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Variability in Pragmatic Abilities in Children with Autism Spectrum Disorder

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Communication involves information beyond what is coded in the linguistic stimuli produced by a speaker. How individuals are able to extract additional, pragmatic meaning from a speaker's utterance (i.e., what kind of skills/knowledge might be involved) is relatively understudied. To address this question, the current study examined 7- to 10-year-old typically developing (TD) children and children with autism spectrum disorder (ASD)'s ability to interpret four different pragmatic devices: conventional implicatures, scalar implicatures, relevance implicatures, and metaphors. We were interested in determining whether variability in children with ASD's ability to process such devices would be found and if so, whether their relative strengths and weaknesses would be related to other deficits often reported in this population (e.g., theory of mind). This may provide insight as to what underlying skills/knowledges are involved in the processing of the different pragmatic devices. To probe the question more directly, we also examined to what extent factors such as working memory, theory of mind, and general language ability predicted TD children's performance on the pragmatic devices. We found that both TD children and children with ASD demonstrated variability, albeit slightly differently, in their ability to interpret these different devices. We also found that the various contributors predicted performance on the pragmatic devices differently. From these findings, we concluded that different pragmatic devices require different sets of skills/knowledge. Moreover, it appears that pragmatics is acquired in a more piecemeal manner, with different pragmatic devices undergoing different developmental trajectories.

Variability in Pragmatic Abilities in Children with Autism Spectrum Disorder

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Chapter 1: Introduction

Engaging in successful discourse requires not only knowledge about the conventional use and meaning of linguistic constructions. It often also requires the ability to incorporate contextual information as well as information about the speaker's knowledge and intent – what is considered the pragmatic use of language. One aspect of pragmatics that remains comparably understudied is the underlying cognitive processes that allow individuals to engage in such type of reasoning. While some work has investigated this in typically developing (TD) adults (Chiappe & Chiappe, 2007; Janssens & Schaeken, 2016), our study aims to provide novel insight by investigating this in TD children and children with autism spectrum disorder (ASD). Investigating how TD children's pragmatic development coincides with development in other domains can reveal to what extent these play a role in pragmatic processing. On the other hand, communication deficits are a key feature in ASD, even among individuals with ASD who have intact structural language abilities (APA, 2013; Eigsti, de Marchena, Schuh, & Kelley, 2011; Dennis, Lazenby, Lockyer, 2001). However, recent investigations into individuals with ASD's pragmatic skills have revealed some areas that are intact (see Naigles & Chin, 2015 for a general overview). Clarification to the nature of the variability of pragmatic ability in this population and how it may be related to deficits in other areas reported in ASD (e.g., theory of mind, Baron-Cohen, 1989; working memory, Schuh & Eigsti, 2012) can reveal the role those skills play in the cognitive process of pragmatic reasoning. The current study, thus, breaks new ground in understanding this variability in the extent of pragmatic deficits in ASD by investigating multiple pragmatic devices (i.e., conventional, scalar, and relevance implicatures as well as metaphors) within the same group of children with ASD, which very few studies have done thus far (c.f., Dennis et al., 2001; Surian, Baron-Cohen, van der Lely, 1996). Moreover, the study also

explored the underlying cognitive processes that might be involved in each pragmatic device, shedding light on how each enables successful communication as well as how each might be organized in relation to the others.

Overview

To use and understand language within a communicative setting requires the ability to extract meaning beyond those encoded in the words and sentence structure of the utterance. That is, there is additional information present in the context that enriches the interpretation of the utterance. For example, the utterance "I have a lot of work" produced in the context in which a colleague is inviting one to a party has a different interpretation than if it was produced in the context where a friend might be asking how one's new business is doing financially. In uttering the sentence "I have a lot of work" in the former scenario, the speaker is not only providing explicit information about their workload but also may intend to additionally mean that s/he is unable to attend the party. In the latter scenario, the speaker again indicates how much work s/he has and also intends an additional message; however, notice that the additional intended meaning here differs from the first scenario – namely, here the speaker may be indicating that the new business is doing financially well. These examples demonstrated two points: first, that an utterance can have additional interpretations besides those stated explicitly in the utterance and second, that different contexts can yield different interpretations. How we come to generate this additional, implicit meaning in relation to the context is one of the foci of the field of pragmatics. More specifically, pragmatics studies the social-communicative function of language that extends beyond information provided by the semantics of utterances, examining how individuals use language in and extract meaning from a social context (Davis, 1991; Davies, 1995).

