather than being an innately specified module) arises from a combination of social and language development in childhood. As a process of social cognition, ToM "is best conceived as a complex interaction of interpersonal and linguistic skills involving, inter alia, the skill of metarepresentation and inference" (Garfield et al., 2001). In this case, children with autism have an impairment in ToM due to having impairments in the social and language (semantic and syntactic) skills necessary for developing ToM, and in cases where children with autism are able to pass false belief tasks, they do so at later verbal mental ages than their typically developing peers. Garfield et al. (2001) suggests that children with autism may have difficulties with understanding mental states because they "remain socially aloof from family conversational partners", in addition to having poor communication and imaginative skills needed for understanding the beliefs and intentions of others. However, deficits in false belief performance can be found in children with specific language impairment, as well (Gillot, Furniss, & Walter, 2004).

Theory of mind (especially false belief performance) has been described as an emergent property in recent years (Ketelaars, van Weerdenburg, Verhoeven, Cuperus, & Jansonius, 2010; Shanker, 2004; Sterck & Begeer, 2010). Research into the emergence of Theory of Mind is driven by findings that language, executive functioning, and working memory are correlated with concurrent ToM performance, and predict future ToM performance as measured by false belief tasks in young children (Moses, 2001; Astington & Jenkins, 1999). The development of ToM, language, and executive functioning seem to develop together interdependently (Doherty, 2009). These newer studies examining the relationship between language, executive functioning and ToM are also consistent with a view that domain general mechanisms guide the development of ToM, rather than ToM being something that is modular or domain specific from the start, though this newer viewpoint is still somewhat controversial (Apperly, Samson, & Humphreys, 2005). Thus, the question is not only about whether theory of mind is necessary for figurative language understanding, but how theory of mind and figurative language understanding develop together along with other cognitive, linguistic, and social abilities over time. Despite a modest number of studies addressing these issues, the literature to date is far from conclusive.

The directionality of the relationship between theory of mind and language abilities has been examined for early language development, but not for figurative language development. Structural language abilities (semantics/vocabulary & syntax) have been found to predict future false belief performance in young children. Astington and Jenkins (1999) conducted a longitudinal study of the relationship between language and theory of mind in 59 typically developing children. The children had a mean age of 40 months old at the first time point, and an average of 47 months old at the third time point. First order false belief performance and language (semantics and syntax) scores increased with age. However, earlier false belief performance did not predict language abilities at later ages. Instead, language at an earlier age predicted future false belief performance, with syntax as a stronger predictor than semantics. It is suggested that language is needed not only to pass the false belief tasks, but also to develop early ToM abilities in a social learning environment (Astington & Jenkins, 1999).

The relationship between language and passing false belief tasks led Tager-Flusberg (2001) to suggest that instead of one ToM "module", there may be various components of ToM that develop along different pathways (with different mechanisms). Thus, there may be differences between the development of "social-cognitive" and "social-perceptual" components of ToM (Tager-Flusberg, 2001). These two components could have different roles in interactions with other social and cognitive systems across development. The social-cognitive aspects of ToM (typically measured by the understanding of false beliefs) may relate more strongly with the development of language and working memory abilities than the social-perceptual aspects of ToM (understanding mental states expressed in faces or voices). The social-perceptual ToM, instead, may develop from social interactions where infants focus on emotions expressed in the face, and may be more related to social development than to language development. Tager-Flusberg (2001) also suggests that the social-cognitive ToM development builds on an earlier system of social-perceptual ToM abilities. However, the relationship between the social-perceptual component of ToM and language development are not well understood.

There is also some evidence that there is a relationship between ToM and figurative language development (Happe 1993; Norbury, 2004). The relevance theory suggests that figurative language requires the listener to have some understanding of the intentions of the speaker, and thus problems with figurative language understanding may be related to deficits in ToM (Happe, 1993). Support for the relevance theory comes from studies with autistic children that found deficits in both false belief performance and difficulty with understanding figurative language, such as metaphor and irony (Happe, 1993; Martin & McDonald, 2004). Impairments in theory of mind have also been implicated as a domain that may be related to pragmatic language impairments found in children with autism, as well (Kissine, 2012; McTear & Conti-Ramsden, 1992, p.160).

Martin and McDonald (2004) examined the understanding of irony and ToM in 14 adults with Asperger syndrome and 24 controls matched on age. ToM was measured by first- and second-order false belief performance. Adults with Asperger syndrome were less able to understand that the people in the stories were just telling ironic jokes. Instead, the individuals with autism were more likely to incorrectly think that the person was lying. Second order ToM performance was related to understanding of ironic jokes (even after controlling for language ability), suggesting that the understanding of mental states is related to understanding pragmatic aspects of figurative language (ie. interpreting the figurative statement in a contextually appropriate way).

Caillies and Le Sourn-Bissaoui (2008) examined performance on a multiple choice idiom comprehension task in 26 typically developing children five to seven years old. In addition, children completed several theory of mind tasks, including first and second order false belief. Theory of mind abilities correlated with verbal ability scores (scores on the Verbal Aptitude Scale measuring various aspects of language including vocabulary and verbal memory abilities) and idiom performance. Language abilities and TOM together predicted variance in low decompositional idioms, with TOM predicting 36% of the variance in low decompositional idioms. However, theory of mind did not significantly predict high decompositionality idioms above the contribution of verbal abilities and age.

Norbury (2004) examined the relationship between idiom understanding and ToM in children with autism, language impairment, and typical development. ToM was measured by first and second-order false belief performance. Norbury (2004) found that there was a correlation between ToM and idiom comprehension (r=.582). However, the false belief tasks were not predictive of idiom comprehension when put into a regression model with age, nonverbal ability, sentence processing, word knowledge, and performance on answering factual questions from the stories. Norbury (2004) found that TOM did not contribute to the multiple regression model, and suggested that the correlation found between idiom performance and false belief performance was likely only due to the shared language components between the TOM and idiom tasks.

Norbury (2005) examined the relationship between metaphor understanding and ToM performance in children with autism and language disorders. Children who passed second-order false belief tasks performed better on the metaphor task than children who only passed first-order false belief tasks, or failed both false belief tasks. However, since ToM performance on the false belief tasks were so highly related to semantic (vocabulary) language abilities, ToM performance was not a significant predictor of metaphor performance in the overall regression analysis. Norbury (2005) suggests that there are multiple "top-down (contextual processing, word knowledge, and experience) and bottom-up (semantic analysis) processes that work synergistically to arrive at metaphor understanding", and that superior syntactic or semantic language abilities may help compensate for potential deficits in first- or second-order false belief understanding.

Vance Trup (2009) examined the relationship between ToM performance and learning of idioms in an intervention for 11 children with autism. Figurative language was measured by a first-order false belief task, as well as the children's RMTE task (Baron-Cohen et al., 2001b). At pre-test, results indicated that both ToM tasks, as well as vocabulary abilities, were related to idiom performance for the children with autism. In addition, children who showed the greatest learning of idiom expressions in the intervention also had higher ToM and vocabulary scores at pre-test. However, the small sample size of 11 children prevented the use of more complex regression models to examine if ToM abilities predicted figurative language abilities above and beyond the contributions of vocabulary abilities.

The majority of previous studies examining the relationship between figurative language and theory of mind have primarily used first and second order false belief tasks (children are asked to reason about beliefs that people hold which do not match reality), as illustrated by tasks where the child is read a story and is asked questions about people's beliefs based on that story (where performance may draw strongly on the child’s language abilities). Since false belief tasks are largely categorical (pass/fail) measures, they may be poor indices of the more subtle understanding of mental states that may relate to learning figurative language in social communicative contexts. These prior studies have largely not used a battery including other advanced ToM tasks which vary in their verbal requirements, to see how the relationship changes depending on the language demands of the ToM tasks (Norbury, 2004; Norbury, 2005). More continuous measures of advanced ToM abilities may be better predictors of individual differences in figurative language abilities than False Belief performance. An open question remains about how additional measures of mentalizing abilities (such as the RMTE and strange stories tasks) may relate to figurative language (including idioms, metaphors and sarcasm), and if they contribute unique variance to figurative or pragmatic language abilities. The use of a developmental trajectory analysis (Thomas et al., 2009) may be particularly helpful for examining whether or not increased performance on figurative and pragmatic language abilities are related to increased performance on the RMTE and/or strange stories tasks, and how the developmental relationships between ToM and language development may differ for children with autism compared to children with typical development.

The role of working memory. Another factor which may be related to language learning in children is working memory. Working memory includes immediate short-term memory necessary for holding information in mind for further cognitive processing (including tasks such as memory span measures which ask the child to recite series of digits, letters, words, or nonwords in the order of which they are presented or in a reverse order), as well as the ability to manipulate that information (Boucher, Mayes, & Bigham, 2012). Boucher, Mayes, & Bigham (2012) suggest that these types of short-term memory and working memory abilities are sometimes (but not always) impaired in individuals with autism.

Some studies have found relationships between working memory and structural language abilities (Baddeley, Gathercole, & Papagno, 1998; Leonard et al., 2007). Baddeley et al. (1998) suggests that phonological short term memory (as measured by a nonword repetition task) is important for language acquisition. The ability to store unknown words in working memory is important in vocabulary acquisition, and this is suggested to be the primary function of the phonological loop. In addition, it is suggested that phonological short term memory is often impaired in children with language disorders, and that reduced phonological working memory abilities may lead to problems with language acquisition (Gathercole & Baddeley, 1990). In addition, Leonard et al. (2007) examined various aspects of working memory (including verbal and nonverbal working memory tasks) and language abilities (a composite of vocabulary, recalling sentences, and narrative abilities) in children with and without language impairment, age 14 years. A strong relationship was found between various aspects of working memory and language abilities, with verbal working memory as the strongest predictor of language abilities.

The relationship between working memory and language abilities have also been examined in children with autism. Gabig (2008) examined the relationship between working memory (using nonword repetition and digit span tasks) and narrative (story retelling) abilities in children with autism. For children with autism, digit span abilities were related to their story recall abilities. Children who scored higher on the digit span measure had better story recall. However, nonword repetition appeared to be closer to typically developing levels than other measures of verbal working memory, and no relationship was found between nonword repetition and story retelling abilities.

The relationship between working memory and figurative language has been examined in adults. Blasko (1999) suggests that individual differences in cognitive abilities such as working memory abilities will relate to the ability to understand metaphors. In addition, Qualls and Harris (2003) found that found that working memory abilities related to figurative language understanding in adults (17 to 73 years old). Qualls and Harris (2003) measured both metaphor and idiom understanding in African American adults, and found that working memory (as measured by an alphabet span task) related to performance both on metaphor and idiom comprehension. Pierce, MacLaren, and Chiappe (2010) examined working memory ability (as measured by a word span task) and performance on a metaphor task in adults (ages 18 to 40 years). Adults with higher working memory abilities were faster at completing the metaphor task than adults with lower working memory abilities (Pierce et al., 2010). Chiappe and Chiappe (2007) found that adults with greater working memory abilities and better performance on a stroop task were faster at interpreting metaphors and performed better in understanding and producing metaphors. Results also found that backwards digit span was a better predictor than forward digit span for metaphor production in adults. The relationship between working memory and metaphor performance remained significant even when controlling for language abilities.

Few studies have examined the relationship between figurative language and working memory abilities in children or adolescents, especially for children with autism. The relationship between working memory abilities and figurative language has been examined in adolescents with traumatic brain injuries (TBI) and typically developing children (Moran, Nippold, & Gillon, 2005). Working memory abilities were associated with proverb comprehension for children with and without TBI, where greater listening span scores were associated with higher proverb comprehension scores.

Some research has examined additional aspects of memory and executive functioning abilities in relation to figurative language in children with autism (Landa and Goldberg, 2005;

Norbury, 2004). Landa and Goldberg (2005) examined figurative language abilities along with executive functioning abilities (including working memory, planning, and cognitive flexibility) in children and adolescents with autism and typical development. Results indicated that executive functioning did not correlate with figurative language for the group of children with autism. However, two executive functioning measures (related to cognitive flexibility) correlated with figurative language for the typically developing group (Landa & Goldberg, 2005). Norbury (2004) found that memory for story context (while not specifically a measure of working memory) was a significant predictor of idiom performance when the idioms were presented in context for children age 8 to 15 years. In addition, children with language disorders (with or without autistic symptoms) showed smaller increases in understanding for idioms when they were presented in context versus out of context, when compared to children without language disorders. Children with autism and language disorders may be less able to use the supportive figurative context for interpreting idioms. There is still an open question, however, of how much of this difficulty with remembering story contexts could be attributed to problems with language (understanding the story) or memory (initially holding the story details in mind and recalling them later).

The relationship between figurative language and working memory abilities may be related to the need to use context to help with interpreting more unfamiliar figurative phrases (Kazmerski, Blasko, & Dessalegn, 2003; Levorato & Cacciari, 1992; Qualls & Harris, 2003). However, little is known about how working memory impacts the acquisition of figurative language in childhood for children with autism or typical development, as few previous studies have directly addressed this question. It may be possible that if working memory is an area of strength for children with autism, they may be able to use these abilities to help with understanding the story context for idioms when they are presented in context. However, if children have poor working memory abilities, this may add an additional constraint on their ability to hold the story context in mind to help them figure out the meaning of unfamiliar phrases. The trajectory analysis (Thomas et al., 2009) may be helpful in examining whether or not there are relationships between working memory and figurative or pragmatic language, as well as whether or not these relationships differ between children with autism and typical development. In addition, there are still remaining questions about how a combination of syntax and vocabulary abilities, theory of mind, working memory, and social skills or symptoms may work together to predict figurative and pragmatic language abilities, which can be examined using multiple regressions including all of these variables together.

Current research

The current research studies will investigate the relationship between figurative language and social, linguistic or other cognitive factors that may be related to the development of figurative language understanding in typical adults (study 1), as well as children with autism and typical development, ages 5 to 12 (study 2). The current research studies will answer questions related to understanding what set of predictors best explain individual differences in figurative language for adults, typically developing children, and children with autism. The current study hypothesizes that structural language abilities, theory of mind abilities, and working memory will contribute to individual differences in idiom performance for both children and adults. In addition, for children a broader range of predictor variables (theory of mind, syntax, vocabulary, social skills, and working memory) will be examined in relation to children's skills not only for idioms but also for non-idiomatic figurative expressions and for pragmatic language expressions. The current study hypothesizes that both children and adults will show relationships between the various predictor variables (theory of mind, basic language abilities, and working memory) and various aspects of figurative and/or pragmatic language.

Chapter 2: Adult idiom comprehension; Study One

While typical adults usually perform far better than children on idiom tasks, research has found that there are individual differences in how well the adults perform on the tasks (Ackerman, 1082; Blasko, 1999; Blasko & Kazmerski, 2006). Various cognitive skills can influence performance on idiom comprehension tasks including: working memory, intelligence, language, and reading abilities (Blasko, 1999; Blakso & Kazmerski, 2006). In addition, adults may perform better on idioms when they are presented in the context of stories than when they are presented in isolation, especially for phrases which may be unfamiliar to them (Ackerman, 1982). The current study examines how theory of mind, working memory, and grammar abilities relate to performance on idioms in and out of context for typical adults. It is hypothesized that adults will perform better on idioms when they are presented in the context of stories when compared to idioms presented in isolation with no context. It is also hypothesized that theory of mind, working memory abilities, and grammatical judgment will all correlate with idioms presented in and out of context.

Methods

Participants. A total of 28 adult college students, age 18 to 21 (mean = 18.82) years, participated in the study. Participants were native English speakers and were free of language impairments or autism. All participants reported their language history backgrounds, and had not been out of the country for more than three years. Any participants who were not native English speakers, or who had originally learned English outside of the US, were excluded from participation. Participants received subject pool course credit for participating.

Measures.

Figurative language. Three idiom tasks were completed by the adults. The familiarity task measured 48 idiom phrases presented out of context for each adult, where they were asked to rate their familiarity with each idiom on a 7 point scale, using a similar method to Titone and Connine (1994). Familiarity ratings were used to select the items for the final version of the idiom task used with children.

After completing the familiarity ratings, they also completed two idiom definition tasks. The original 48 items from the familiarity task were divided into two measures of 24 items, where half of the items were presented out of context, and then a separate subset of 24 items were presented in the context of short paragraphs. A different sub-set of phrases were presented in each definition task, to reduce the possibility of carry-over effects during the one hour session. The idioms were counterbalanced such that 14 adults saw an idiom presented out of context and the remaining 14 adults saw the same idiom presented in context. Idiom responses were classified as: correct figurative meaning, related figurative meaning, literal, restated, not related (to the idiom meaning), and no response ("I don't know"). Total scores for each of the two definition tasks could range between 0 and 48, with correct figurative answers worth 2 points, related figurative answers worth 1 point, and all other responses worth 0 points. Two undergraduate research assistants independently scored the idiom responses, % agreement was high between the two coders (78.6%), Kappa = .514. The coders met to resolve differences in their scores.

Theory of Mind. Theory of mind was measured by the adult version of the "Reading the Mind in the Eyes task" (Baron-Cohen, et al. 2001a). This measure presented pictures of the eye regions of faces with four words or phrases depicting thoughts or feelings on the page. The adult version of the Reading the mind in the eyes task contained more advanced language than the child version of the measure, and the adults were asked to circle the word on an answer sheet that they thought best matched the picture. This task has a total of 36 pictures, with each correct response being worth 1 point. Scores can range from 0 to 36.

Structural Language. Adults completed the grammaticality judgment sub-test from the *Comprehensive Assessment of Spoken Language (CASL)* (Carrow-Woolfolk, 1999). The experimenter said sentences out loud that were either grammatical or ungrammatical, and the participants had to respond by saying whether it was or wasn't grammatical (yes or no), and then fixing the sentence if it wasn't grammatical. The task ends when participants have five incorrect answers in a row. The grammaticality judgment subtest has a reliability between .77 and .82 for individuals 16 to 21. Standard scores are calculated from the raw total of correct items.

Working Memory. The forward digit span and backwards digit span tasks asked participants to repeat increasingly long series of numbers (Gathercole, Service, Hitch, Adams & Martin, 1999; Arkenberg, 2005). The two digit span tasks (forward and backward) may measure slightly different aspects of working memory, where forward digit only requires short-term remembering of the digits and the backwards span requires manipulation of the information to be able to recite the numbers in the reverse order of which they were presented (Reynolds, 1997). The numbers were spoken by the examiner at a rate of one per second. Immediately after the string of numbers was spoken, the participant repeated the series of numbers at his or her own rate. For the forwards digit span task, participants were asked to repeat the numbers in the same order that they heard them. The backwards digit span task presented different numbers where participants were asked to repeat them in the reverse order. The task ended when participants had two incorrect responses in a block of three items of the same length. Points were awarded for each correct series of numbers from 2 to 9 number digits, with a maximum score of 24.

Procedures. Adults completed these tasks individually in the laboratory after reading and signing a consent form. For the familiarity ratings, they were given the full set of 48 idioms presented out of context in a pencil and paper format. Participants were asked to read each idiom phrase, and then rate their familiarity with the item. After completing the familiarity ratings, they completed the adult "Reading the Mind in the Eyes" task, by looking at the pictures of faces in a binder and circling the correct responses on the provided answer sheet. They were asked to write the meaning of 24 of the idioms presented out of context. For the in-context task, They were asked to read the paragraphs containing the remaining 24 idioms, and then write down the meaning for each phrase. Towards the end of the session, the three orally presented tasks were administered, including the grammaticality subtest of the *CASL*, the forward digit span task, and the backwards digit span task. For all three of these tasks, the experimenter read the test items out loud and the participants responded verbally.

Analysis: Due to problems of skew and kurtosis for the grammaticality judgment task, non-parametric correlations (Spearman's rho) were conducted for examining relationship between the grammaticality judgment task and the two idiom comprehension measures. Pearson's correlations and ANOVAs were used for all other data.

Results

Role of Context. Overall, the adults performed better on idiom comprehension when the idioms were presented in the context of supportive stories (M=42.28), compared to when they were presented out of context (M=32.75), $t(27) = 10.56$, $p<.001$.

Predictors of individual differences in idiom performance. For idioms presented out of context, there is a significant relationship between grammaticality standard scores and idiom comprehension, where adults with higher grammaticality scores also have higher out-of-context idiom comprehension scores, $r_s(28)=.595$, $p<.001$. There is also a relationship between grammaticality scores and scores for idioms presented in a supportive context, where adults with higher grammaticality scores also have higher in-context idiom comprehension scores, $r_s(28)=.334$, $p<.05$.

For the adult RMTE task, there is a different pattern of results for idioms presented in and out of context. For idioms presented out of context, there is a significant relationship between adult RMTE scores and idiom comprehension, $r(28) = .571$, $p<.001$. For idioms presented in context, there is not a significant relationship between the adult RMTE scores and idiom comprehension, $r(28)=.113$, $p=.28$.

Forward and backward digit span tasks were not correlated with idiom performance, either for the in-context or out-of-context idiom measure, all $p>.15$.

Adult study brief discussion of central findings

Consistent with the previous literature (Ackerman, 1982), results found that adults were able to state the meaning of more idiomatic phrases when they were presented in a linguistic story context compared to when idioms were presented in isolation. In addition, individual differences in basic language abilities (as measured by a standardized task measuring grammar) were related to idiom comprehension abilities for adults, both when the idioms are presented in context and out of context. This suggests that basic language abilities may be an important factor contributing to idiom comprehension in adults.

Theory of Mind was only related to performance when the idioms were presented out of context, and not when the idioms were presented in a supportive context. It is possible that for healthy adults, understanding complex thoughts and emotions from the face (RMTE) is more helpful for learning and remembering the meanings of idioms in real-world settings (and thus remembering idioms presented without any linguistic context). It is possible that individual differences in theory of mind may not be as important for the adults' abstracting the meaning of idioms from a linguistic story context. However, future research should examine additional measures of theory of mind, as well as vary the amount of linguistic context presented in the stories to examine these relationships more closely.

While some previous studies found a relationship between working memory and figurative language in adults (Blasko, 1999; Qualls & Harris, 2003), the current study did not find significant correlations between either working memory measure and idiom comprehension for adults. It is possible that other measures of working memory abilities may be better than forward and backward digit span for adult idiom comprehension, and future research should examine the relationship between a greater number of working memory abilities and idiom comprehension.

Chapter 3: Figurative and pragmatic language in children, study two

Research questions and hypotheses

Question 1. Are there differences between children with autism and typical development on idiom comprehension, other nonliteral language abilities (the nonliteral subtest of the CASL measures understanding of figurative phrases such as metaphor, indirect requests, and sarcasm), and pragmatic language abilities? Since structural language abilities, including syntax, have been associated in prior work with increased performance on figurative and pragmatic language abilities, a group comparison analysis will be done by splitting the typically developing controls into two control groups, one language-matched and one matched on age and non-verbal IQ.

It is hypothesized that there will be a significant difference in all aspects of language skills for the children with autism compared to their age-matched peers during a group-level comparison. In addition, children with autism may not show a delay when compared to a language-matched group consisting of typically developing children matched on syntax age equivalence scores, who are slightly younger in chronological age as a group. Item-level factors will also be considered when examining performance on the idiom measure (including familiarity, transparency, and the role of context). It is hypothesized that idioms presented in context will be easier for children to understand than idioms presented out of context. In addition, idioms which are higher on familiarity and decompositionality will be easier to comprehend than idioms with lower familiarity and decompositionality. The group of children with autism will also be divided into a low and average syntax group to see how children with autism, with and without delays in their syntax, perform on figurative and pragmatic language. It is hypothesized that children with autism who have more severe delays in their syntax abilities will have more severe delays in their figurative and pragmatic language abilities.

Question 2. For children with and without autism, what is the relationship between basic language abilities (syntax and vocabulary) or chronological age and our three outcome variables (idioms, nonliteral, and pragmatic abilities) when examined in a trajectory analysis? For the trajectory analysis, performance on the idiom, nonliteral, and pragmatic language measures will be examined for autistic and typically developing children, using the trajectory analysis methods of Thomas et al. (2009). Since the trajectory approach doesn't require theory-driven matching, and excluding the highest performing TD children may lead to bias in the trajectories, a larger total sample of children (syntax-match, age-match, and additional children who were not included in the matched groups) with typical development is included in this analysis. Trajectories are created using separate regressions for the TD group and the ASD group examining how idioms, nonliteral language, and pragmatic language abilities increase with each of three predictor variables: chronological age, language-age equivalence scores for syntax and language-age equivalence scores for vocabulary. Then these trajectories for the TD and ASD groups are examined (using ANCOVAs with diagnosis, chronological age or language-age, and their interaction as variables) to see if the two groups differ in their onset or rate of development for each of the three predictors.

The trajectory analysis is able to distinguish between several different types of delays in the development of idiom, nonliteral, or pragmatic language abilities. For example, if there is a difference in the development of any of these 3 advanced language skills for the ASD group, the analysis approach can detect a delayed onset, slowed rate of development, or both (Thomas et al., 2009). It is hypothesized that both the ASD and TD group will show significant increases in figurative and pragmatic abilities with each of the three predictor variables (age, syntax, and vocabulary). Significant relationships between basic language abilities and figurative or pragmatic abilities would support the dynamic systems and neuroconstructivist theories. If the language outcome variables don't show significant trajectories, it suggests that these skills develop independently from each other, supporting a more modular view of development. In addition, since the neuroconstructivist theories of development suggest that the children with autism may not have figurative language delays beyond that of their structural language delays, the current study hypothesizes that while children with autism may have significantly different figurative or pragmatic language trajectories from the TD group when examining chronological age, the two groups will not have significantly different figurative or pragmatic language trajectories when examining age-equivalence scores in syntax or vocabulary.

Question 3. For children with and without autism, do ToM abilities (as measured by RMTE and the strange stories task) predict each of our three outcome variables (idiom, nonliteral, and pragmatic language)? The same trajectory approach used previously will be examined with each of the two TOM measures (Reading the mind in the eyes and strange stories) separately as predictors for each of the three outcome variables (idiom, nonliteral, and pragmatic language). It is hypothesized that there will be significant relationships between the TOM variables and each of the three outcome variables for children with autism and typical development. In addition, it is predicted that that children with autism and typical development will show similar trajectories for the relationship between TOM and each of the three outcome variables.

Question 4. For children with and without autism, do working memory (WM) abilities (as measured by forward and backward digit span) predict performance the three outcome variables (idiom, nonliteral, and pragmatic language) when examined in the trajectory analysis? It is hypothesized that both groups will show significant trajectories between WM and the three outcome variables. In addition, it is predicted that children with autism and typical development will show similar trajectories between WM abilities and each of the three outcome variables.

Question 5. What combination of variables predicts each of our three outcome variables? Do a combination of TOM, WM, autistic social skills, and structural language skills (vocabulary and syntax) predict our three outcome variables (idiom, nonliteral, and pragmatic language)? Multiple regressions will be used to examine how these three factors together predict idiom performance. It is hypothesized that some unique variance will be attributed to each of these predictors, and that in combination they will account for considerable variance in idiom, nonliteral, and pragmatic language abilities.

Methods

Design & participants. The current study includes a group of children with autism spectrum disorders (ASD) and a group of children with typical development. The trajectory analysis and subsequent multiple regression analyses (answering Questions 2 through 5) uses the full group of typical control children. From the larger group of typical controls, two groups of children (matched individually to the ASD group) were chosen to serve as age-matched or language- matched controls for the purpose of the group-level analysis (answering Question 1).

A parent or legal guardian provided informed consent prior to their child's participation in the study. An experimenter read an assent form out loud to the children, and all children provided verbal assent. The experiment was discontinued if the child asked to discontinue during the study due to boredom (one 12 year old typical control child for whom some of the tasks were too easy), or showed discomfort with the testing procedures (one child with autism who got frustrated when he didn't know the answers to questions). The experimental procedures complied with the standards of the Penn State internal review board (protocol ID #'s 36916, 36596, & 35892).

ASD group. The ASD group consists of a total of 27 children (22 m, 5 f) diagnosed with an autism spectrum disorder, ages 5 to 12 (M = 9.07) years. Classification of the child was based on parent report of a previous diagnosis of an autism spectrum disorder. In addition, parents provided information about other comorbid disorders, participation in speech therapy in schools, etc. A parent for each child was asked to complete the *Social Responsiveness Scale (SRS)*, which measures autistic social symptoms present over the last 6 months (Constantino, 2002). Scores on the SRS ranged from 51 to 153 for the children diagnosed with autism. The one child scoring below 60 on this measure was still receiving autism treatment services. See table 1.

Parental report of diagnosis indicates that 7 of the children were diagnosed with autism, 13 with Asperger's syndrome, 5 with PDD-NOS, and 2 with high functioning autism. The racial makeup of this group is mostly white/Caucasian, with 2 Hispanic, 1 American Indian, and 1 mixed-race (Caucasian/African American). Eighteen of the children are currently enrolled in speech therapy or were enrolled in speech therapy in the last school year. Eight of the children had no listed comorbid diagnosis reported by a parent. All other children had between one and three possible comorbid diagnoses reported by a parent. Comorbid diagnoses include: ADHD (n=7), ODD (n=3), disruptive behavior disorder (n=2), anxiety (n=4), sensory processing disorders (n=3) and seizures (n=1). In addition, 11 of the children have also been previously diagnosed with having speech/language impairments or delays.

Participants were recruited through several methods, including fliers distributed by teachers at schools or special education classrooms targeting children with autism or other special needs in central PA. Fliers were also distributed by staff at the Children's Institute at the National Autism Conference. Participants were also recruited by distributing fliers through the *autism*Match database sponsored by the Children's Hospital of Philadelphia (CHOPP).

Typically developing controls. A total of 76 children (46 m, 30 f) without a previous diagnosis of autism or other developmental disorder, ages 5 to 12 years (M = 8.4 years), participated in the study as controls. Participants were recruited from the FIRSt Families database through the Child Study Center at Penn State. The parents of the control group also completed the SRS. The trajectory analyses used this full group of typically developing children (TD) to examine how idiom comprehension increases with chronological or language age. The regression analysis also uses this full TD group for comparison to the ASD group. The group matching statistical comparison uses two-tailed t-tests.

Six children (not included in the above totals) were excluded from the study (original n = 82). Two children were excluded from the study due to having a raw score above 60 on the SRS screening measure, but not having a parent-reported previous clinical diagnosis of autism. Four additional children were excluded from the control group based on parental report that the children had been previously diagnosed with ADHD or a language delay/disorder.

Age-matched control group (CAM). The chronological age matched control (CAM) group included 27 typically developing children (19 m, 9 f), ages 5 to 12 (mean = 9.07) years. The children in the CAM group were individually matched to members of the ASD group based on chronological age (in years) and nonverbal IQ (standard and age-equivalence scores). The results of t-tests indicated that the CAM and ASD groups do not significantly differ on: chronological age, nonverbal IQ standard scores, and nonverbal IQ age-equivalence scores (all $p>.3$). The CAM group has significantly higher verbal IQ and syntax standard scores and age-equivalence scores compared to the ASD group (all $p<.05$).

Language Matched control group (LAM). The Language-age Matched (LAM) control group consists of a separate subset of 27 children with typical development (14 m, 13 f), ages 5 to 12 (mean = 7.85) years. The LAM control group was individually matched to members of the ASD group based on Syntax age-equivalence scores. The LAM and ASD groups do not significantly differ on verbal IQ age-equivalence scores, nonverbal IQ age-equivalence scores, or syntax age-equivalence scores (all $p>.5$). The LAM group is significantly younger than the ASD group and has significantly higher standardized language scores (all $p<.05$). There were more girls in the LAM group compared to the ASD group. However, a t-test comparison of male versus female in the typical group suggests that idiom performance did not differ by gender (p>.2). The two typical control groups also significantly differ from each other on chronological age and syntax age-equivalence scores (p<.05). See table 1.

Table 1. Descriptive information about the ASD group with the 3 control groups: Age-Matched, Language-Matched, and the full TD group. For each group, the mean for chronological age in months, verbal IQ (vocabulary) and nonverbal IQ standard and age-equivalence scores, syntax standard and age-equivalence scores, and SRS total raw scores are included.

	ASD group	Age-Matched	Language-Matched	Full TD group
# of participants	27	27	27	76
Age in months	115.66	114.19	99.52*	106.51
Nonverbal IQ standard score	98.73	103.26	105.18*	107.15*
Nonverbal IQ age-equiv. (months)	118.42	128.00	115.96	128.09
Verbal IQ/vocabulary Standard Scores	96.74	109.76**	112.74**	112.25**
Verbal IQ/vocabulary age-equiv. (months)	112.44	134.12*	118.11	128.93*
Syntax Standard scores	82.67	99.55**	95.81**	100.07**
Syntax age-equiv. (months)	92.74	116.00**	94.70	108.67*
SRS total raw	104.92	23.41**	24.37**	22.57**

Note: * p<.05, ** p<.01 – indicates group is significantly different from ASD group

Measures.

Figurative and pragmatic language. Three measures of figurative language and one measure of pragmatic language were included in this study.

Idioms out of context. During the first session, children were asked to explain the meaning of 6 idiomatic phrases presented in isolation (for example, “What does ‘raining cats and dogs' mean?"). The out of context items were six idioms rated as low familiarity by adults in study 1, and five of the six were rated as low on transparency based on the adult descriptive norms by Titone and Connine (1994). Instructions were read to the child along with one practice item, with feedback, before the start of the test items. Children were asked to verbally state the meaning of each low familiarity idiom, which were read aloud to the children. Idiom responses were classified as: correct figurative meaning, related figurative meaning, literal, restated, not related (to the idiom meaning), and no response ("I don't know"). Two undergraduate research assistants, blind to diagnosis, independently scored the idiom responses. Percent agreement between the two coders was high (94%), Kappa = .763. The two coders met to resolve conflicts in their coding. Total scores for the six items could range between 0 and 12, with correct figurative answers worth 2 points, related figurative answers worth 1 point, and all other responses worth 0 points.

Idioms in context. Later in the first session, a total of 25 idioms were presented in the context of a short paragraph that supports the figurative meaning of the phrase. This consisted of 20 real idioms and 5 novel idiomatic phrases (see table 2). The 20 real idioms varied on their decompositionality and transparency. Ten of the idioms were rated as high on decompositionality (transparent), and half will be low on decompositionality (opaque) based on the ratings from Titone and Connine (1994). In addition, the results of the adult familiarity ratings from study 1 were used to choose high and low familiarity idioms, such that the idioms were chosen only when the ratings of familiarity from study 1 were consistent with the Titone and Connine (1994) scores. In addition, five opaque "novel" idioms previously used by Cain et al. (2005) were included in this measure, to see how children used context for figuring out the meaning of expressions with no previous exposure. These phrases were translations of non-

English European idioms. See appendix 1 for a list of idioms used in this study. Appendix 1 also includes an example idiom story along with sample responses from the children illustrating the coding scheme used. Instructions were read to the child along with one practice item, with feedback, before the start of the test items. The story containing the idiom was read to the child followed by a question asking them to define the idiom from that story. Children were asked to verbally state the meaning of each idiom. Responses for the idioms were classified as: correct figurative meaning, related figurative meaning, literal, restated, not related (to the idiom meaning), and no response (“I don’t know”). Two undergraduate research assistants, blind to diagnosis, independently scored the idiom responses. Percent agreement between the two coders was high (87%), Kappa = .818. The two coders met to resolve conflicts in their coding. Correct figurative answers were worth 2 points, related figurative answers worth 1 point, and all other responses worth 0 points (literal, not related, or restated responses). The total scores on the measure could range from 0 to 50 points. For the set of 20 real idioms (excluding the 5 novel idioms), scores could range from 0 to 40.

Table 2. Twenty real idioms were chosen based on familiarity and transparency (high or low on each dimension). Five novel idioms are also included in the overall measure, for a total of 25 idioms.

	High familiarity	Low familiarity	Novel
Transparent	5 items	5 items	0
Opaque	5 items	5 items	5 items

Nonliteral/figurative language. During the second session, the Nonliteral Language subtest of the Comprehensive Assessment of Spoken Language (CASL) was completed. This standardized test measures comprehension of figurative phrases which are not idiomatic, and are instead designed to contain various types of nonliteral language, which they divide into figurative, sarcasm, and indirect requests (Carrow-Woolfolk, 1999). Closer examination of the items suggests that this test contains a large variety of different types of non-idiomatic figurative phrases such as: metaphors ("you are such a turtle"), simile ("I feel like an ice cube"), sarcasm ("when dad saw Seth lying in front of the television, he said "I see you're training hard for the marathon"), indirect requests ("I want all eyes on the board"), and more (Carrow-Woolfolk, 1999). When the researcher administered the items, they would say out loud: "The teacher told the class that he wanted all eyes on the board. What did he mean?" and a correct response would be something similar to "Look at the board" or "pay attention" (Carrow-Woolfolk, 1999). Two practice items are administered before the start of the test, with feedback given to ensure understanding of the task. Since this subtest was designed for children ages 7 and older, the children younger than 7 are excluded from analyses using the standard scores or age-equivalence scores, but are included in analyses using raw scores. Since the test does not allow for scoring when children have no correct responses, the two children scoring zero points on this measure (one ASD and one TD) are excluded from all analysis with this measure. The test is completed when the participant hits the ceiling rule of 5 incorrect items in a row. This subtest has a reported internal reliability between .78 and .92. Total raw scores could range from 1 to 50 on this measure. Raw scores were converted into standard scores only for children above age 7.

Pragmatic Language. The Pragmatic Judgment subtest of the *CASL* was also completed, where this subtest examined the child's "knowledge and use of pragmatic rules of language" (Carrow-Woolfolk, 1999). Items on this measure involved judging the appropriate use of language in a social context, and verbally producing language appropriate for the context. This included items such as saying how you would introduce people to each other, greeting people appropriately, ordering food in a restaurant, making requests, saying please and thank you, et cetera. For example, the experimenter would say "Jason needs help carrying his books and football equipment to school. Tell me how he could ask his brother to help him," and a correct response would be something similar to "Would you please help me?" or "Will you carry some books?". Another item asks "Debby gives Tom half her candy bar. What does Tom say to Debby?" The earlier items have illustrative pictures and the more advanced items do not. Two practice items are administered before the start of the test, with feedback given to ensure understanding of the task. The test is completed when the participant hits the ceiling rule of 5 incorrect items in a row. The reported internal reliability for this test is high, .77 to .92 (Carrow-Woolfolk, 1999). Raw scores (out of a possible 60 items) were converted into age-equivalence scores and standard scores.

Structural Language measures. Two measures were used to examine basic language abilities, one measuring syntax abilities and the other a verbal IQ measure tapping into vocabulary and work knowledge.