Individuals with ASD appear to be particularly impaired in this domain. ASD is a pervasive developmental disorder categorized by restricted, repetitive pattern of behavior or activities and social-communicative impairments (DSM-V; APA, 2013). Given the social nature of their impairments, difficulties in the pragmatic use of language have been consistently reported in individuals with ASD (Kelley, 2011; Loukusa & Moilanen, 2009). Examples of pragmatic impairments include difficulty with interpreting nonliteral language (i.e., figurative language) such as irony and metaphors (Happé, 1993), with integrating general knowledge to make inferences about a story (Loukusa & Moilanen, 2009), with understanding humor (Emerich, Creaghead, Grether, Murray, & Grasha, 2003), and with disambiguating homographs (e.g., Jolliffe & Baron-Cohen, 1999). This pattern of impairments is found even in individuals with ASD who have a history of minimal to no language delay (Eigsti et al., 2011). Different sources for such impairments have been proposed, including linkages with the ability to comprehend mental states and beliefs of others, more specifically, theory of mind (TOM; Happé, 1993) as well as to linkages with more general/low-level processes such working memory (Eigsti & Schuh, 2017).

However, recent work as well as a closer examination of previous literature, has indicated that children with ASD are not impaired in *all* aspects of pragmatic abilities. For example, children with ASD demonstrate the ability to make certain types of inferences (e.g., Chevallier, Wilson, Happé, & Noveck, 2010), can appropriately adjust their language depending on the linguistic competence of their partner (Volden, Maggill-Evans, Goulden, & Clarks, 2007), and can engage in conversational repair (Volden, 2004). Moreover, recent findings have conflicted with previous claims of impairments in some aspects of pragmatic functioning in this population,

such as metaphors (Melogno, D'Ardia, Pinto, & Levi, 2012) and irony (Pexman, Rostad, McMorris, Climie, Stowkowy, & Glenwright, 2011).

This raises two issues. First, it appears that there are inconsistencies concerning the pragmatic abilities in which children with ASD are impaired. Children with ASD appear to be able to engage in some types of pragmatic reasoning but show deficits in others. However, individual studies in the extant literature have largely focused on individual pragmatic devices. As these studies utilized different methodologies (e.g., forced-choice sentence completion as in Norbury, 2005; truth-value judgments as in Chevallier et al., 2010) and different samples (e.g., sample with a mean verbal IQ of 111.0 in Chevallier et al., 2010 compared to one with a mean verbal IQ of 86 in de Villiers et al., 2009), it is difficult to make comparisons across studies and determine whether children with ASD indeed demonstrate differential impairments in the area of pragmatics more broadly.

Of the studies that have examined multiple types of pragmatic devices within a single sample, they are nonetheless limited. Dennis et al. (2001), for example, examined 9-year-olds with ASD's ability to interpret presuppositions (i.e., mutually known or assumed background information or belief about the world or context), pragmatic inferences, and metaphors and found differential impairments. In particular, they found that children with ASD performed more poorly on metaphors and pragmatic inferences but not on presuppositions when compared to age-matched TD controls. However, their sample size was relatively small (i.e., $n = 8$ per group) and the extent to which pragmatic performance varied within group was not examined. Surian et al. (1996), on the other hand, examined different types of conventional implicatures in children with ASD but focused on how well they were able to detect violations of the corresponding maxims (e.g., relevance, quantity, etc.) and not on how well they were able to *interpret* those

implicatures. Thus, there remains limited literature investigating multiple types of pragmatic devices in individuals with ASD; of those that have examined this, they have not addressed the question regarding within group variability of pragmatic skill in children with ASD. If children with ASD indeed show differential pragmatic impairments, this raises the second issue. In particular, it might suggest that the underlying processes and knowledge responsible for children's ability to engage in pragmatic reasoning may also be different across devices. Further investigations to what those different processes might be will therefore be needed.