Syntax. The Syntax Construction subtest of the CASL was completed (Carrow-Woolfolk, 1999). The syntax construction test presents pictures to the children and asks them to verbally complete sentences using imitation of a sentence presented by the experimenter, targeting a specific syntactic form for each item, focusing on the use of syntax rules. For example, the experimenter could say "Finish what I say. This dog is little (point). This dog (point) ____" and the child is expected to respond with something similar to "is big" or "is larger". All of the items on this sub-test have illustrative pictures. At higher difficulty levels, some of the items asked the child to combine two or more sentences together. A few of the items also include imitation ("say exactly what I say..."). The syntactic forms tested include structures such as: plurals, verb tenses, dependent clauses, adverbs, etc. The structures grow increasingly more complex throughout the test. Two practice items were administered before the start of the task, with feedback given to ensure understanding. The test is completed when the participant hits the ceiling rule of 5 incorrect items in a row. The reported internal reliability for this sub-test is high, .73 to .88 (Carrow-Woolfolk, 1999). Raw scores (out of a possible 60 items) were converted into age-equivalence scores and standard scores.

Vocabulary. The Kaufman Brief Intelligence Test, 2nd edition (KBIT2) was used to measure aspects of vocabulary and word knowledge that the test makers refer to as a "verbal IQ" test (Kaufman & Kaufman, 2004). The verbal IQ score was a composite of two sub-tests measuring vocabulary and word knowledge (verbal knowledge and riddles). The verbal knowledge sub-test measured receptive vocabulary. During the task, the experimenter asked the child to point to the picture that matched what they said (ie. “point to gift”), where there were six possible picture choices for each item. Vocabulary items increased in difficulty levels during the test and the test was completed when the child missed four items in a row. The riddles sub-test measures verbal comprehension, reasoning, and vocabulary knowledge in a task requiring production of a target vocabulary word (or one of a set of possible responses). During the riddles task, the experimenter read questions such as “What is something shiny and hard that people wear on their finger?” and the child was asked to verbally respond using only one word (ie. “ring” or "thimble"). Another example is: “What hops, eats carrots, and has long ears?” with the correct answer being “bunny” or “rabbit”. Feedback was given only for incorrect responses on appropriate practice items, and the test ended when the child got four consecutive incorrect responses. This composite measure of the verbal knowledge and riddles subtests will also be referred to as a vocabulary measure, since all items concerned some aspect of vocabulary/word knowledge or use. The internal-consistency reliability reported for ages 4 to 18 on this sub-test is high, .90 (Kaufman & Kaufman, 2004). The raw scores could range from 1 to 60 for verbal knowledge, and 1 to 48 for riddles. Total raw scores were computed using the sum of the two sub-tests. Total raw scores were converted into standard scores and age-equivalence scores.

Theory of Mind. Children completed two tests to measure advanced ToM abilities.

Strange stories. The ‘strange stories’ was used to measure advance ToM performance based on a subset of 6 of the mentalizing stories from O’Hare et al. (2009). This version of the Strange Stories task was chosen because it contains norms from over 100 children, and contains explicit scoring procedures with lists of acceptable mental state answers for coding responses. The mentalizing stories measure understanding of lies, persuasion, deception, etc. Since the full task includes some figurative items, any item that bordered too closely on figurative language (including jokes, figures of speech, pretend, and sarcasm) were excluded. For the mentalizing stories, children are read a short paragraph, and then asked questions such as “is it true what Peter said” and “why does he say that?” which required the child to respond about the person being deceptive, trying to lie, “ignorance of her real intentions”, etc. Two clipart pictures depicting people or objects relevant to each story were presented as memory aids. A total of six stories were chosen (lie, white lie, misunderstanding, contrary emotions, appearance/reality, and forget). Two undergraduate research assistants, blind to diagnosis, independently coded the strange stories measure. The “is it true” question was included since all of the items chosen for this test had a correct yes or no answer (all the answers were no except the story about the police man, where the correct answer was yes – that he was surprised by what the burglar did). Percent agreement between the two coders in the current study was high (92%), Kappa = .87. The two coders met to resolve differences in their coding. Each story is worth up to 3 points (one point for "is it true" and 2 points for justification), for a total possible score of 0 to 18.

RMTE. The children's version of the "Reading the mind in the eyes" (RMTE) task was completed (Baron-Cohen et al., 2001b). During this task, children matched words/phrases depicting mental states (i.e. shy, worried, not believing, or kind) to pictures of the eye regions of faces. Each item has one picture of the eye regions of a face, with four words around the eyes. The experimenter read the answer choices aloud for each picture, and asked which word matched the thoughts/emotions of the person in the picture. There are a total of 28 items, with a possible range of scores from 0 to 28.

Working Memory. Two measures of working memory were included in the current study.

Forward digit span. The forward digit span task asked participants to successfully repeat increasingly long series of numbers (Gathercole et al., 1999; Arkenberg, 2005). The numbers were spoken by the examiner at a rate of one per second. Immediately after the string of numbers was spoken, the participant repeated the series of numbers at his or her own rate. For the forward digit span task, the participants were instructed to repeat the numbers in the same order that they heard them, and only responses said in the same order were counted as correct. The task ended when participants had at least two incorrect responses in a block of three items of the same length. Points were awarded for each correct series of numbers from 2 to 9 number digits, with a maximum score of 24.

Backward digit span. The backward digit span was constructed and administered similar to that of the forward digit span. However, the participants were instead asked to repeat the numbers in the reverse order that they heard them (for example, if the experimenter said 1 2 3, the correct response was 3 2 1). The task ended when participants had two incorrect responses in a block of three items of the same length. Points were awarded for each correct series of numbers from 2 to 9 number digits, with a maximum score of 24.

Nonverbal Intelligence and social skills. For the purpose of group assignment, nonverbal IQ and performance on the Social Responsiveness Scale (an index of impairments in a range of social skills associated with a diagnosis of autism) were measured

The nonverbal IQ score consisted of the Matrices subtest of the KBIT-2 (Kaufman & Kaufman, 2004). This test presented visual stimuli (either meaningful objects or abstract designs). The participants were presented with at least five multiple-response options and were asked to choose which picture goes best with the target stimuli picture or matrices of pictures (2x2 or 3x3). The stimuli increased in complexity and abstractness over the course of the measure. Feedback was given only for incorrect responses on the appropriate practice items, and the test ended when the participant hit the ceiling rule of four consecutive incorrect responses. Internal-consistency reliability for ages 4 to 18 on this sub-test is high, .86 (Kaufman & Kaufman, 2004). Raw scores could range from 1 to 46, and the raw scores were used to compute standard scores and age-equivalence scores.

One parent for each child completed the *Social Responsiveness Scale (SRS)*, which is a measure of autism social symptom severity and social skills (Constantino, 2002). This measure was used to confirm the diagnosis of autism for the ASD group, and was administered for the typically developing group to ensure that they do not score in the autism symptom range. This scale was chosen because it is sensitive to autistic social impairments for children with autism, Asperger's syndrome, and pervasive developmental disorder (PDD). The SRS has 65 items, rated on a 4 point scale (from not true = 1 to almost always true = 4), where the parent rates the child’s behavior over the last 6 months. Calculation of total scores use a 0 to 3 point scale, where some of the items are reverse coded. This item includes multiple subscales, tapping into autistic preoccupations along with receptive, cognitive, expressive, and motivational aspects of social behavior. Items include a wide variety of skills such as: "plays appropriately with children his or her own age", "thinks or talks about the same things over and over", "has good personal hygiene", "avoids eye contact or has unusual eye contact, and "seems self-confident when interacting with others (reverse coded)." This measure allows for examining a range of severity of social impairments, allowing this measure to be used as a quantitative measure of overall social functioning for children with autism. The *SRS* may also be a useful measure of social skills for children with typical development, as it includes many items that are potentially of relevance for any child in the current study's age range of 5 to 12 years, though it is not commonly used to measure the social skills of typically developing children (and children scoring above 60 on this measure were excluded from the control group). Scores are calculated as raw scores and T-scores, though the test recommends the use of raw scores for research purposes (Constantino, 2002). Total raw scores can range between 0 and 195, with higher scores indicating more social impairments (ie. higher levels of autistic social symptoms).

Procedure. The study was completed over two sessions, lasing approximately one hour each (for a total of 2 hours of data collection). For most lab visits, the sessions were completed approximately one week apart. For home visit appointments (12 of the ASD families who were unable to travel to the lab), or for lab visits when the family was unable to schedule two different appointment days (due to traveling distance or scheduling conflicts), both sessions were completed on the same day, with a 5 to 15 minute break between the two sessions. One or two breaks (lasting 2 to 10 minutes) were also provided during each of the hour sessions as needed.

Differences in study setting and timing are unlikely to effect the results, since all other study procedures were kept as similar as possible across the locations.

During session 1, a parent (or legal guardian) signed a consent form prior to participation and completed a brief demographic questionnaire (including questions related to previous diagnosis) and the *SRS* for their child. During session 1, children gave verbal assent, and then completed half of the measures for the study, including both of the idiom comprehension measures (out of context idioms always came before in context idioms). During both sessions, the measures were read aloud to the children, and children were asked to respond verbally (or by pointing when appropriate). During session 2, children completed the nonliteral language subtest of the *CASL.* The other predictor measures were divided between the two sessions so an equal number of tasks were completed in each session.

To help with maintaining attention during the session, children tracked their own progress through the tasks using stamp charts with circles for each of the tasks that needed to be completed during the session. Children got to choose one of an assortment of fun self-inking stamps and were able to stamp a circle each time they finished a task.

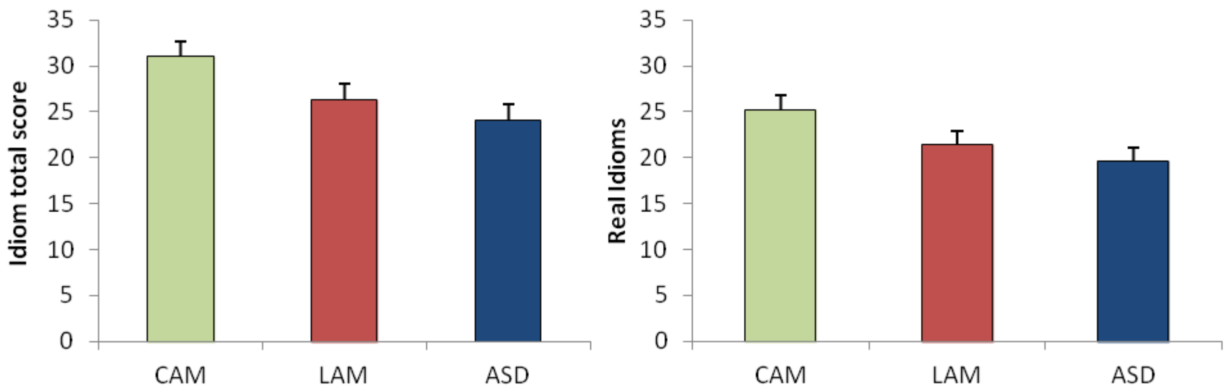
Results

Question 1: Group Comparisons. The performance of children with ASD was compared to two matched control groups, one matched on chronological age and nonverbal IQ (CAM group), and the other matched on syntax language-age equivalence scores (LAM group). Three language tasks are examined in the group comparison analysis: scores on the idiom comprehension measure, raw scores from the nonliteral language subtest of the CASL, and age-equivalence scores for the pragmatic subtest of the CASL. ANOVAS with one-tailed t-tests are used for examining possible group differences for these results.

Overall idiom performance. Children with ASD perform similar to language-matched controls on idiom performance, but lower than age-matched controls. A one-way ANOVA was conducted comparing total idiom scores (out of 50 possible points) for the ASD group, CAM and LAM control groups. There was an effect of diagnosis group on idiom comprehension total scores, $F(2,78) = 3.85$, $p<.05$, $\eta^2= .09$. The one-tailed t-tests indicate that the CAM group (M = 31.04) performed significantly higher than the ASD group (M =24.41) on idiom comprehension, $t(52) = 2.68$, $p<.01$, d=.73. However, there was not a significant difference between the LAM group (M = 26.33) and the ASD group (M =24.41) on idiom performance, $t(52)= 0.76$, $p>.2$, d=.21. There was also a significant difference between the two TD comparison groups (CAM and LAM), $t(52) = 1.98$, $p<.05$, d=.54. See figure 1.

When examining the 20 real idioms (excluding the five novel phrases), the pattern of results is similar. A one-way ANOVA was conducted comparing total idiom scores (out of 40 possible points) for the ASD group, CAM and LAM control groups. There was an effect of diagnosis group on idiom comprehension total scores, $F(2,78) = 3.79$, p<05, $\eta^2= .09$. Follow-up one-tailed t-tests were used to examine differences between the ASD group and each of the two control groups separately. The CAM group (M =25.52) performed significantly higher than the ASD group (M =19.59) on idiom comprehension, $t(52) = 2.75$, $p<.01$, d=.75. There was not a significant difference between the LAM group (M =21.41) and the ASD group (M =19.59) on idiom performance, $t(52)= 0.83$, $p>.2$, d=.23. There was also a significant difference between the two TD comparison groups (CAM and LAM), $t(52) = 1.87$, $p<.05$, d=.51. See figure 1.

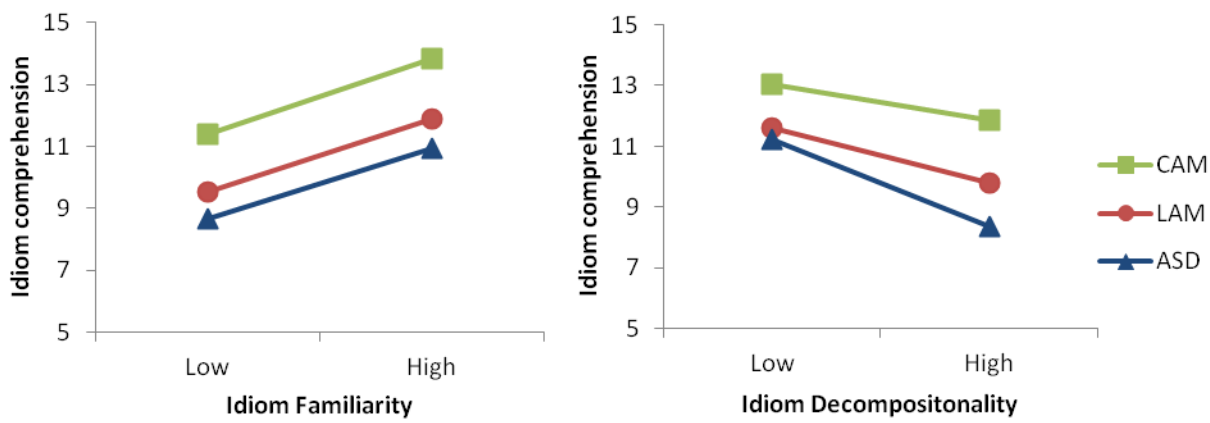
Figure 1. Total idiom scores including all items (means with SEM) and scores from the 20 "real" idioms from the idiom task (means with SEM) for the three groups (age-matched controls, language-matched controls, and ASD).



Idiom item-level factors. Familiarity has a positive effect on performance for idioms. To examine the effect of familiarity for each group, a mixed factors ANOVA was conducted with familiarity (low vs high) as a within-subjects factor and diagnostic group (ASD, LAM, and CAM) as a between-subjects factor. The five novel idioms were excluded from this analysis. There was a main effect of familiarity, where performance was better for high familiar (M= 12.22) idioms than low familiar (M= 9.86) idioms, $F(1,78) = 45.15$, $p<.01$, $\eta_p^2 = .367$. There was also a main effect of diagnostic group, $F(2,78) = 3.80$, $p<.05$, $\eta_p^2 = .09$. There was no interaction between familiarity and diagnostic group, $F(2,78) = 0.02$, $p>.9$, $\eta_p^2 = .001$. See figure 2.

Decompositionality (based upon categories from prior adult data) had a negative effect on idiom performance. To examine the effect of decompositionality for each group, a mixed factors ANOVA was conducted with decompositionality (low vs high) as a within-subjects factor and diagnostic group (ASD, LAM, and CAM) as a between-subjects factor. The five novel idioms were excluded from this analysis. There was a main effect of decompositionality, though an examination of the means shows that this is in an unexpected direction where performance was better for low decompositionality idioms (*M*=12.07) than highly decompositionality idioms (M=10.01), $F(1,78) = 39.57$, $p<.001$, $\eta_p^2 = .337$. There was also a main effect of diagnostic group, $F(2,78) = 3.80$, $p<.05$, $\eta_p^2 = .09$. There was not a significant interaction between decompositionality and diagnosis $F(2,78) = 149$, $p>.3$, $\eta_p^2 = .04$. While the current study found the opposite of what could be expected from the prior literature overall for the effect of decompositionality, Norbury (2004) found this same trend using a similar task and coding scheme. See figure 2.

Figure 2. Scores on low and high Familiarity and decompositionality idioms for the three groups (age-matched controls, language-matched controls, and ASD).



Role of context in idiom comprehension. Children with ASD and TD perform better on low familiarity idioms presented in context than out of context. To examine the role of context in idiom comprehension, six low familiarity idioms presented out of context were compared to the same six idioms when presented in-context. A mixed factors ANOVA was conducted with context (in-context versus out of context) as a repeated measures variable and group (ASD, CAM, and LAM) as a between subjects factor. There was a main effect of context, where scores for in-context (*M*= 6.33) idioms were higher than out of context (*M*=1.19) idioms, $F(1,78) =$

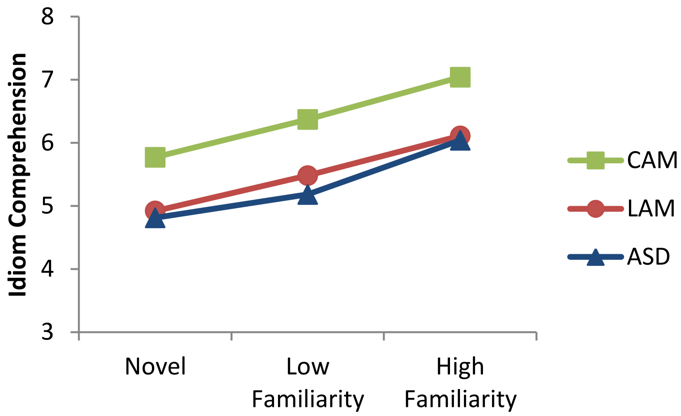
257.53, p<.001, η_p^2 = .77. The effect of group was not significant, $F(2,78) = 2.19$, p=.12, η_p^2 = .05. There was no interaction between group and context, $F(2,78) = .36$, p>.6, η_p^2 = .01.

Children with ASD and typical development are able to use context to abstract the meaning of novel (made-up) idioms. To examine performance for the novel idioms versus increasing levels of familiarity for real idioms, performance on the five low decompositionality items from each familiarity category (novel, low familiarity, and high familiarity) were examined. A mixed factors ANOVA was conducted with exposure (novel, low familiarity, and high familiarity) as a within-subjects factor and group (ASD, CAM, and LAM) as a between-subjects factor. There was a main effect of exposure, $F(1,78) = 26.52$, p<.001, η_p^2 = .25. There was not a significant effect for group, though there was a trend, $F(2,78)$= 2.38, p=.1, η_p^2 = .06. There was no interaction between exposure and group, $F(2,78)$= .08, p>.9, η_p^2 = .001. The effect of exposure was examined, where there was a significant difference between novel (M= 5.17) and low familiarity (low decompositionality) items (M= 5.68), $t(81) = 1.76$, p<.05, d=.21. Low familiarity (low decompositionality) idioms (M=5.68) were also significantly different from high familiarity (low decompositionality) idioms (M=6.39), consistent with the previous results examining high versus low familiarity idioms, $t(81) = 3.05$, p<.01, d=.3.

Performance specifically on the novel idioms were compared for the groups using one-tailed t-tests. There was not a significant difference between the CAM group (M=5.78) and the ASD group (M=4.81) on novel idioms, though there was a trend in the expected direction, $t(52)$= 1.56, p=.065, d=.43. There was also not a significant difference between the LAM group (M=4.93) and ASD group (M=4.81) on novel idioms, $t(52)$= .18, p>.4, d=.05. There was also a non-significant trend for the difference between the control groups (LAM and CAM), $t(52)$=

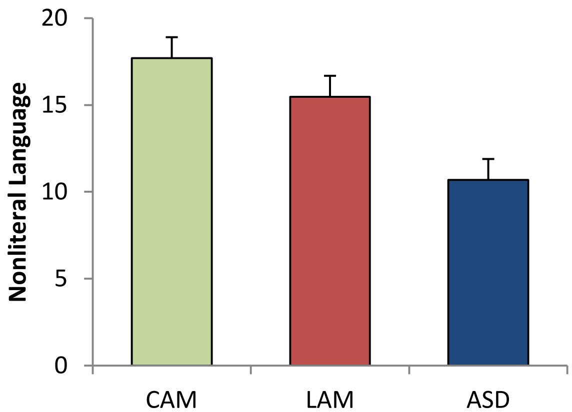
1.59, *p*=.1, *d*=.34. This suggests that children with ASD are able to abstract the meaning of novel idioms from a supportive linguistic context as well as their TD peers. See figure 3.

Figure 3. Scores (means) on novel, low familiarity, and high familiarity idioms with low decompositionality, for each of the three groups.



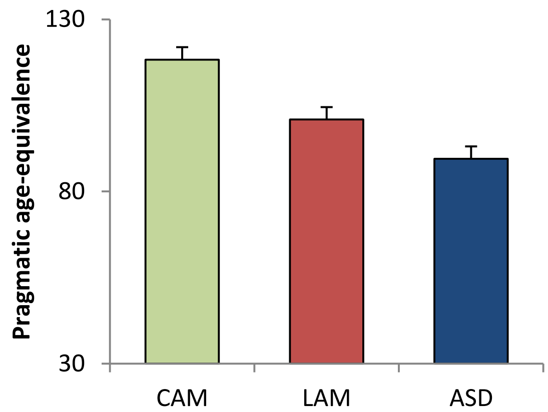
Nonliteral CASL performance. Children with autism scored lower than language-matched controls and age-matched controls on nonliteral language. To examine group differences in raw scores from the Nonliteral *CASL* subtest for the ASD group, CAM group, and LAM group, a one-way ANOVA was conducted. For the nonliteral CASL raw scores, there was an overall effect of diagnostic group, $F(2,77) = 4.94$, $p<.01$, $\eta^2 = .11$. Follow-up one-tailed t-tests were used to examine the difference between the ASD group and each of the two control groups. The CAM group (M = 17.70) had significantly higher raw scores on the nonliteral CASL subtest compared to the ASD group (M = 10.69), $t(51) = 3.34$, $p<.01$, d=.93. The LAM group (M = 15.48) also had significantly higher nonliteral CASL raw scores compared to the ASD group (M = 10.69), $t(51) = 2.21$, $p<.05$, d=.62. This suggests that nonliteral language abilities may be impaired for children with ASD beyond their deficits in syntax. The CAM and LAM control groups do not significantly differ from each other, $t(52) = .89$, p=.19, d=.24. See figure 4.

Figure 4. Nonliteral language raw scores (mean with SEM) for the three groups (age-matched, language-matched, and autism).



Pragmatic CASL performance. To examine differences in Pragmatic CASL age-equivalence scores for the ASD group, CAM group, and LAM group, a one-way ANOVA was conducted. For the pragmatic age-equivalence scores, there was an overall effect of diagnostic group, $F(2,76) = 5.9$, $p<.01$, $\eta^2= .13$. Follow-up one-tailed t-tests were used to examine the difference between the ASD group and each of the two control groups. The CAM group (M = 118.30 months) had significantly higher age-equivalence scores on the pragmatic CASL subtest compared to the ASD group (M = 89.58 months), $t(50) = 3.22$, $p<.001$, d=.88. The LAM group (M = 100.92 months) also had significantly higher pragmatic CASL age-equivalence scores compared to the ASD group (M = 89.58 months), $t(51) = 1.77$, $p<.05$, d=.50. This supports previous results finding pragmatic language deficits in children with ASD beyond their structural language impairments. The CAM and LAM control groups also significantly differ on their pragmatic language age-equivalence scores, t(51) =1.8, p<.05, d=.48. . See figure 5.

Figure 5. Pragmatic language age-equivalence scores (mean with SEM) for the three groups (age-matched, language-matched, and autism).



Autism language groups**.** The impact of language levels on the performance of children with ASD for idiom, nonliteral, and pragmatic language measures was examined in another group comparison. Since the group of children with autism had a wide range in syntax and other language standardized scores, the group of children with autism were split based on a median split of their syntax standard scores into low (Range: 51 to 82, *M* = 71.9) and average (Range: 84 to 104, M = 94.91) syntax groups. The two children below age seven years were excluded from this analysis so that standard scores on the nonliteral language CASL subtest could be examined. One-tailed t-tests were used to examine differences between the low syntax and high syntax groups. The age range of both ASD groups was 7 to 12 years, and there was not a significant difference in age between the low syntax ASD group (*M*=9.23 years) and the high syntax ASD group (*M*=9.50 years), $t(23) = -.42$, $p>.3$. There was not a significant difference for nonverbal IQ between the low syntax ASD group (*M*= 93.5) and the average syntax ASD group (*M*= 102.75), $t(22) = -1.28$, $p>.1$. In addition, there was not a difference in overall autism social symptoms, as measured by the Social Responsiveness Scale, between the low syntax ASD group (*M* = 106.0) and the average syntax ASD group (*M* = 104.8), $t(22)=.11$, $p>.4$. For vocabulary (verbal IQ) standard scores, the low syntax group had significantly lower scores than the average syntax ASD group, though the means of both groups were in the average range, $t(23) = -3.04$, $p < .01$, $d = -1.26$. See table 3.

For pragmatic CASL standard scores, the low syntax ASD group had significantly lower scores than the average syntax ASD group, $t(22) = -3.20$, *p*<.01.001, $d = -1.36$. For nonliteral CASL standard scores, the low syntax ASD group had significantly lower scores than the average syntax ASD group, $t(23) = -1.91$, $p < .05$, $d = -.50$. For the 20 real idioms (out of 40 points), there was a significant difference between the low syntax ASD group and the average syntax ASD group, $t(23) = -3.02$, *p*<.01.001, $d = -1.21$. See table 3.

Table 3. Mean (and range) for scores on the standardized language measures and performance on the 20 real idioms for children with autism with low ($M = 71.9$) or average ($M = 94.9$) syntax standard scores.

	Low Syntax ASD (*n*=13)	Average syntax ASD (*n*=12)
Vocabulary (Verbal IQ) Standard score	*M*= 91.69 (74-117)	*M*= 104.25 (94-116)
Pragmatic Standard score	*M*=73.91 (44-98)	*M*= 89.58 (73-104)
Nonliteral Standard score	*M*= 86.69 (65-104)	*M*= 95.5 (82-117)
Idioms raw score (out of 40)	*M*= 17.84 (9-27)	*M*= 24.50 (16-31)

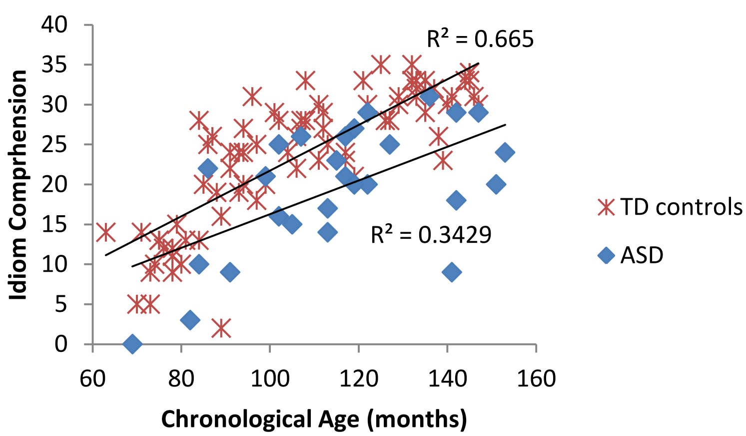
Question 2: Developmental trajectory analysis. For the developmental trajectory approach, the analysis included the full group of children with typical development (TD) and children with autism (ASD). The trajectory analysis approach follows the methods of Thomas et al. (2009), where separate regressions are conducted for each group to see if idiom

comprehension (the 20 real idioms, out of 40 possible points), nonliteral language performance (CASL subtest raw scores), or pragmatic language performance (CASL subtest age-equivalence scores) increase with chronological or structural language abilities (as measured by syntax construction age-equivalence scores) or vocabulary (as measured by verbal IQ age-equivalence scores).

To compare developmental trajectories, an ANCOVA is conducted with diagnosis as a fixed factor, age (or age-equivalence scores) as a covariate, and their interaction as variables. Thomas et al., (2009) suggests that the outcome variables need to be re-scaled to compare the groups starting from the youngest age at which the two groups overlap to be able to interpret differences between groups in the intercept. To compare the trajectories of the TD and ASD groups, a "months from youngest disordered age" variable was created for chronological age, subtracting each individual's score (from both groups) from the youngest age of the ASD group, so that zero represented the first point of overlap between the two trajectories (Thomas et al., 2009). For the two structural language variables where the TD group performed higher than the ASD group, this was instead scaled to months from youngest typical mental age. Thus, diagnosis, months from youngest age of overlap, and their interaction were then entered into ANCOVA models to examine possible differences between the intercept of the trajectories (indicated by a significant effect of diagnosis), or in the slope of the trajectory (indicated by a significant interaction).

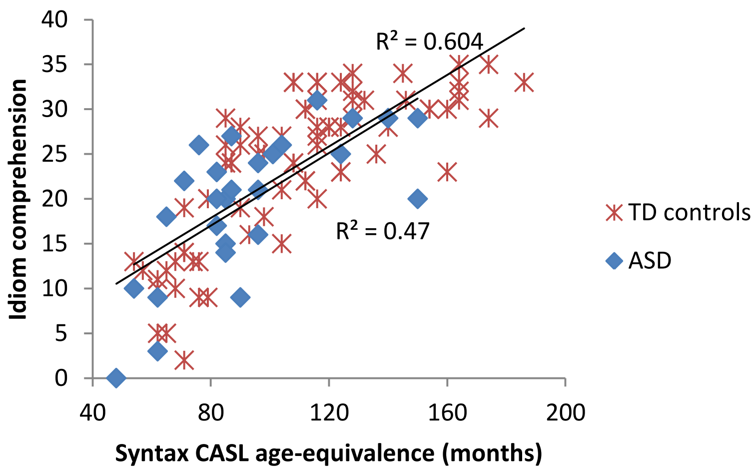
Idiom comprehension trajectories. Linear regressions were used to examine the relationship between idiom performance (performance on the 20 real idioms, out of 40 points) and chronological age (in months) for the TD and ASD groups. For the TD group, idiom performance increased with age, $R^2 = .67$, $F(1,74) = 146.87$, $p<.001$. Idiom performance also increased with age for the ASD group, R^2= .34, F(1,25) = 13.04, p<.01. To compare these trajectories in idiom comprehension, an ANCOVA was conducted, with diagnosis, age (in months from youngest disordered age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a significant delay in onset, F(1,99) = 1.34, p>.2, η_p^2= .01. There is an overall significant effect for chronological age (in months), F(1,99) = 84.85, p<.001, η_p^2= .46. The interaction between age and diagnosis was not significant, suggesting that the two groups did not exhibit a significantly different rate of development, F(1,99) = 1.93, p=.17, η_p^2= .02. See figure 6.

Figure 6. Chronological age trajectory for idiom comprehension for children with ASD and TD.



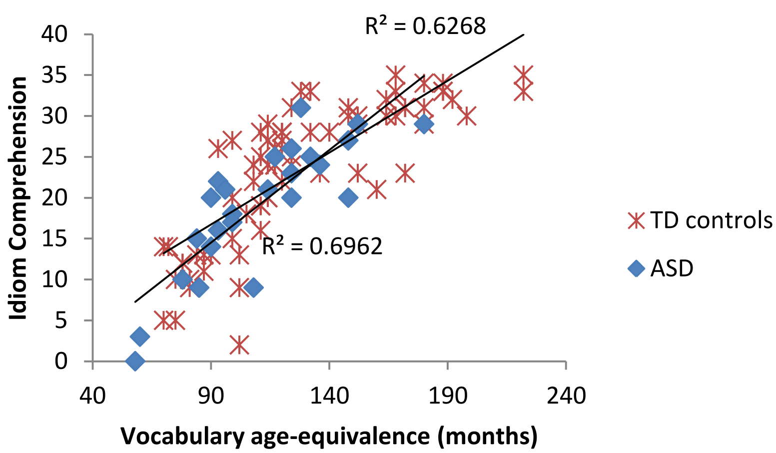
Linear regressions were used to examine the relationship between idiom performance (score on the 20 real idiom items) and syntax age-equivalence scores for each of the two groups. For the TD group, idiom performance increased with syntax age-equivalence scores, R^2= .60, F(1,74) = 112.84, p<.001. For the ASD group, idiom performance increased with syntax age-equivalence scores, R^2= .47, F(1,25) = 22.17, p<.001. To compare these trajectories in idiom comprehension, an ANCOVA was conducted, with diagnosis, Syntax age-equivalence scores (in months from youngest typical age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,99) = .18$, $p>.6$, $\eta_p^2=.002$. There is an overall significant effect for syntax age-equivalence scores, $F(1,99) = 83.60$, $p<.001$, $\eta_p^2=.458$. The interaction between syntax age-equivalence scores and diagnosis was not significant, suggesting that the two groups did not exhibit a significantly different rate of development, $F(1,99) = .005$, $p>.9$, $\eta_p^2=.001$. See figure 7.

Figure 7. Syntax age-equivalence trajectory for idiom comprehension for children with ASD and TD.



Linear regressions were used to examine the relationship between idiom performance (scores on the 20 real idiom items) and vocabulary abilities (as measured by the Verbal IQ subtest of the KBIT-2) for each of the two groups. For the TD group, idiom performance increased with vocabulary age-equivalence scores, $R^2= .63$, $F(1,74) = 120.94$, $p<.001$. For the ASD group, idiom performance increased with vocabulary age-equivalence scores, $R^2= .70$, $F(1,25) = 57.28$, $p<.001$. To compare these trajectories in idiom comprehension, an ANCOVA was conducted, with diagnosis, vocabulary age-equivalence scores (in months from youngest typical age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,99) = 2.6$, $p=.11$, $\eta_p^2=.03$. There is an overall significant effect for vocabulary age-equivalence scores, $F(1,99) = 120.8$, $p<.001$, $\eta_p^2=.56$. The interaction between vocabulary age-equivalence and diagnosis was not significant, suggesting that the two groups did not exhibit a significantly different rate of development, $F(1,99) = 1.91$, $p=.17$, $\eta_p^2=.02$. See figure 8.

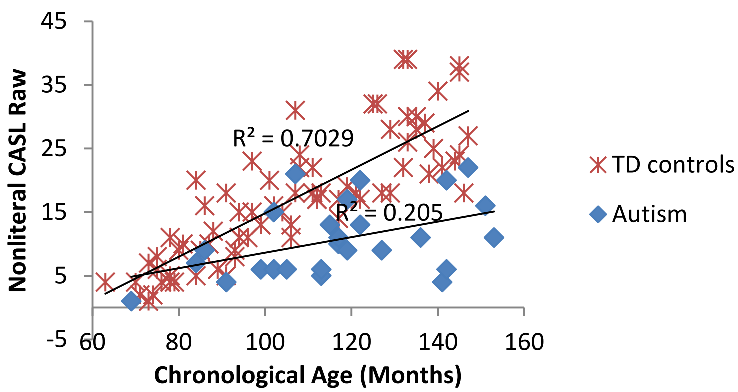
Figure 8. Vocabulary age-equivalence trajectory for idiom comprehension for children with ASD and TD.



Nonliteral CASL trajectories. Linear regressions were used to examine the relationship between nonliteral language CASL raw scores and chronological age (in months) for each of the two groups. For the TD group, nonliteral language raw scores increased with age, $R^2= .70$, $F(1,73) = 172.7$, $p<.001$. Nonliteral raw scores also increased with age for the ASD group, $R^2= .21$, $F(1,24) = 6.19$, $p<.05$. To compare these trajectories in Nonliteral CASL raw scores, an

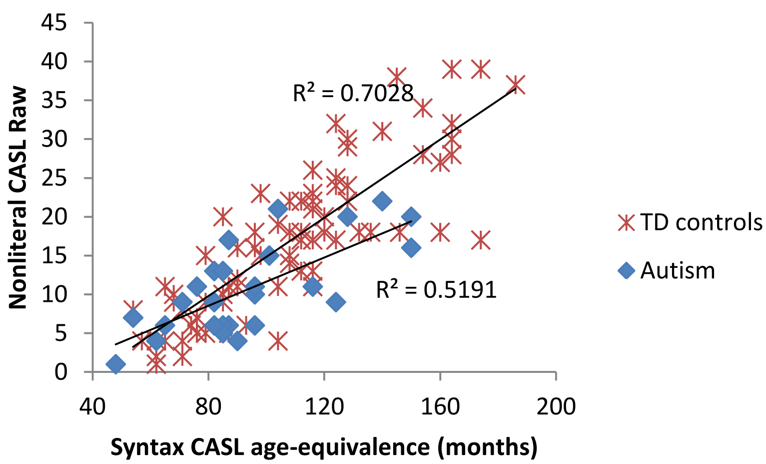
ANCOVA was conducted, with diagnosis, age (in months from youngest disordered age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,97) = .05$, $p>.8$. There is an overall significant effect for chronological age, $F(1,97) = 69.35$, $p<.001$. The interaction between age and diagnosis was significant, suggesting that the ASD group exhibited a slower rate of development for nonverbal scores with age compared to the TD group, $F(1,97) = 15.64$, $p<.001$. See figure 9.

Figure 9. Chronological age trajectory for nonliteral language for children with ASD and TD.



Linear regressions were used to examine the relationship between nonliteral language CASL raw scores and syntax CASL age-equivalence scores for each of the two groups. For the TD group, nonliteral language raw scores increased with syntax age-equivalence scores, R^2= .703, $F(1,73) = 172.66$, $p<.001$. For the ASD group, idiom performance increased with syntax age-equivalence scores, R^2=.52, $F(1,24) = 25.91$, $p<.001$. To compare these trajectories in Nonliteral CASL raw scores, an ANCOVA was conducted, with diagnosis, syntax age-equivalence scores (in months from youngest typical age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,97) = .34$, $p>.5$, $\eta_p^2=.003$. There is an overall significant effect for syntax age-equivalence scores, $F(1,97) = 95.19$, $p<.001$ $\eta_p^2=.50$. The interaction between syntax age-equivalence scores and diagnosis was significant, $F(1,97) = 5.32$, $p<.05$, $\eta_p^2=.05$. This indicates that the children with autism exhibited a slower rate of development for nonliteral subtest scores with Syntax age-equivalence scores compared to the children with typical development. See figure 10.