The current dissertation had two aims. The first aim was to clarify the nature of pragmatic deficits in children with ASD. When investigating different pragmatic devices within the same individuals, do children with ASD demonstrate differentiated versus universal impairments in their pragmatic reasoning? The second aim was to evaluate the possible contributors that enable reasoning about different types of pragmatic language.

This chapter is organized as follows: First, the different pragmatic devices that were of focus in this dissertation are introduced. Whereas the field of pragmatics encompasses a broad scope of communicative functions, the dissertation focused on a subset of pragmatic language that has either revealed mixed findings or has been explored only in a limited fashion in the autism literature. These include inferential (i.e., implicatures) and figurative language (i.e., metaphors). Second, a brief overview will be presented regarding the state of the empirical literature involving adults and which open questions might yet remain. This is followed by a short commentary on how investigations into TD children and children ASD may help address these open questions. Note that these overviews pertain to the second aim of our study. We present issues relevant for this aim first as it was necessary to first introduce, more generally, the concepts of implicatures and metaphors and what is currently known about them. We return to

our first aim in next section of the chapter, where we review the development of these pragmatic abilities in TD children and in children with ASD. There we also include what the literature has revealed regarding potential contributors to the various pragmatic types in these populations. As pragmatic abilities typically require some knowledge beyond the literal meaning of the utterance, the following studies by necessity included children with ASD who have some competency in language. Finally, the dissertation aims and predictions are presented.

Implicatures: relevance, scalar, and conventional

Within a communicative setting, there is often information presented that is not explicitly encoded in the linguistic signal produced by a speaker. In other words, there is information that is implicated but not explicitly stated – this information is called *implicatures*. To begin, there are two broad categories of implicatures as proposed by Grice (1989). One type involves those that were introduced in the beginning of the chapter, in which what is being implicated is not carried by a specific form and can differ vastly depending on the context, as seen in the case with the utterance *I have a lot of work* (i.e., there is no additional, conventional meaning associated with the form). Termed as *conversational* implicatures (e.g., Grice, 1989), these implicatures are generated from the features or context of discourse and considerations of the goal and intentions of the speaker. In contrast, *conventional* implicatures are ones in which what is implicated is part of the meaning of an utterance. More in-depth discussion of these two types of implicatures follows.

Conversational implicatures. Under the Gricean account, conversational implicatures are derived through the mutual assumption of both speaker and hearer that individuals will make contributions that only further the goal of the conversation (i.e., the *Cooperative Principle*). This is further defined by four maxims:

Maxim of Quantity Make your contribution as informative as is required. Do not make your contribution more informative than is required.

Maxim of Quality Try to make your contribution one that is true. Do not say what you believe to be false or which you lack adequate evidence.

Maxim of Relation Be relevant.

Maxim of Manner Be perspicuous. Avoid obscurity of expression or ambiguity. Be brief and orderly.

(Grice, 1989, pp. 26-27)

The hearer is able to infer a conversational implicature through the assumption that the speaker is indeed following this general principle and the four maxims. For example, for a speaker to satisfy the maxim of relation when uttering *I have a lot of work* in response to the question *Are you going to the party,* there must be additional information intended besides that of the individual's workload (i.e., the implicature that they will not be attending the party). If not, the speaker would have made an irrelevant contribution that does not further the goal of the conversation and as such, would have been behaving uncooperatively. Thus, by assuming that the speaker is being relevant and understanding that work often conflicts with the ability to attend parties, together, the hearer can conclude that what the speaker implicated was that s/he is not going to the party.