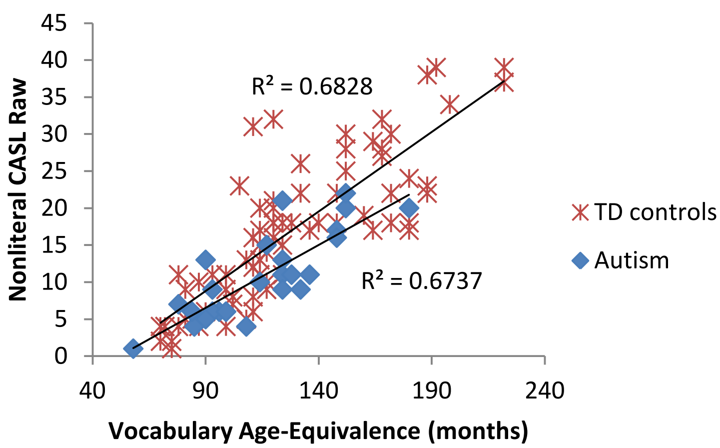
Figure 10. Syntax age-equivalence trajectory for nonliteral language for children with ASD and TD.



Linear regressions were used to examine the relationship between nonliteral language raw scores and vocabulary age-equivalence scores for each of the two groups. For the TD group, nonliteral language raw scores increased with vocabulary age equivalence scores, $R^2= .683$, $F(1,71) = 152.86$, $p<.001$. For the ASD group, nonliteral language scores increased with vocabulary age-equivalence scores, $R^2=.67$, $F(1,24) = 49.56$, $p<.001$. To compare these trajectories in Nonliteral CASL scores, an ANCOVA was conducted, with diagnosis, vocabulary age-equivalence scores (in months from youngest typical age), and their interaction as variables.

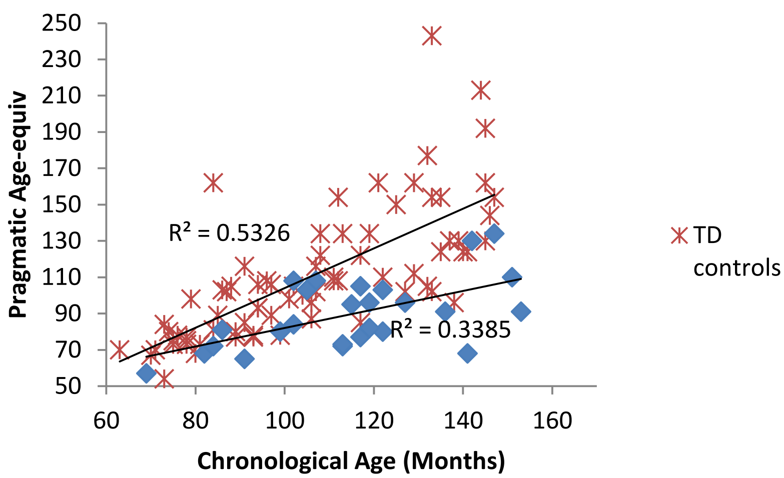
There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,95) = .39$, $p>.5$, $\eta_p^2=.004$. There was an overall significant effect for vocabulary age-equivalence, $F(1,97) = 93.98$, $p<.001$, $\eta_p^2=.50$. The interaction between vocabulary age-equivalence and diagnosis was not significant, suggesting that the two groups did not exhibit a significantly different rate of nonliteral language development when examining vocabulary age-equivalence scores, $F(1,99) = 1.3$, $p>.2$, $\eta_p^2=.01$. See figure 11.

Figure 11. Vocabulary age-equivalence trajectory for nonliteral language for children with ASD and TD.



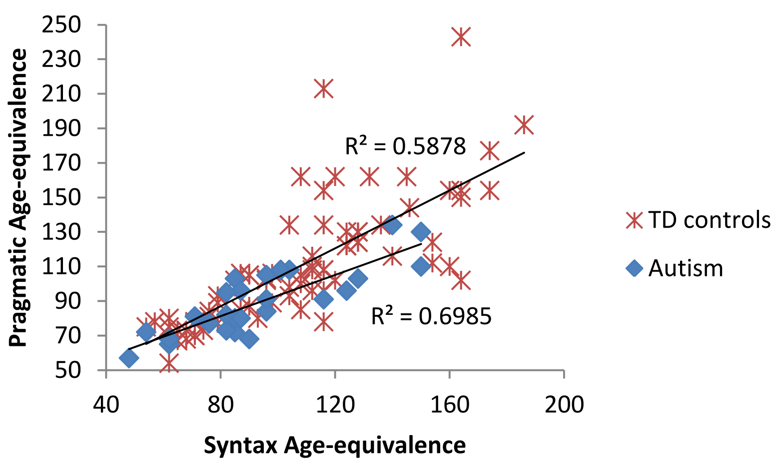
Pragmatic language trajectories. Linear regressions were used to examine the relationship between pragmatic language CASL age-equivalence scores and chronological age (in months) for the TD and ASD groups. For the TD group, Pragmatic language scores increased with age, $R^2= .53$, $F(1,73) = 83.19$, $p<001$. Pragmatic scores also increased with age for the ASD group, $R^2= .34$, $F(1,24) = 12.28$, $p<.01$. To compare these trajectories in pragmatic CASL scores, an ANCOVA was conducted, with diagnosis, age (in months from youngest disordered age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,97) = .11$, $p>.7$. There is an overall significant effect for chronological age, $F(1,97) = 46.75$, $p<.001$. The interaction between age and diagnosis was significant, $F(1,97) = 6.21$, $p<.05$. This suggests that the children with autism exhibited a slower rate of development for pragmatic scores with chronological age compared to the children with typical development. See figure 12.

Figure 12. Chronological age trajectory for pragmatic language scores for children with ASD and TD.



Linear regressions were used to examine the relationship between pragmatic language age-equivalence scores and syntax age-equivalence scores for each of the two groups. For the TD group, pragmatic language scores increased with syntax age-equivalence scores, $R^2= .588$, $F(1,73) = 104.12$, $p<.001$. For the ASD group, pragmatic scores increased with syntax age-equivalence scores, $R^2=.70$, $F(1,24) = 55.61$, $p<.001$. To compare these trajectories in Pragmatic raw scores, an ANCOVA was conducted, with diagnosis, syntax age-equivalence scores (in months from youngest disordered age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,97) = .01$, $p>.9$, $\eta_p^2=.00$. There is an overall significant effect for syntax age-equivalence scores, $F(1,97) = 71.24$, $p<.001$ $\eta_p^2=.423$. The interaction between syntax age-equivalence scores and diagnosis was not significant, suggesting that the two groups did not exhibit a significantly different rate of pragmatic language development with syntax age-equivalence scores, $F(1,97) = 2.04$, $p>.15$, $\eta_p^2=.02$. See figure 13.

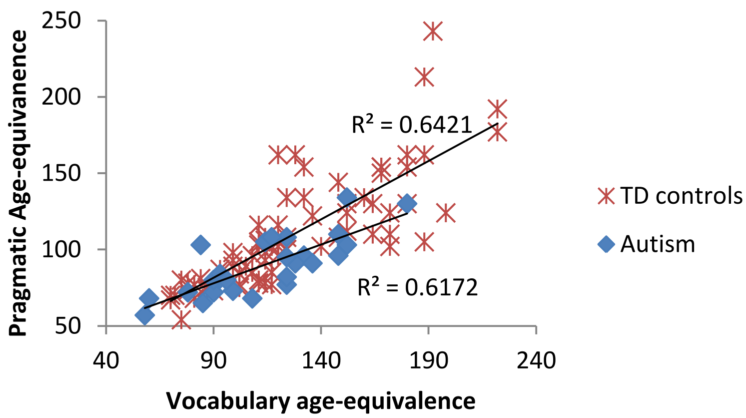
Figure 13. Syntax age-equivalence trajectory for pragmatic languages for children with ASD and TD.



To further examine the relationship between pragmatic language and structural language abilities, vocabulary age-equivalence scores were examined for each of the two groups. Linear regressions were used to examine the relationship between pragmatic language age-equivalence scores and vocabulary age-equivalence scores for each of the two groups. For the TD group, pragmatic language raw scores increased with vocabulary age-equivalence scores, $R^2 = .64$,

$F(1,71) = 127.63$, $p < .001$. For the ASD group, pragmatic language scores increased with vocabulary age-equivalence scores, $R^2 = .62$, $F(1,24) = 38.70$, $p < .001$. To compare these trajectories in Pragmatic language scores, an ANCOVA was conducted, with diagnosis, vocabulary age-equivalence scores (in months from youngest typical age), and their interaction as variables. There was not a significant effect of group, suggesting that the groups did not significantly differ at the youngest age of the ASD group and that there is not a delay in onset, $F(1,95) = .037$, $p > .8$, $\eta_p^2 = .00$. There was an overall significant effect for vocabulary age-equivalence, $F(1,95) = 75.88$, $p < .001$, $\eta_p^2 = .44$. The interaction between vocabulary age-equivalence and diagnosis was not significant, suggesting that the two groups did not exhibit a significantly different rate of development, though there was a trend, $F(1,95) = 3.13$, $p < .1$, $\eta_p^2 = .03$. See figure 14.

Figure 14. Vocabulary age-equivalence trajectory for pragmatic language for children with ASD and TD.



Question 3: Theory of mind. The role of TOM in predicting idiom, nonliteral, and pragmatic language development was examined using the same trajectory analysis approach as above. Individual regressions (for the TD and ASD groups) were conducted between each of the

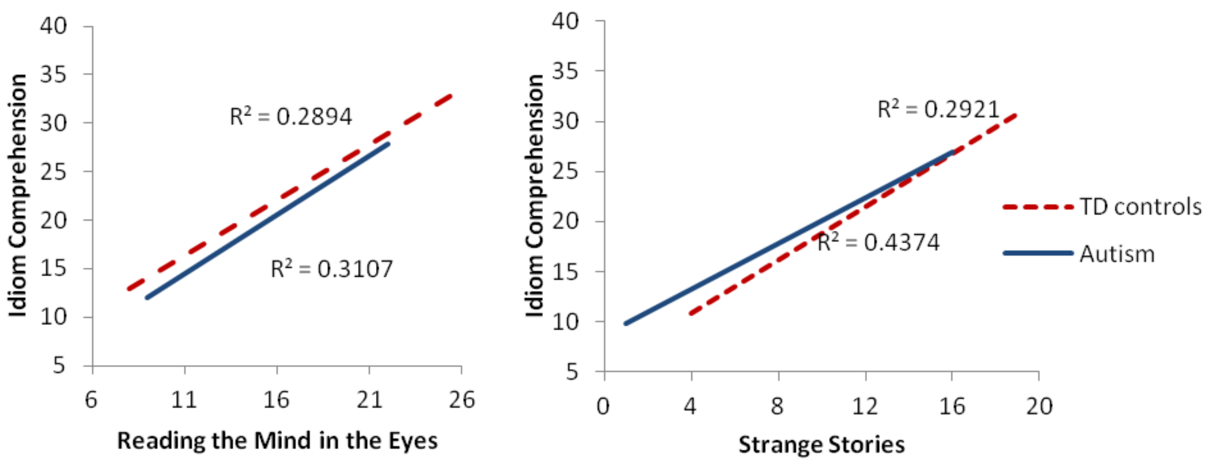
two TOM measures and each of the three outcome variables. Then, ANCOVAs were used to compare the group trajectories. For the ANCOVA analysis, the TOM scores were scaled such that the trajectories compare the lowest score at which the two groups overlap.

Theory of mind and idiom comprehension. Linear regressions were used to examine the relationship between idiom performance (scores on the 20 real idioms) and scores on the RMTE for each of the two groups (TD and ASD). For the TD group, idiom performance increased with RMTE score, R^2= .29, F(1,74) = 30.13, p<.001. Idiom performance also increased with RMTE score for the ASD group, R^2= .31, F(1,25) = 11.27, p<.01. To compare these trajectories in idiom comprehension, an ANCOVA was conducted, with diagnosis, RMTE (score from lowest ASD score), and their interaction as variables. There was not a significant effect of diagnosis group, F(1,99) = .35, p>.2, η_p^2= .004. There is an overall significant effect for RMTE, F(1,99) = 30.58, p<.001, η_p^2= .236. The interaction between RMTE and diagnosis was not significant, F(1,99) = .03, p>.8, η_p^2= .000. There was neither a delayed onset nor a significant difference in rate. See figure 15.

Linear regressions were used to examine the relationship between idiom performance and scores on the Strange Stories measure for each of the two groups (TD and ASD). For the TD group, idiom performance increased with Strange Stories score, R^2= .29, F(1,74) = 30.53, p<.001. Idiom performance also increased with RMTE score for the ASD group, R^2= .44, F(1,25) = 11.27, p<.01. To compare these trajectories in idiom comprehension, an ANCOVA was conducted, with diagnosis, Strange Stories (score from lowest typical score), and their interaction as variables. There was not a significant effect of diagnosis group, F(1,99) = .60, p>.4, η_p^2= .006. There is an overall significant effect for Strange Stories, F(1,99) = 44.37, p<.001, η_p^2= .31. The interaction between strange stories and diagnosis was not significant,

$F(1,99) = .26$, $p>.6$, $\eta_p^2 = .003$. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 15.

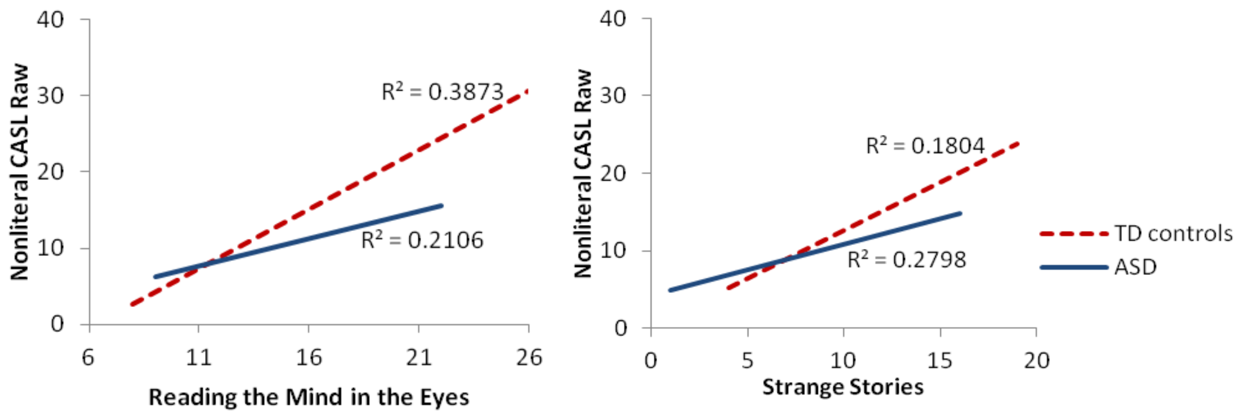
Figure 15. RMTE and Strange Stories trajectories for idiom comprehension for children with ASD and TD.



Theory of mind and nonliteral language. Linear regressions were used to examine the relationship between nonliteral language raw and scores on the RMTE for each of the two groups (TD and ASD). For the TD group, nonliteral language raw scores increased with RMTE score, $R^2 = .387$, $F(1,74) = 46.11$, $p<.001$. Nonliteral language raw scores also increased with RMTE score for the ASD group, $R^2 = .211$, $F(1,25) = 6.24$, $p<.05$. To compare these trajectories for nonliteral language scores, an ANCOVA was conducted, with diagnosis, RMTE (score from lowest disordered score, calculated same as MYDA for age trajectories), and their interaction as variables. There was not a significant effect of diagnosis group, $F(1,97) = .355$, $p>.5$. There is an overall significant effect for RMTE, $F(1,97) = 26.82$, $p<.001$. The interaction between RMTE and diagnosis had a non-significant trend, $F(1,99) = 3.68$, $p=.06$. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 16.

Linear regressions were used to examine the relationship between nonliteral language raw and scores on the strange stories for each of the two groups (TD and ASD). For the TD group, nonliteral language raw scores increased with strange stories score, $R^2 = .18$, $F(1,73) = 16.01$, $p<.001$. Nonliteral language raw scores also increased with strange stories score for the ASD group, $R^2 = .28$, $F(1,24) = 6.4$, $p<.05$. To compare these trajectories for nonliteral language scores, an ANCOVA was conducted, with diagnosis, strange stories (score from lowest typical score), and their interaction as variables. There was not a significant effect of diagnosis group, $F(1,97) = .18$, $p>.6$, $\eta_p^2 = .002$. There is an overall significant effect for strange stories, $F(1,97) = 17.89$, $p<.001$, $\eta_p^2 = .156$. The interaction between strange stories and diagnosis was not significant, $F(1,97) = 1.58$, $p>.21$, $\eta_p^2 = .016$. There was neither a delayed onset nor a significant difference in rate. See figure 16.

Figure 16. RMTE and Strange Stories trajectories for Nonliteral CASL raw scores for children with ASD and TD.

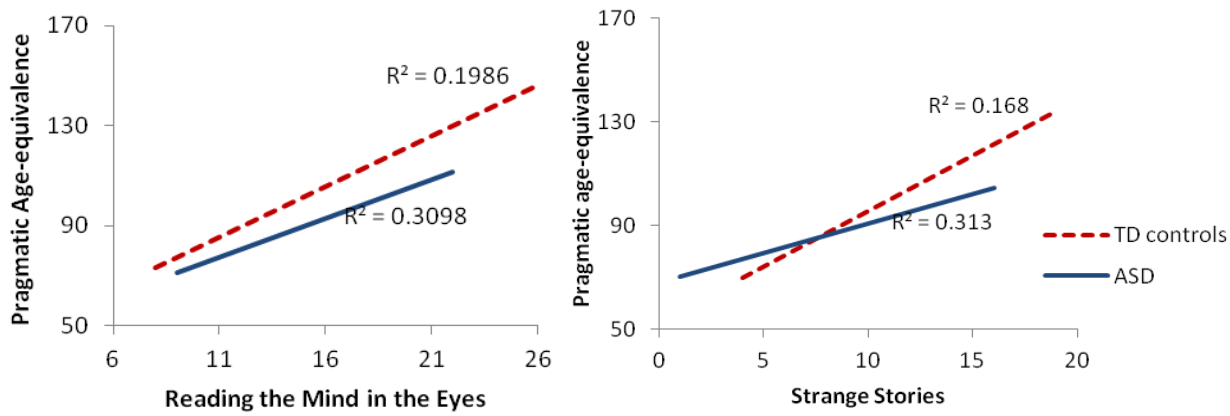


Theory of Mind and pragmatic language. Linear regressions were used to examine the relationship between pragmatic age-equivalence scores and scores on the RMTE for each of the two groups (TD and ASD). For the TD group, pragmatic age-equivalence scores increased with

RMTE score, R^2= .199, $F(1,73) = 18.09$, $p<.001$. Pragmatic age-equivalence scores also increased with RMTE score for the ASD group, R^2= .31, $F(1,24) = 10.77$, $p<.01$. To compare these trajectories for pragmatic age-equivalence scores, an ANCOVA was conducted, with diagnosis, RMTE (score from lowest disordered score), and their interaction as variables. There was not a significant effect of diagnosis group, $F(1,97) = .18$, $p>.6$. There is an overall significant effect for RMTE, $F(1,97) = 14.39$, $p<.001$. The interaction between RMTE and diagnosis was not significant, $F(1,99) = .28$, $p>.6$. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 17.

Linear regressions were used to examine the relationship between pragmatic age-equivalence and scores on the strange stories for each of the two groups (TD and ASD). For the TD group, pragmatic age-equivalence scores increased with strange stories score, R^2= .17, $F(1,73) = 14.74$, $p<.001$. Pragmatic age-equivalence scores also increased with strange stories score for the ASD group, R^2= .31, $F(1,24) = 10.94$, $p<.01$. To compare these trajectories for pragmatic age-equivalence scores, an ANCOVA was conducted, with diagnosis, strange stories (score from lowest typical score), and their interaction as variables. There was not a significant effect of diagnosis group, $F(1,97) = .18$, $p>.6$, η_p^2= .002. There is an overall significant effect for strange stories, $F(1,97) = 17.89$, $p<.001$, η_p^2= .156. The interaction between strange stories and diagnosis was not significant, $F(1,97) = 1.59$, $p>.2$, η_p^2= .016. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 17.

Figure 17. RMTE and Strange Stories trajectories for pragmatic age-equivalence for children with ASD and TD.

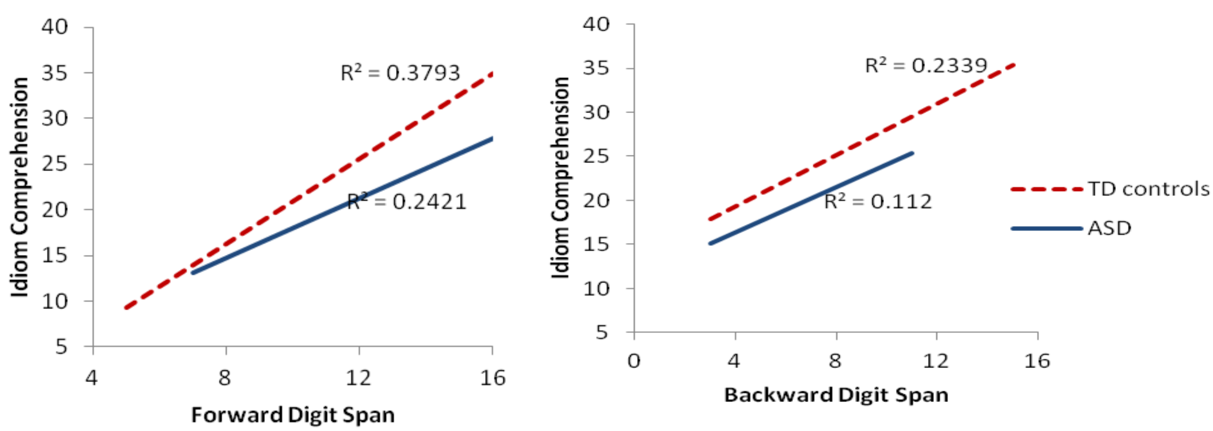


Question 4: Working memory. The role of WM in idiom, nonliteral, and pragmatic language development was examined using the same trajectory analysis approach as above. Visual inspection of the data indicated that there was an outlier in the TD group (one child scored five points higher on forward digit span than the next highest child), and so the following analyses are run with that outlier removed.

WM and idiom comprehension. Linear regressions were used to examine the relationship between idiom performance (scores on the 20 real idioms) and scores on the forward digit span measure for each of the two groups (TD and ASD). For the TD group, idiom performance increased with forward digit span score, R^2= .38, F(1,73) = 44.62, p<.001. Idiom performance also increased with forward digit span score for the ASD group, R^2= .24, F(1,25) = 7.98, p<.01. To compare these trajectories in idiom comprehension, an ANCOVA was conducted, with diagnosis, forward digit span (score from lowest ASD score, calculated same as MYDA for age trajectories), and their interaction as variables. There was not a significant effect of diagnosis group, F(1,98) = .08, p>.7, η_p^2= .001. There is an overall significant effect for Forward Digit span, F(1,99) = 40.37, p<.001, η_p^2= .31. The interaction between forward digit span and diagnosis was not significant, $F(1,99) = 1.16$, $p>.2$, $\eta_p^2 = .012$. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 18.

Linear regressions were used to examine the relationship between idiom performance (scores on the 20 real idioms) and scores on the backwards digit span measure for each of the two groups (TD and ASD). For the TD group, idiom performance increased with backward digit span score, $R^2 = .23$, $F(1,74) = 22.58$, $p<.001$. However, for the ASD group, there was not a significant relationship between backward digit span and idiom comprehension, though there is a trend, $R^2 = .112$, $F(1,24) = 3.03$, $p=.1$. Since there was not a significant trajectory for the ASD group for backward digit span, the ANCOVA comparison was not conducted. See figure 18.

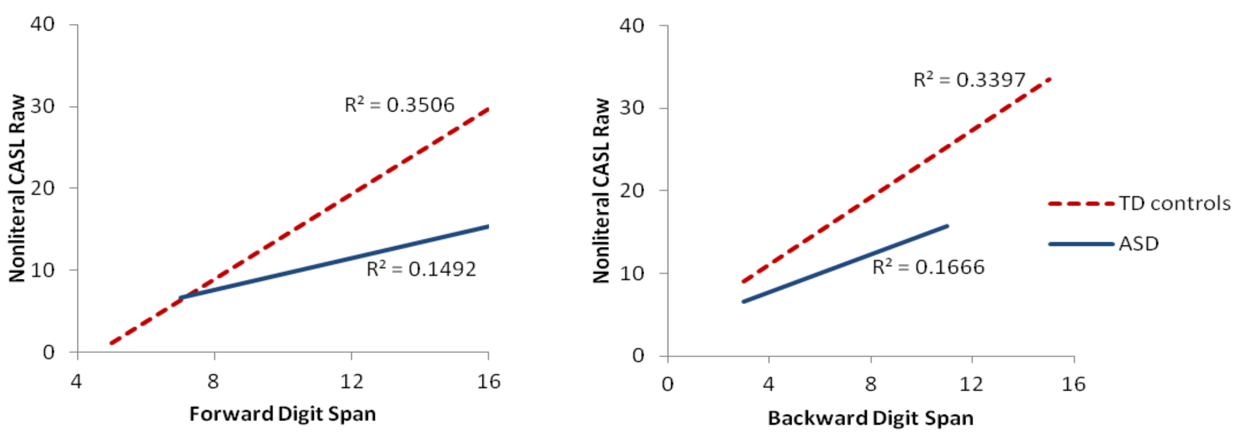
Figure 18. Forward digit span and backward digit span trajectories for idiom comprehension in children with ASD and TD.



WM and Nonliteral Language. Linear regressions were used to examine the relationship between nonliteral language raw scores and scores on the forward digit span measure for each of the two groups (TD and ASD). For the TD group, nonliteral language scores increased with forward digit span score, $R^2 = .35$, $F(1,73) = 40.07$, $p<.001$. For the ASD group, there was a non-significant trend between nonliteral language scores and forward digit span, suggesting that this measure was not a good predictor for nonliteral language abilities, R^2= .14, F(1,24) = 4.2, p=.051. Since there was not a significant trajectory for the ASD group for backward digit span, the ANCOVA comparison was not conducted. See figure 19.

Linear regressions were used to examine the relationship between nonliteral language raw scores and scores on the backward digit span measure for each of the two groups (TD and ASD). For the TD group, nonliteral language scores increased with backward digit span score, R^2= .34, F(1,73) = 37.56, p<.001. Nonliteral language scores also increased with backward digit span score for the ASD group, R^2= .17, F(1,23) = 4.59, p<.05. To compare these trajectories in nonliteral language, an ANCOVA was conducted, with diagnosis, backward digit span (score from lowest ASD score, calculated same as MYDA for age trajectories), and their interaction as variables. There was not a significant effect of diagnosis group, F(1,96) = .56, p>.4. There is an overall significant effect for backward digit span, F(1,96) = 16.63, p<.001. The interaction between backward digit span and diagnosis was not significant, F(1,96) = 1.36, p>.2. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 19.

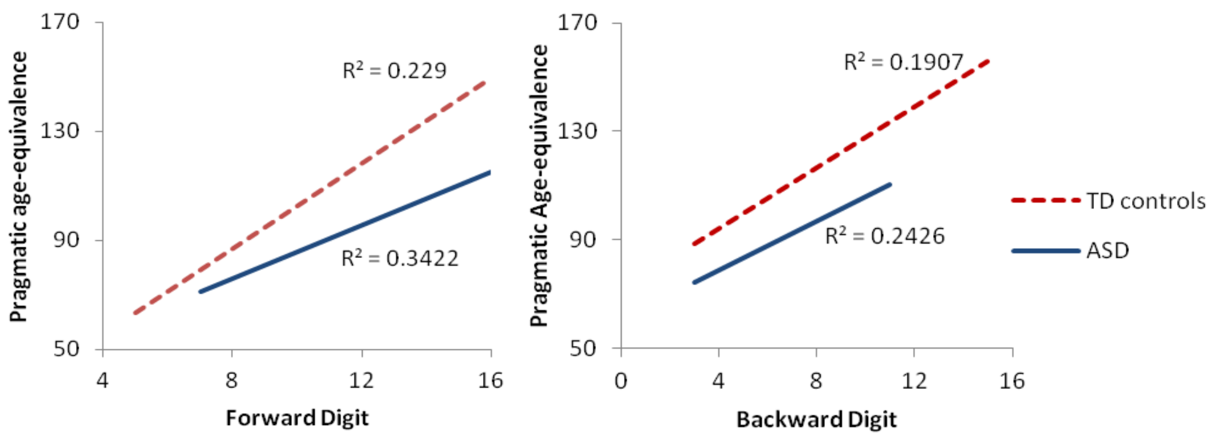
Figure 19. Forward digit span and backward digit span trajectories for nonliteral CASL raw scores for children with ASD and TD.



WM and Pragmatic Language. Linear regressions were used to examine the relationship between pragmatic language age-equivalence and scores on the forward digit span measure for each of the two groups (TD and ASD). For the TD group, pragmatic language scores increased with forward digit span score, $R^2 = .23$, $F(1,72) = 21.39$, $p<.001$. Pragmatic language scores also increased with forward digit span score for the ASD group, $R^2 = .34$, $F(1,24) = 12.48$, $p<.01$. To compare these trajectories in pragmatic language, an ANCOVA was conducted, with diagnosis, forward digit span (score from lowest ASD score, calculated same as MYDA for age trajectories), and their interaction as variables. There was not a significant effect of diagnosis group, $F(1,96) = .36$, $p>.5$. There is an overall significant effect for Forward Digit span, $F(1,96) = 19.11$, $p<.001$. The interaction between forward digit span and diagnosis was not significant, $F(1,96) = 1.03$, $p>.3$. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 20.

Linear regressions were used to examine the relationship between pragmatic language age-equivalence and scores on the backward digit span measure for each of the two groups (TD and ASD). For the TD group, pragmatic language scores increased with backward digit span score, $R^2 = .19$, $F(1,73) = 17.20$, $p<.001$. Pragmatic language scores also increased with backward digit span score for the ASD group, $R^2 = .243$, $F(1,23) = 7.37$, $p<.05$. To compare these trajectories in pragmatic language, an ANCOVA was conducted, with diagnosis, backward digit span (score from lowest typical score), and their interaction as variables. There was not a significant effect of diagnosis group, $F(1,96) = 1.30$, $p>.2$. There is an overall significant effect for backward digit span, $F(1,96) = 11.0$, $p<.001$. The interaction between backward digit span and diagnosis was not significant, $F(1,96) = .14$, $p> .7$. Thus, there was neither a delayed onset nor a significant difference in rate. See figure 20.

Figure 20. Forward digit span and Backward digit span trajectories for pragmatic age-equivalence scores for children with ASD and TD.



Question 5: What combination of cognitive, basic language, and social variables predict idiom, nonliteral, and pragmatic language? For this analysis, children with ASD and typical development are included together in a backwards regression model (*n*=99). The domains examined for possible cognitive and social predictors in this model include: syntax age-equivalence scores, vocabulary (Verbal IQ) age-equivalence scores, theory of mind (RMTE and strange stories), working memory (forward and backward digit span measures), and social skills (social responsiveness scale). The seven possible predictor variables were entered in backwards elimination multiple regression models for each of the three outcome variables.

What combination of variables predicts idiom comprehension? The seven possible predictor variables (vocabulary age-equivalence, Syntax age-equivalence, forward digit, backward digit, RMTE, strange stories, and social responsiveness scale) were entered in a backwards elimination multiple regression model, with idiom comprehension (scores on the 20 real idioms) as the outcome variable. The final stage of the model accounted for 71.8% of the variance in idiom comprehension scores for the children with autism and TD (R^2 = .718), and included only three variables: vocabulary age-equivalence, RMTE, and strange stories scores. Vocabulary age-equivalence was a significant predictor of idiom comprehension, β= .63, *p*<.001. There was a trend for a relationship between RMTE (a measure of TOM performance) and idiom comprehension in the model, β= .118, *p*=.083. Strange stories (the second measure of TOM performance) was also a significant predictor of idiom comprehension, β= .21, *p*<.001.

What combination of variables predicts nonliteral language raw scores? The seven possible predictor variables (vocabulary age-equivalence, Syntax age-equivalence, forward digit, backward digit, RMTE, strange stories, and social responsiveness scores) were entered as predictors in a backwards elimination multiple regression model, with nonliteral language raw scores as the outcome variable. The final stage of the model accounted for 77.8% of the variance in nonliteral language raw scores for children with autism and TD (R^2 = .778), and included four variables: vocabulary age-equivalence, syntax age-equivalence, RMTE, and social responsiveness scale scores. Vocabulary age-equivalence was a significant predictor of nonliteral language, β= .395, *p*<.001. Syntax age-equivalence was a significant predictor of nonliteral language, β= .363, *p*<.001. RMTE (a measure of TOM performance) was a significant predictor of nonliteral language, β= .17, *p*<.01. The social responsiveness scale was a significant predictor of idiom comprehension, indicating that children with higher levels of autism social symptoms had lower nonliteral language scores, β= -.14, *p*<.01.

What combination of variables predicts pragmatic age-equivalence scores? The seven possible predictor variables (vocabulary age-equivalence, syntax age-equivalence, forward digit, backward digit, RMTE, strange stories, and social responsiveness scale scores) were entered as predictors in a backwards elimination multiple regression model, with pragmatic age-equivalence scores as the outcome variable. The final model included four variables: vocabulary age-equivalence, syntax age-equivalence, forward digit span, and Social Responsiveness Scale. However, examination of the beta weights and *p*-values suggested that the effect of forward digit span was not significant and that the sign on the beta weight had reversed from positive to negative in this model, suggesting that there are issues of multicolinearity. Thus, backward digit span was removed and the model was re-run without this variable.

The final stage of the model accounted for 68.7% of the variance in pragmatic language age-equivalence scores for children with autism and TD ($R^2 = .687$), and included three variables: vocabulary age-equivalence, syntax age-equivalence, and social responsiveness scale scores. Vocabulary age-equivalence was a significant predictor of pragmatic language, $\beta = .51$, $p < .001$. Syntax age-equivalence was a significant predictor of pragmatic language, $\beta = .31$, $p < .01$. The social responsiveness scale was a significant predictor of idiom comprehension, indicating that children with higher levels of autism social symptoms had lower nonliteral language scores, $\beta = -.14$, $p < .01$.

Child study brief discussion of central findings

The current study found that children with autism do not have a specific deficit in idiom comprehension, beyond their delays in syntax. This conclusion was supported by convergent findings across multiple analyses. For the idioms presented in a short story context, the group comparison analysis found that idiom scores did not differ between the autism group and language-matched control group. The language-age trajectory analysis did not find differences in the idiom comprehension trajectories (onset, or rate of development) of children with autism and typical development. The importance of syntax levels was further shown by the lower idiom scores for a subset of children with autism who had relatively low syntax standard scores compared with a subset of children with autism who had average syntax standard scores.

For the measure of nonliteral language subtest of the CASL (measuring non-idiomatic figurative language such as metaphors, indirect requests, and sarcasm), there was a significantly lower level of performance for the children with autism as compared with the language-matched TD children in the group analysis. This difference was also found for a pragmatic language subtest from the CASL. For the trajectory analysis, there was a delay in the rate of development for non-idiomatic figurative expressions (on the nonliteral subtest of the CASL) in relation to the measures of chronological age and syntax age-equivalence scores. However, there was not a significant difference between the two groups for non-idiomatic figurative expressions in the trajectory for vocabulary age-equivalence scores. For the pragmatic measure, there was a significant delay in the rate of development with chronological age. Both measures of structural language abilities (vocabulary age-equivalence and syntax age-equivalence), however, did not show differences in the onsets or rates of development between the children with autism and typical development for pragmatic language.

The trajectories for theory of mind and working memory suggest that there are relationships between the TOM and WM variables and each of the three outcome variables, though working memory abilities show differences in which measures are predictive of figurative and pragmatic abilities. The results of backwards elimination multiple regressions indicated that different combinations of basic language abilities (vocabulary and/or syntax), theory of mind, and social skills (but not working memory) contributed unique variance for each of the three outcome variables.

General Discussion

Figurative and pragmatic language development in children with autism and children with typical development as revealed in group-level analyses

Idiom comprehension. Results from the current study suggest that comprehension of idioms presented in a supportive linguistic context may not be specifically impaired in children with autism, beyond their impairments in structural language. For the group-level analysis, while the children with autism scored lower than their age and nonverbal IQ matched typically developing peers on idiom comprehension, they did not have significantly lower idiom scores than the younger language-matched control group for total scores or scores on the 20 real English idioms. In addition the two TD control groups also had significantly different scores, with the older CAM group having higher scores than the younger LAM group. . Overall, the idiom results support the hypothesis of Gernsbacher & Pripas-Kapit (2012) who suggest that children with autism won't show delays in their figurative language abilities when groups are matched on syntax abilities, since figurative language likely draws on their structural language development. In this case, the variables (chronological age or syntax age)used for matching had an effect on whether or not the children with autism showed a significant delay, with language levels reducing the effects between the children with autism and typical development, suggesting that structural language abilities may play an important role in figurative development.

When the group of children with autism was divided into two language sub-groups, having low or average syntax standard scores (age and nonverbal IQ did not differ between the two sub-groups), the low syntax ASD group had significantly poorer idiom comprehension scores than the average syntax ASD group. Given that the two ASD groups did not differ on chronological age, the results of this difference can’t be attributed to potential differences in chronological age, and thus are likely due to differences in the children's structural language abilities. This is consistent with previous research which has found that children with language deficits in syntax or vocabulary (with or without autism) perform worse on measures of idiom performance and also with the idea that idiom comprehension is not independent of structural language abilities (Qualls et al., 2004; Norbury, 2004).

The effect of likely previous exposure to the idiomatic phrases (familiarity/novelty) prior to participating in the study was examined as one of the item-level factors in the group analysis. There was an effect of familiarity/novelty for the idiom phrases in the current study. Children with autism and typical development scored higher on idioms where they likely had more exposure to the phrases. However, the current study did not measure the familiarity of the child participants with the study's idiom phrases. Instead, the current child study relied on average adult ratings from the adult pilot study, and from the Titone & Connine (1994) database. Since the novel idioms were translations of European idioms used in a previous study to examine comprehension of unknown phrases by English speakers (Cain et al., 2005), it makes it highly likely that the children would not have been previously exposed to the novel phrases (and thus could not have simply memorized the meanings prior to the study). The current study found that children with autism are able to use context for interpreting unfamiliar or novel figurative phrases, since the children with autism do not statistically differ from the language-matched typically-developing group for either the novel or the low familiarity idioms. Overall, it is likely that both previous exposure (increasing familiarity with the phrases) along with the use of the linguistic context are important for interpreting phrases. Six of the idioms were presented in both the out of context task and the in-context task, where the out of context task always happened before the in-context task (with at least one task between them to encourage forgetting).