Different maxims evoke different implicatures (e.g., maxim of relevance → relevance implicature; maxim of quantity → quantity implicature, etc.). As the previous example involved assumptions regarding the speaker fulfilling the maxim of relation, it was an example of a **relevance implicature**. An example of a quantity implicature would be a speaker responding with, *I finished some of my homework*, in response to the question, *Did you finish your*

homework yet? In this scenario, the implicature that some **but not all** of the homework was completed arises from the maxim of quantity (e.g., make your contribution as informative as is required). Assuming that the speaker has provided as much information as possible regarding how much homework s/he has done, then it is implied that only a portion of the homework has been completed. If the homework was indeed all completed, the speaker should have used a stronger or more informative term (i.e., *all*). In using the weaker/less informative term *some* in the circumstance in which all of the homework was completed, the speaker would have violated the quantity maxim, as s/he has not provided the maximum information that could be provided.

In fact, this type of quantity implicature that involves the use of a weaker term to implicate that the stronger term does not hold is called a **scalar implicature** (Horn, 1972). To elaborate, some terms can be logically ordered in their informational strength; the term, *some* is "weaker" than *all*. That is, while *all* logically encompasses *some*, the reverse is not true. For example, having eaten all cookies logically entails that 'I ate some cookies' but having eaten some cookies does not logically entail that 'I ate all cookies'. Thus, in using the word *some* as in *I ate some of the cookies*, the speaker implies that the stronger statement (i.e., *I ate all of the cookies*) does not hold (i.e., if the speaker had indeed eaten all the cookies, the stronger term, *all* rather than *some* should have been used in order to meet the Maxim of Quantity).[1]

Here, I will also briefly discuss the notions of generalized and particularized conversational implicatures as it will later help inform our predictions regarding which implicatures children with ASD might have difficulties with. When describing conversational

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[1] Other terms are organized into similar informational scales (Horn, 1972; e.g., <some, all>; <might, must>; <or, and>) and across these different scales, the use of the weaker term can generate scalar implicatures.

implicatures, Grice further sub-categorized such implicatures into generalized and particularized conversational implicatures. Scalar implicatures are examples of **generalized conversational implicatures**, where there is an implicature typically associated with a particular form/construction (see also Levinson, 2000). For example, there is a tendency for speakers to use scalar terms to generate scalar implicatures (e.g., people often use *some* to imply *some but not all*). In that sense, there is some conventionality in how scalar terms are used. However, the implicature associated with the scalar terms is not part of the term's semantic/encoded meaning. In the case of *some*, the implicature some **but not all** is not part of the semantic meaning of s*ome*. This can be potentially demonstrated when using the term to mean generic amount as in *Give me some cookies over there*. Additionally, the associated implicature (**but not all**) can be cancelled directly as in *Some dogs like treats, in fact all do* without disrupting the interpretability of the utterance.

In contrast, **particularized conversational implicatures** do not have common implicature meanings associated with a particular construction/form. As seen in the relevance implicature examples, the implicature that emerges from the utterance *I have a lot of work* greatly varies depending on the context in which it is stated (e.g., the speaker cannot go to the party in the first scenario; the business is doing well in the second scenario). In this sense, particularized conversational implicatures, such as relevance implicatures, depend heavily on the features of the context/discourse.

Conventional implicatures. While conversational implicatures are ones that arise from the *Cooperative Principle* and their maxims, Grice (1989) defined conventional implicatures as

meanings that are part of and entailed by the encoded meaning of a lexical item or construction.[2] They tend to be generated by default; moreover, what is implicated is relatively invariant to contextual characteristics (at least in comparison to conversational implicatures). The use of *but* is an often-cited example of a conventional implicature device. For example, the sentence *Sarah is happy but poor*, typically invokes a sense of contrast (here, between being happy and being poor and more specifically, that being poor may preclude one from being happy). This is because the sense of contrast is part of the conventional/lexicalized meaning of *but*. However, despite being part of the encoded meaning of a form, Grice nonetheless considered the content of conventional implicatures as being separate from "what is said." "What is said" can be thought of as the truth-conditional content of the speaker utterance or the speaker's central message (Potts, 2015).[3] Under this formulation, in the previous example, "what is said" involves not the contrast between being poor and happy, but rather that Sarah is happy and that Sarah is poor. Note that conventional implicatures are similar to that of generalized conversational implicatures (e.g., scalar implicatures) in that there is an implicature that is associated with a particular form/construction. However, the two differ in that for conventional implicatures, what is implicated is part of the conventional meaning of the form whereas for generalized conversational implicatures, it is not.