Anecdotally, several children in the study recognized that they knew the answer when the idioms were presented in-context when they didn't previously know those phrases when they were presented out of context. For the in-context task, it is likely that use of clues about the idiom's meaning comes from listening to the story and abstracting relevant details.

Theories of idiom comprehension suggest that the individual words in phrases are used to help figure out the idiom's meaning and that high decompositional idioms should be easier to understand for children and adults (Nippold & Duthie, 2003). In the current study, there was an unexpected result for the effect of decompositionality, where low decompositional (opaque) idioms had higher scores in all the groups compared to high decompositional (transparent) idioms. This is the opposite of the expected trend suggested by previous studies with adults. However, several other studies have failed to find this expected item-level effect (Norbury, 2004; Whyte et al., 2011). In addition, since the ratings of decompositionality came from adults (and not the children themselves), that may also have contributed to the results found here. However, this may be unlikely since the extreme ends of the decompositonality spectrum were chosen, and that decompositionality is thought to be a relatively fixed property of the idiom (ie. "raining cats and dogs" is always highly decompositional since the word "raining" appears in both the idiom and the meaning).

It is possible that there may be some conditions where children don't rely on the individual words in the idiomatic phrase to figure out the meaning of the phrases. It is also possible that very high decompositionality for the phrases may lead some children to produce more literal responses or lower quality responses if the figurative and literal meanings are too confusingly similar and interfere with attending to the important story details. A more transient nature of the use of decompositionality could explain why some studies find conflicting results.

In some cases, using the individual words in an idiom's phrase will lead you to the incorrect literal interpretation. When there are better contextual cues to rely on, decompositionality of the phrases may have a reduced effect on understanding the idioms. Future research should try to use familiarity and decompositionality ratings from the children participating in the study to further clarify the role of these item-level variables. In addition, future research could vary the task demands and amount of context to see under what conditions children are more likely to use the item decompositionality as a factor in their comprehension strategy.

Taken together, the pattern of results for total scores and sub-sets of idioms suggests that children with autism are delayed in idiom comprehension compared to age and nonverbal IQ-matched peers. However, as a group their impairments in idiom comprehension are likely in line with their language comprehension difficulties in general, since the means of the typical control group matched on syntax language-age are overall much closer (and not significantly different from) that of the group of children with autism spectrum disorders. This is also supported by the higher idiom scores for the children with autism who have average syntax abilities compared to the children with autism who have low syntax abilities.

Nonliteral/figurative language. While the children with autism did not show a deficit in idiom comprehension compared to their language-matched peers in the group matching analysis, they did have significantly lower scores on the nonliteral language subtests of the CASL compared to their language-matched peers. In the group-level analysis, the children with autism had significantly lower raw scores for the nonliteral language subtest of the CASL when compared to either the age-matched or the language-matched typical control group. The two typically developing groups do not significantly differ from each other on nonliteral expressions (including metaphor, sarcasm, and other forms of non-idiomatic figurative language), though examination of the means indicate that the trends of the differences between means are in the expected direction even if it didn't reach significance.

For the examination of low versus average syntax scores for the children with autism, the children with low syntax standard scores showed greater delays in their nonliteral language standard scores. The average syntax group of children with autism did not show an overall delay in nonliteral language standard scores. This is consistent with studies examining the role of structural language abilities in interpreting other types of figurative phrases (such as metaphors) for children with autism or other language impairments, in suggesting that syntax and vocabulary abilities may be important for understanding figurative language (Highnam et al., 1999; Jones & Stone, 1989; Norbury, 2005). So, while the children with autism differed from both control groups on raw scores from the nonliteral language subtest of the CASL, the analysis of examining standard scores for the children with autism in particular suggests that syntax may still play an important role, even if it doesn't completely eliminate the difference between the ASD and TD groups.

Pragmatic language. In the group-level analysis, children with autism showed significant delays in their pragmatic language age-equivalence scores compared to both typical control groups (the age-matched and the language-matched group), similar to the results found for non-idiomatic figurative expressions. There was also a significant difference in the expected direction between the two typically developing groups (CAM and LAM). These results do suggest overall that children with autism may have nonliteral and pragmatic language deficits that, while partially explained by their delays in syntax abilities, may still relate to other aspects of their disorder (such as poor social skills or theory of mind).

Examination of the standard scores for the low syntax ASD versus average syntax ASD groups indicated that the children with low syntax abilities have a mean on pragmatic abilities more than one standard deviation below average (with one child with a standard score of 44 on pragmatics, indicating a very severe delay in pragmatic language abilities). However, these pragmatic language deficits were generally in line with their syntax deficits, as all children selected for the low syntax ASD group had scores below one standard deviation on syntax. The average syntax ASD group had mean scores in the normal range for the pragmatic language tests. Since the two ASD sub-groups in this analysis had similar mean ages and nonverbal IQ, and this analysis uses standard scores on the language measures, results from this analysis cannot be attributed to differences in chronological age or overall intelligence. This suggests that delays in pragmatic language abilities may be more common or severe in children who also have delays in their syntax abilities.

Autism is a developmental disorder which is characterized by impairments in language learning and social interactions. Consistent with previous studies, in the group level analyses children with autism did show delays in figurative and pragmatic language compared to their age-matched peers (Dennis et al., 2001; MacKay & Shaw, 2004; Volden et al., 2009). The present study is the first to show that these delays compared to age and nonverbal IQ-matched peers are significant in the same sample of children for all three domains: idiomatic expressions, non-idiomatic figurative expressions (such as sarcasm and metaphor and indirect requests), and pragmatic expressions. However, for the idiom measure in particular, there was not a significant difference between the ASD group and the language-matched control group, and the differences for the other two measures were smaller (though still significant). Thus, the current study does not fully support the idea that either figurative or pragmatic aspects of language are “specifically” impaired in the case of autism (Gernsbacher & Pripas-Kapit, 2012). Accordingly, discussion of further results below will focus on how vocabulary and syntax functioning, along with theory of mind, working memory, and social skills, may dynamically contribute together during development of both children with ASD and Typically Developing children.

The impact of age, syntax, and vocabulary skills on figurative and pragmatic language abilities in children with autism and TD, as revealed in trajectory analyses

Idiom comprehension. The current study also used a cross-sectional trajectory approach, following the methods of Thomas et al., (2009) to examine the development of idiom comprehension for children with autism and typical development. The children with autism and typical development both show significant increases in idiom scores with chronological age and basic language abilities (syntax age-equivalence scores and vocabulary age-equivalence scores). Surprisingly, the children with autism did not show either a delayed onset or slowed rate in idiom comprehension development when comparing the trajectories for chronological age. The children with autism also did not show either a delayed onset or slowed rate of idiom comprehension development when examining trajectories for either vocabulary or syntax. This is consistent with the findings from the current study’s group-level analyses, and taken together, this set of results suggests that scores of structural language abilities may be better predictors of idiom development than the diagnosis of autism in particular. While developmental trajectories have been used to examine performance on metaphor and metanomy (Runblad & Annaz, 2010), this is the first study to apply the Thomas et al. (2009) trajectory analyses for idioms for children with autism and typical development.

Overall, the results for idiom performance in the current study are consistent with the findings of Norbury (2004), in which the group of children with autism only showed significant delays in idiom performance when they also had delays in their structural language abilities. The current study supports the hypothesis of Gernsbacher & Pripas-Kapit (2012), suggesting that children with autism will perform particularly poorly on figurative language measures if they are "less skilled at language comprehension" in general. The current study, however, provides a more differentiated and more thorough examination of these issues than prior literature, not only for children with ASD but also for typically developing children. Examining both vocabulary and syntax in the trajectory and multiple regression analyses allowed for examining how these two aspects of structural language show similar (or different) relationships with idiom performance and other aspects of figurative and pragmatic language development. The results in combination support the overall idea that various domains of language dynamically develop together throughout childhood.

Nonliteral language. In the trajectory analysis, the children with autism and typical development do show increasing scores on the nonliteral language test with chronological age and both measures of basic language abilities (vocabulary and syntax). Recall that this nonliteral test measures a wide variety of non-idiomatic figurative expressions including: indirect requests, sarcasm, metaphors, and similes. When comparing the trajectories of the groups, the nonliteral language measure showed a delayed rate of development for both chronological age and syntax age-equivalence scores for the children with autism. However, the nonliteral language measure did not show a delayed rate of development when vocabulary age-equivalence was used as a predictor. Overall, children with autism show a delayed rate of development nonliteral language when compared to their typically developing peers on chronological age, but at least some of this delay is likely due to their basic language impairments, especially performance on vocabulary.

Let us consider in more detail why skills in vocabulary and syntax may be important contributors to children's learning to understand figurative phrases. As listeners, children need to know the meaning of the words and the structure of the phrases as an important step toward being able to detect that a literal interpretation is unlikely. For example, it is not likely that the speaker literally means that they want you to get up and press your eyes against the chalkboard or draw pictures of eyes on the chalkboard for the indirect request of wanting “all eyes on the board”. Once the child learner realizes that the literal meaning of an expression does not make sense they may then try to use the relevant cues from the linguistic and social context to figure out the meaning of the phrases. Over repeated learning opportunities, once syntax and vocabulary skills are high enough, children do show age-related increases in their understanding of figurative expressions. Increasing age itself likely does not explain such increases; so what we need to pursue are identification of what particular linguistic, cognitive, and social skills are actual facilitators of children's progress in learning and using varied figurative expressions and varied pragmatic expressions.

Rundblad and Annaz (2010) used a developmental trajectory analysis to examine two different aspects of figurative language (metaphor and metonyms) in children with autism across an age range similar to that of the current study. The children with autism in their study did not show a significant relationship between either age or vocabulary abilities (verbal mental age) and metaphor performance. In addition, many of the children with autism scored zero out of 10 on metaphor comprehension. However, the metaphor measure appeared to be difficult for even the typically developing children in their sample, suggesting that task difficulty may have contributed to floor effects for the children with autism in that study, making it harder to interpret the lack of significant trajectories for metaphor performance in children with autism.

Metonyms were easier for both groups than metaphors. Metonym performance increased with vocabulary (verbal mental age) for both the autism and typical group and the two groups showed similar trajectories in this analysis.

It is still possible that different aspects of language abilities may be more impaired than others in children with autism. However, the neuroconstructivist theory of development suggests that the domains of language still do not develop completely independently, as the current study suggests that understanding figurative aspects of language still draws on understanding of the underlying structural language components.

Pragmatic language. The trajectory analysis examining pragmatic age-equivalence scores, while the children with autism showed a slower rate of development for the pragmatic age-equivalence scores with chronological age compared to typically developing children, the structural language trajectories (for both syntax and vocabulary) did not differ between the two groups. Thus, contrary to expectations, the children with autism did not show a delay in the onset or delays in the rate of pragmatic language development with either measure of structural language abilities as the predictor. However, this is consistent with some previous research has found that structural language measures can be a particularly good predictor of pragmatic language abilities, using other measures of structural and pragmatic language abilities (Volden et al., 2009). Reichow, Salamack, Paul, Volkmar, & Klin (2008) found that the pragmatic judgment subtest of the CASL (used in the current study) correlated significantly with the Vineland Adaptive Behaviors Scale, suggesting that it is a valid measure of pragmatic language difficulties in children with autism. These trajectory results for vocabulary and syntax as related to pragmatic understanding also match closely the findings in trajectory analyses for children's understanding of idioms.

Future research should more closely examine various aspects of pragmatic language using a trajectory analysis approach. Lam and Yeung (2012) found deficits in a range of different pragmatic abilities using the Pragmatic Rating Scale (including three subscales: "Disinhibited social communication, Awkward/inadequate expression, and odd verbal interaction") for children and adolescents with autism (ages 8 to 15). A weakness of the Lam and Yeung (2012) study is that they used chronological age as a covariate (ie. something to be controlled for), rather than as a one variable of interest (examining how pragmatic language develops over time). In addition, they did not examine any other possible individual difference variables for the autism group (including vocabulary, syntax, or autism symptom severity) to see how they influenced pragmatic language abilities. The Pragmatic Rating Scale, or other observational pragmatic measures, have the advantage of allowing you to observe the actual use of language in social situations. The pragmatic language measure of the CASL, instead, tries to ellicit specific pragmatic constructions by presenting various situations to the child and asking how they would respond ("The telephone rings. You pick it up. What do you say?"). It is possible that various aspects of pragmatic language may show differing trajectories with age or structural language abilities in trajectory analyses, similar to how different aspects of figurative language show differing developmental trajectories in the current study and in Rundblad & Annaz (2010).

The relationship between Theory of Mind and figurative and pragmatic language development as revealed in trajectory analyses

Both TOM measures were significantly related to idiom skills, non-idiomatic figurative language skills, and pragmatic language in the trajectory analyses both for children with autism and typical development. The children with autism also did not show either a delayed onset or slowed rate of pragmatic language or figurative language development when examining trajectories for either TOM measure. The RMTE measure examines understanding complex expressions and mental states from the eye regions of faces. The Strange stories measure asks the child to listen to a story and say whether the person is telling the truth, (for example, saying that it's not true when the girl says that she doesn't want to go to the park, when she really does) and being able to explain the mental states related to why they said the incorrect statement (she said that she didn't want to go to the park because she is afraid of walking past the house with the nasty dog that jumps up at the gate and barks). Both of these aspects of understanding the mental states of others may contribute to understanding idioms and other nonliteral phrases. Understanding mental states of others may aid in the ability to detect when the speaker is saying something where the literal meaning of the words does not match the intent of the speaker.

Other studies have found significant relationships between theory of mind abilities and figurative language for children using first and/or second-order false belief performance, even when controlling for language abilities (Caillies & Le Sourn-Bissaoui, 2008; Martin & McDonald, 2004). Thus, in some cases, false belief may be a significant predictor of figurative abilities. However, a broader range of advanced theory of mind abilities may do a better job of capturing a broader range of ToM and mentalizing abilities overall. The strange stories and RMTE measures may tap into more complex aspects of mentalizing abilities that may have a stronger relationship to the development of complex language comprehension strategies involved in interpreting figurative language, which requires going beyond the surface meaning of words and phrases to form new and contextually appropriate interpretations in the context of conversations. The individuals with autism in the current study showed a wide range of performance on the RMTE and strange stories task. For strange stories, children with autism scored between 1 and 16 (out of 18) on the measure. For the RMTE tasks, children with autism scored between 9 and 22 (out of 28) on the measure. This suggests that some of the children with autism do quite well on these advanced TOM measures (while other children don't).

Traditional theories of TOM deficits in autism have considered TOM to be largely modular in nature, leading people to conclude that children with autism lack a theory of mind or lack empathy when they do poorly on false belief tasks (Happe, 1993; Martion & McDonald, 2004). However, the large range of scores on the current study's advanced TOM measures suggests that there are measures of TOM which are sensitive to individual differences in ways that allow for TOM to be examined as something that isn't just pass/fail, as with typical scores on the false belief tasks (Gernsbacher & Pripas-Kapit, 2012). Instead of thinking of TOM development as development of a module, the neuroconstructivist theories and emergentist theories suggest that TOM should be thought of as something less domain-specific in early childhood, and is instead a skill that emerges and continues to develop across childhood and into adulthood in conjunction with language and other cognitive and social abilities (Doherty, 2009; Karmiloff-Smith, 1998; Ketelaars et al., 2010; Miller, 2006; Shanker, 2004).

The relationship between working memory and figurative and pragmatic language development

At least one of the two working memory measures were significantly related to idiom skills, non-idiomatic figurative language skills, and pragmatic language in the trajectory analyses both for children with autism and typical development. The children with autism also did not show either a delayed onset or slowed rate of pragmatic language or figurative language development when examining trajectories for either WM measure, though this comparison was not conducted for the few cases where there was not a significant trajectory for the autism group.

For the children (with autism and typical development) in the current sample, the forward digit span measure did relate to idiom performance in the trajectory analysis. Backwards digit span was not a significant predictor for the children with autism in the trajectory analysis, but was a significant predictor for the children with typical development. For the nonliteral language subtest of the CASL, the trajectory analysis suggested that backwards digit span (but not forward digit span) significantly predicted performance for children with autism. Both working memory measures related to nonliteral language for the typically developing children.

Vosniadou (1987) suggests that memory abilities should be important for children to interpret figurative language such as metaphors, since children need a sufficiently large information processing capacity to make the associations necessary to understand figurative language. However, neither WM measure was significant the regression analysis including structural language abilities, TOM, and autistic social symptoms. This suggests that while WM may significantly relate to figurative language understanding, the two measures used in the current study do not significantly predict nonliteral language above the contributions of structural language abilities.

When examining the relationship between digit span measures and figurative language performance, the two span measures (forward and backward) may tap into different skills, and thus they may have different relationships with figurative language performance. Chiappe and Chiappe (2007) found that backwards digit span significantly predicted the quality of metaphors produced by adults, but that forward digit span wasn't predictive. In addition, several working memory variables had independent contributions to metaphor above the contribution of vocabulary abilities. Future research should examine working memory and metaphor performance more closely in children with and without autism. Metaphors and similes may draw more on having to manipulate the individual words in the phrase (compared to idioms, where the words may not always contribute reliably to the phrase's meaning) to make comparisons, in working memory space, about how the girl's legs could be like spaghetti after her long walk in the hot sun, or for understanding that the surgeon was a seamstress in her precision of the operation.

Few studies have examined the relationship of working memory and figurative language abilities in children. Landa and Goldberg (2005) found that executive functioning abilities, including measures of working memory, did not correlate with figurative language for a group of children with autism. Some aspects of executive functioning did correlate with figurative language abilities for typically developing children in that sample. In addition, previous research has found relationships between structural aspects of language (vocabulary and syntax) and working memory (Gathercole & Baddeley, 1990; Leonard et al., 2007)

For the pragmatic language subtest of the CASL, the trajectory analysis in the current study showed that both WM measures were significant predictors, for both children with autism and typical development. Working memory has not been commonly examined in relation to pragmatic language abilities; however it is likely that all aspects of language may draw on working memory abilities in some way.

In summary, one or both WM measures as used in trajectory analyses were significantly related to children's progress on understanding pragmatic expressions and idioms and non-idiomatic figurative expressions. Nevertheless, the working memory variables were not significant predictors of figurative language skills or pragmatic language skills in regressions (see below) which included additional predictors including vocabulary, syntax, social skills, and theory of mind measures. For the current study, the overall pattern of results suggests that forward and backward digit span do not add strongly to models of children's learning of pragmatic expressions or idiomatic expressions or metaphors, sarcasm, indirect requests, and similes.

It may also be possible that certain structural language abilities may actually be a mediator between working memory and figurative language, since research on young children have found sometimes that working memory relates to the development of vocabulary and syntax abilities, and that impairments in working memory abilities can lead to some forms of language impairments (Gathercole & Baddeley, 1990; Leonard et al., 2007). Future research should examine a wider range of memory and executive functioning abilities, with a larger sample of children with autism, to see how they relate to various types of figurative language or pragmatic abilities. Future research should also examine how these skills develop longitudinally to see how working memory interacts with the development of multiple language domains. It is also possible that more complex memory tasks could contribute more strongly to figurative and pragmatic language.

What combination of cognitive and social abilities predicts figurative and pragmatic language abilities?

As indicated in the discussions above, it was important for the current study to examine how rich combinations of various cognitive, basic language, and social abilities may work together to support children's progress in understanding variations in figurative and pragmatic language comprehension. This question was examined using backward-elimination multiple regression models. In order to insure acceptable power, these models include both the children with autism and typical development. For each outcome variable, at least 68% of total variance is accounted for, but with a different combination of significant predictors for idiomatic expressions, non-idiomatic figurative language, and pragmatic expressions. For these analyses, social skills were entered as a potential predictor along with the six other variables examined in the group-comparison and/or trajectory analyses: vocabulary, syntax, RMTE/TOM, strange stories/TOM, forward digit span/WM, and backward digit span/WM.

Children's abilities to interpret idioms included 20 real English idioms (for example, *hit the sack*, *pulling her leg*, and *hold your horses*). Vocabulary (as measured by verbal IQ age-equivalence scores of the KBIT-2) was the strongest predictor of idiom understanding in multiple regression, followed by each of the two TOM measures (reading the mind in the eyes and strange stories). This significant combination accounted for 71.8% of variance in idiom scores. Over many years of interactions with others, children who make progress in understanding more and more idioms must not only process relevant vocabulary but to learn a new idiom must in dynamic fashion bring together a recognition that a speaker intends a nonliteral meaning and the identification of that particular meaning. So, for the context of learning new idioms, the current multiple regression results suggest that close attention to the intent and emotions of others (as tapped by both Theory of Mind measures) needs to be combined rapidly with clarity on the structural aspects of language carrying the idiom. In line with predictions from Dynamic Systems and the neuroconstructivist theories of language development, the combination of component processes accounts for considerable variance in the development of idiom comprehension across childhood. To be able to understand idiomatic expressions (especially when they are unfamiliar to you), you need to be able to extract the meaning from the linguistic (understanding the meaning of the words and structure of a story or in the context of interactions with a person) and social context of that information (ie. understanding that the speaker doesn't mean cats and dogs are actually falling from the sky when they say it is “raining cats and dogs outside”, or that they don't actually have a third eye growing out of the back of their head when they say that “I have eyes on the back of my head”, and instead being able to infer from the person's mental states what they actually mean).

The nonliteral language measure of the CASL examines performance on a wide range of types of figurative expressions (each presented in a couple of short sentences providing some context), including a range of various non-idiomatic figurative expressions, including understanding metaphor/simile phrases ("*you are such a turtle*"), indirect requests ("*the teacher wanted all eyes on the board*"), and sarcasm (“*I see you are training hard for that marathon!*”). For the current study, a combination of both aspects of structural language (syntax and vocabulary age-equivalence scores), one measure of TOM (RMTE), and social skills (social responsiveness scale) scores predicted 77.8% of the variance in nonliteral language raw scores. The child’s ability to understand the basic structural aspects of language, the child’s ability to recognize complex emotions and expressions from the eye regions of faces, and the child’s level of social skills are all contributing to the child’s ability to understand the nonliteral expressions used on this task. In this case, multiple converging abilities are coming together in a dynamic fashion to support children's learning to understanding a variety of figurative phrases. This is consistent with the theory of Vosniadou (1987), which suggests that both linguistic and contextual information are used to understand the meaning of figurative phrases. Vosniadou (1987) suggests that there are several limitations that impact the learning of metaphor & simile in childhood, including the understanding the meaning of the words (ie. the simile “*The boy moved like a snake*” requires the vocabulary & knowledge of snake-like features to attribute to the boy). During a classroom interaction, understanding that the teacher wants "*all eyes on the board*" requires understanding the structural aspects of what the teacher is saying, and also the intent of what the teacher wants you to do (stop whatever you were doing and look at the chalkboard while listening to the teacher). Understanding that "*you are such a turtle*" means that you are slow, and not that you are green, requires understanding the meaning of turtle and being able to choose the feature of the turtle that most likely matches what the person intends.

The pragmatic language subtest of the CASL measures understanding of the rules of language use in a social context (such as answering a telephone, saying please and thank you, and asking for directions). For the pragmatic language measure of the CASL, both measures of structural language (syntax and vocabulary age-equivalence scores) along with social skills (social responsiveness scale) scores predicted 68.7% of the variance. In this case, we get a slightly different pattern of results than that found for either idiom comprehension or non-idiomatic figurative language. The current study supports the hypotheses from previous research that structural language and social skills together contribute to success in pragmatic language (Louska & Moilanen, 2009). For example, *understanding how to ask a stranger for directions* requires both knowledge of the structural aspects of language (being able to effectively express your desire) and the ability to express this information politely, so that you are asking for help in a way that is likely going to convince a stranger to want to help you find the place where you need to go. For one of the other items, where a boy was talking about worms during lunch, knowing that the boys got up from the table because the topic was gross likely involves knowledge of the words and syntax for the story (knowing that worms are small slimy creatures that spend most of their time in dirt, and lunch time is usually when people are eating food) along with understanding the appropriate social conventions (that most people find worms gross and also find talking about gross things to be inappropriate during lunch).

Comparison of adult study one and child study two results

Results from the two studies (with adults and children) suggest that vocabulary and syntax are important predictors of figurative and pragmatic language abilities (Highnam et al., 1999; Levorato, 1993; Johnson, 1991; Norbury, 2004; Qualls et al., 2004). For the adults, grammaticality judgment scores related to idioms for both tasks (idioms presented in context or out of context). For the children with autism and typical development, both vocabulary and syntax abilities significantly predicted scores on idiom presented in context, as well as other nonliteral and pragmatic language abilities.

Theory of mind (as measured by the child and adult versions of the RMTE) is related to idiom comprehension, as well. For the adults, the RMTE measure correlated with idiom performance out of context. For the children with autism and typical development, the advanced ToM measures (RMTE and strange stories) related positively to idiom comprehension (presented in context), nonliteral language, and pragmatic language abilities. The results also suggest that ToM abilities contribute unique variance to children's understanding of idioms and non-idiomatic figurative expressions, even when included in a model with vocabulary and syntax abilities. This converging evidence supports the idea of ToM as an emergent property, where language and TOM abilities may develop together interdependently (Doherty, 2009, p. 207; Ketelaars et al., 2010; Shanker, 2004). Since TOM is important for both children and adults, individual differences in complex emotion recognition and mentalizing abilities likely is an important dynamic feature of understanding figurative language. In conversations, you need to be able to recognize that the person isn't literally meaning what they say, so facial expressions could be one way in which people express the fact that they do not intend to be literal with their statement.

The results from working memory tasks (the forward and backward digit span) were much more mixed across the two studies. The backwards digit span did not relate to idiom comprehension for adults or children with autism, but did relate to idiom comprehension for typically developing children in the trajectory analysis. The forwards digit span did not correlate with adult idiom performance. There was a significant relationship between forward digit span and idiom comprehension for both groups of children (with autism or typical development) in the trajectory analysis. Overall, this suggests that some aspects of working memory may be important for children to be able to understand figurative and pragmatic language, such as being able to hold information in mind - in the case of forward digit span, and/or the ability to manipulate that information in working memory - in the case of backward digit span. Neither working memory variable was a significant predictor of idiom comprehension in models which also included structural language abilities and theory of mind. For the nonliteral and pragmatic measures, while working memory abilities were significant predictors in the trajectory analysis for children with autism and typical development, working memory abilities were not significant predictors in the multiple regressions with structural language, TOM, and autistic symptoms. So, while working memory doesn't correlate with idiom performance with adults, some aspects of working memory does seem to relate to relate to comprehension of figurative and pragmatic language for children, even if working memory doesn't provide unique predictive ability in multiple regression models containing vocabulary, syntax, and theory of mind and social skills.

Results from the adult study found that working memory (as measured by forward and backward digit span) did not relate to idiom comprehension, for idioms either presented in or out of context. The studies used to derive theories about the relationship between working memory and figurative language have usually examined metaphors and have mostly looked at these skills in healthy adults (Blasko, 1999; Chiappe & Chiappe, 2007; Qualls & Harris, 2003). Qualls & Harris (2003) found that working memory, as measured by alphabet span, correlated with idiom performance for adults. However, another aspect of working memory in the same study (a size judgment span measure) did not relate to idiom performance (Qualls & Harris, 2003). Thus, it is still an open question as to which measures of working memory may contribute to idiom comprehension and other types of figurative and pragmatic language skills.

Combined, the results from multiple approaches suggest that syntax and vocabulary language abilities and theory of mind are all good predictors of idiom comprehension abilities in children and adults. It is likely that comprehending figurative language involves understanding the complex mental states of the speaker to understand that the person is not intending to be literal in their statement, and that the ability to comprehend the individual words and syntactic structure of the utterance also aids in understanding the sometimes complicated meaning of the figurative expression.

Conclusions and future directions

Prior literature on children at 5 to 12 years of age provided some evidence that skills in understanding figurative expressions (idioms, metaphors, sarcasm, indirect requests) and pragmatic expressions for those with ASD lag behind skills in TD children. The present study addressed this topic using fairly comprehensive methods and for the field a relatively large sample size. The results suggest that children with ASD show a delay in idiomatic expressions, other figurative expressions, and pragmatic expressions when the comparison group of TD children is not matched on syntax age to the ASD children. For these findings and for the many other significant findings covered above and below, nearly all effect sizes fell in the medium to very large effect size range and the majority were in the large to very large categories.

Going well beyond prior studies in examining the role of language levels in helping to explain *why* children with ASD may be behind, the current findings are consistent across 3 types of analyses in showing the significant contributions of basic language skills. Syntax, vocabulary, or both, depending on particular analyses, were always significant contributors to outcomes. In group analyses, for idioms and other figurative expressions and pragmatic expressions a Language-Matched (matched on syntax age) group of TD children was always closer in performance to the group of children with ASD. The language matched group not significantly different from the children with ASD for idioms in particular. This suggests that reducing the syntax gap reduces or eliminates the figurative or pragmatic language understanding gap. Group analyses also show that the older age-matched TD group was higher in these figurative and pragmatic skills than the younger language-matched TD group, and in all but one of the analyses, this advantage was significant. The inclusion of two typically developing comparison groups (each group separately matched to the children with autism) is a strength for the current study, since the majority of previous studies on figurative language have only used one typically developing control group, and are also often not matched on syntax abilities.

The trajectory analysis (Thomas et al. 2009) is particularly important for being able to distinguish different types of delays. The current study used the trajectory analyses to examine how a variety of predictors (age, syntax, vocabulary, theory of mind, and working memory) all relate to measures of figurative (idioms and nonliteral language) and pragmatic language. Trajectory analyses also reveal a systematic and significant increase with increasing syntax and vocabulary levels for idioms, other figurative expressions, and pragmatic expressions. For the idiom and pragmatic outcome language measures, trajectories also revealed no ASD vs TD difference in onset or in rate of development with vocabulary and syntax age-equivalence scores. However, for pragmatic expressions there was a modestly and significantly lower rate of development favoring TD over ASD as syntax (but not vocabulary) language levels increased.

The children with TD and ASD showed similar trajectories for theory of mind when related to each of the outcome language variables overall. For working memory, the majority of the comparisons showed similar trajectories for the three outcome variables, with two exceptions where backward digit span wasn't predictive of idioms and forward digit span wasn't predictive of other nonliteral expressions for the children with autism.

A further clear contribution of the current study relative to prior literature is that the backwards elimination multiple regression results of the child study show that various combinations of structural language abilities, theory of mind, and social skills (but not working memory) contributed to pragmatic and figurative language abilities in the children with and without autism. All of these potential contributors to development of skills in figurative and pragmatic language are analyzed together so that one can see which of the potential predictors are strongest, second strongest, and so on. In these analyses for all three outcome variables, vocabulary was the strongest contributor, and for pragmatic expressions and non-idiomatic expressions, the second strongest contributor was syntax levels. Thus, the multiple regressions again emphasize the importance of basic language skills as foundation skills for learning and using idioms, other idiomatic expressions, and pragmatic socially-embedded expressions. For idiom and the nonliteral language tests, theory of mind was a significant predictor, and for nonliteral and pragmatic language, social skills (as measured by the parent-report social responsiveness scale) also contributed to the models.

Future research should examine additional figurative and pragmatic abilities using trajectory models. The current study showed that children with autism who also had a delay in syntax abilities showed much lower scores on all other language measures compared to children with autism who scored more in the average range on syntax, though the ranges of scores of the two groups overlapped (so, skills other than syntax, such as theory of mind and vocabulary and social skills, still play some role in the development of figurative and pragmatic language abilities). A weakness of the Runblad and Annaz (2010) study using a developmental trajectory approach is that syntax abilities were not measured (and only one measure of vocabulary was measured) for predicting figurative language. Since the children with autism overall had a severe delay in vocabulary abilities in their study (an average standard score of 76), it is likely that they may have had even more severe delays in their syntax and language comprehension abilities as a group overall, making the results of Runblad and Annaz (2010) likely not generalizable to children with autism without structural language impairments. When trajectory analyses were used to examine face recognition abilities in children with high and low functioning autism separately, results indicated that only high functioning children showed significant age and mental age trajectories, whereas low functioning children with autism did not (Annaz, Karmiloff-Smith, Johnson, & Thomas, 2009). High and low functioning children with autism in future systematic research may show different developmental trajectories with regards to other domains, including many aspects of language.

Again note that in the current study those ASD children with average rather than low syntax standard scores demonstrated significantly higher skills for idioms, non-idiomatic expressions, metaphors/similes and indirect requests and sarcasm and vocabulary. Metaphor comprehension, and other figurative abilities and pragmatic abilities, should be measured more systematically along with multiple measures of structural language abilities (including syntax and vocabulary production or comprehension or fluency) in future research with larger sample sizes of high and low functioning children with autism to examine these remaining questions. It may be important to distinguish between high and low functioning children with autism for examining whether or not different sub-groups of children with autism show different trajectories in their development of figurative language. One weakness of the trajectory analyses used in the current study is that they are cross-sectional, and so they can't address questions about change over time within individual children (Thomas et al., 2009). Future research should examine the development of figurative and pragmatic language abilities using a longitudinal trajectory analysis approach to further examine development of these skills and the processes that contribute to their growth

The current study suggests that a combination of cognitive/linguistic and social abilities (including vocabulary, syntax, theory of mind, and social skills) dynamically interact during development to lead to either improved or impaired figurative and pragmatic language abilities (Nelson & Arkenberg, 2008). However, it is still possible for different underlying mechanisms to lead to similar performance on standardized tests for children with autism and typical development (Annaz et al., 2008). Neuroimaging studies of figurative language use and learning are important for examining how figurative language is represented in the brain for individuals with autism and typical development. For example, Kazmerski et al. (2003) found evidence of differences for higher and lower IQ adults in the timing of ERP waveforms when making judgments about metaphors, even when both groups were able to interpret metaphors behaviorally. Neuroimaging has been used to examine differences between how children and adolescents with autism or typical development use context and prosody to interpret ironic phrases (Wang, Lee, Sigman, & Dapretto, 2006). Gold et al. (2010) used ERPs to examine individual differences in how adults with Asperger’s syndrome comprehend metaphors. Neuroimaging data suggests that individuals with autism have differences in how figurative language is processed in the brain. Future research should also use longitudinal studies to examine how the brains of children with autism may develop differently than children with typical development.

Longitudinal studies of figurative and pragmatic language, especially in combination with neuroimaging techniques such as ERP and fMRI, are a particularly important future direction for seeing how children with autism develop a range of language skills (narrative vocabulary, syntax, pragmatic, and figurative) over time. Since the current study is cross-sectional, we cannot make strong claims with regard to the directionality of causal relationships between the variables. Longitudinal studies, although rare, have been able to examine the directionality of effects between language and theory of mind when examining early vocabulary and syntax development (Astington & Jenkins, 1999).

Understanding more about the development of various language structures (and how they may develop together) can help with understanding targets for intervention. It may be necessary to intervene on multiple areas of weaknesses to support learning that is tailored to the individual's areas of weakness and strengths (Nelson, 1989; Nelson et al., 2004; Nelson & Arkenberg, 2008). Certainly it is clear that a majority of the children with ASD in the current study were behind in more than one domain of language relative to typically-developing children. Fortunately, recent interventions have been successful for teaching children with autism and other communication disorders about figurative language (including idioms) and other social-pragmatic abilities (Abrahamsen & Smith, 2000; Adams, Baxendale, Lloyd, & Aldred, 2005; Ingersol, 2010; Whyte et al., 2011). In addition, the Comprehensive Assessment of Spoken Language standardized test could be an important tool for clinicians and speech pathologists to use in examining the profiles of various language domains for children with autism and other language impairments for choosing targets of the various areas of language that may need more or less intensive intervention for individual children.

In conclusion, the current study is consistent with the neuroconstructivist and other dynamic systems perspectives of development, where various domains of cognitive, linguistic, and social abilities develop together and show mutual facilitative influences across childhood through adulthood (Karmiloff-Smith, 1998; Oliver et al., 2000; Nelson & Arkenberg, 2004). The cross-sectional developmental trajectory approach provides information about the rates of language development for children with typical development and autism, and the types of delays in figurative and pragmatic abilities that may occur for children with autism compared to children with typical development. These trajectories provide evidence that children with autism (especially children with higher structural language skills, theory of mind, and working memory) still show development in various figurative and pragmatic skills (and the delays seen in language and social abilities do not indicate a lack of development). The planned group analyses and the multiple regression analyses further clarify the processes at work in development. Thus, the current study provides an important set of analyses and discussions of how multiple domains of structural language, theory of mind, working memory, and social skills may develop together in a way that supports the learning of figurative and pragmatic language abilities. Further, the results indicate that the particular patterns of cognitive/linguistic/social skills that underlie progress are partly similar and partly contrasting for the three domains of outcomes studied: idioms, non-idiomatic figurative expressions, and pragmatic expressions.

Appendix. Idioms used for the in-context measure for children and example story from the measure.

High Familiarity Idioms

Low Decompositionality	High Decompositionality
A piece of cake	Hold your horses
Break the ice	Slipped my mind
Hit the sack	Cost an arm and a leg
Skate on thin ice	Talking a mile a minute
Pulling her leg	Keep a level head

Low Familiarity Idioms

Low Decompositionality	High Decompositionality
Have egg on my face	Get the eye
Coming up roses	Praised it to the skies
Spinning a yarn	Force my hand
Get your goat	Saved my skin
Cool their heels	Grease the wheels

Novel idioms (From Cain, Oakhill, & Lemmon, 2005).

Low Decompositionality
The turtle is shrouded
eat a leaf
pet the horse first
at the green
Have salt in your pumpkin

Example item from the in-context measure:

In-context story: I was supposed to go to my friend's house after school on Friday. However, I didn't make it to my friend's house because it **slipped my mind.**

Question: What does "slipped my mind" mean?

Correct answer example (2 points): You forgot about it
Related figurative example (1 point): You don't think about it (needs to say "forget" for 2 points)
Literal example (0 points): Your mind crazy; Slip on soap or banana peel
Restated example (0 points): Slipped your mind
Not related (0 points): I had to do chores; Skip

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Elisabeth M. Whyte - Curriculum Vitae

The Pennsylvania State University, University Park, PA
PhD. Developmental Psychology, August 2012

University of California, San Diego
B. A., Psychology, June 2006

Publications

Nelson, K. E., Welsh, J. A**., Vance Trup, E. M**., & Greenberg, M. T. (2011). Language delays of impoverished preschool children in relation to early academic and emotion recognition skills. *First Language*, *31(2)* 164-194. DOI: 10.1177/0142723710391887

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