The concept of conventional implicature is not without controversy (Bach, 1999; Potts, 2015). The nature of conventional implicature may suggest that such a phenomenon would be

[2] They generally do not impact the truth-value of what is said.
[3] It should be noted, of course, that the definition of what is considered to be "what is said" by a speaker is heavily debated and unfortunately beyond the scope of the current dissertation.

more appropriate to consider in the area of semantics rather than pragmatics.[4] On the other hand, one can make the argument that conventional implicatures are not completely indifferent to the surrounding context (Potts, 2015). For example, while *but* will elicit a sense of contrast, what is particularly being contrasted will vary depending on the surrounding phrases/constructions (e.g., being happy and being poor is contrasted in *Sarah is happy but poor* while being huge and being agile is contrasted in *Sarah is huge but agile*). Thus, while the somewhat contentious status of conventional implicature is acknowledged here, the notion of *conventional implicature* (as formulated by Grice and others) will nonetheless be considered as a type of implicature in the current dissertation as it has been relatively understudied in both the TD and ASD developmental literatures.

Metaphors

Metaphors, broadly, can be defined as the use of one concept to represent or refer to another. More specifically, and in the domain of language, metaphors such as *the moon was a light bulb*, often involve a topic (e.g., the moon) and a “vehicle" (e.g., light bulb) from which common properties are compared and highlighted (e.g., round, bright, etc.; Lakoff & Johnson, 1980). The nature and origins of metaphors have been hotly debated and are beyond the scope of the current dissertation. However, the Gricean view will be discussed briefly. The traditional Gricean view proposes that metaphors can arise through the flouting of the Cooperative Principle maxims. When the speaker violates a maxim in such a blatant way, it serves as a cue for the hearer to know that the speaker must mean something else. In the case of metaphors, such as *the*

[4] Additionally, some have challenged the notion of conventional implicatures altogether (Bach, 1999). Under Bach’s account, for example, implicature generated from the use of *but* would be categorized as an entailment rather than an implicature.

moon is a light bulb, simply expressing the literal meaning would be to express a falsehood. Assuming that the speaker has similar world knowledge as the hearer (more specifically that the moon is *not* an actual light bulb), this would be an obvious violation of the maxim of quality. As such, the conclusion drawn would be that such flouting of a maxim should be a cue to the hearer that the literal meaning is probably not what the speaker intended to express. Rather, a more probable supposition is that the speaker is trying to *highlight* similarities between the moon and light bulbs. Under this proposal, metaphors are implicatures, whereby the literal interpretation is first accessed, followed by the detection of the insufficiency of the literal interpretation, and lastly the search for another, non-literal interpretation.[5]

Findings from the TD adult empirical literature

Thus far, we have introduced the theoretical notion of implicatures (and their subtypes) as well as metaphors and considered how these might arise in discourse. It should be noted, however, that Grice's original proposal was not necessarily intended to detail the *cognitive process* by which implicatures are derived but rather, served as a description of communicative behavior between speakers and hearers (Schwarz, 2016; Geurts & Rubio-Fernandez, 2015). As such, much of the current empirical work concerning such pragmatic devices has focused on

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[5] While our study was not aimed to evaluate the different theories of metaphor, it should be noted that there are other views besides the one posited by Grice. For example, under the Relevance Theory (Sperber & Wilson, 1986; 2004) view, the use of a metaphor is to actually assert the metaphorical meaning itself (i.e., it is part of "what is said" rather than "what is implicated"). The hearer accesses the metaphorical meaning by adjusting and/or creating new concepts and constructions "online," in real time, by looking through their lexical and world knowledge to find the most optimally relevant interpretation. In the case of *the moon is a light bulb,* the hearer will create an "ad hoc" concept that broadens the category of LIGHT BULB to include not only actual light bulbs but also astronomical bodies, such as moons. Thus, when interpreting *the moon is a light bulb*, the hearer is accessing the ad hoc LIGHT BULB category, which applies the same features for light bulbs and moons.

measures of information processing (e.g., reaction time) as tools to probe the underlying cognitive processes involved to help bridge the gap between theoretical and psychological descriptions of how language is used in a social, communicative context. In particular, experimental work with adults has investigated whether the processing of implicatures and figurative language such as metaphors is effortful and involves access first to the literal interpretation then the pragmatic interpretation, vs. whether the pragmatic interpretation is accessed immediately (see Schwarz, 2016 for discussion).

Hamblin and Gibbs (2003) compared adults' reading time of utterances involving conversational implicatures (e.g., responding *I usually sleep wearing earplugs* in the context of someone inquiring about whether a dormitory is noisy) and those that did not involve additional pragmatic enrichment (e.g., responding *This is a very noisy building* in the same context). They found that adults took longer to read utterances that involved conversational implicatures than utterances that did not. Additionally, when asked whether the utterance contained one or two intended meanings, adults tended to report that utterances involving conversational implicatures as having two intended meanings while utterances that do not as having only one. Together, these findings suggest that adults distinguish between what is said and what is implicated. Additionally, accessing the latter appears to take additional time (rather than being accessed directly, without first analyzing what is being said).

Examining specifically scalar implicatures, Bott and Noveck (2003) presented adults with utterances such as *Some elephants are mammals* along with the explicit instruction to interpret *some* to mean either "some and possibly all" (logical interpretation) or "some but not all" (pragmatic interpretation). They found that adults took longer to make truth-value judgments of such utterances (i.e., is the utterance true or false) under the pragmatic instruction compared to

the logical instruction, suggesting that pragmatic interpretations of scalar implicatures are accessed via multiple steps rather than directly (see also Huang & Snedecker, 2009; Noveck and Posada, 2003; Tomlinson Jr., Baily, & Bott, 2013). In contrast, Grodner, Klein, Carbary, and Tanenhaus (2010), utilizing a visual-world paradigm, did not find that adults took longer to shift to the target when the utterance involved a scalar implicature compared to when the utterance did not (see also Breheny, Ferguson, & Katsos, 2013). Grodner et al. (2010) proposed that such divergent findings may be due to the difference in the context (e.g., is a small or large set being referred to) and to the alternatives (e.g., presence of numerals or not) presented across the different experiments (see also Gibbs, 2017 for discussion).

With metaphors, studies using reaction time suggest that familiarity can impact how quickly the pragmatic meaning can be accessed. Initial work by Glucksberg, Gildea, and Bookin (1982) found that when adults were told to judge the **literal truth** of utterances, they nonetheless took longer to judge utterances containing a metaphor (e.g., *Some jobs are birds*) compared to those that did not (e.g., *Some fish are eagles*).[6] This was taken to mean that the participants accessed the metaphorical interpretation simultaneously with the literal meaning, which subsequently interfered with their ability to quickly judge whether the literal meaning was true or not (see also Gildea & Glucksberg, 1983). Subsequent work by Giora and Fein (1999) has found that familiar metaphors were read as quickly as literal utterances, whereas novel metaphors were read more slowly (see also Giora, 2002 for a review). Together, this demonstrates that the same

[6] Note, in both utterances, the literal interpretation would be false. Thus, if participants were just assessing the literal interpretation (as they were instructed to), they should judge both utterances to be false at a similar speed. However, if the metaphorical utterances took longer to reject, the authors took this to mean that the metaphorical meaning was accessed at the same time and needed to be suppressed to correctly judge that the literal interpretation of the utterance as false.

process (e.g., access literal interpretation, notice a speaker is flouting a conversational maxim, followed by a search for additional, relevant meaning) may not be accurate for describing how all metaphors are accessed and interpreted.

Open questions. Studies focusing on the information processing of implicatures and metaphors have provided cognitive insight into how a hearer might arrive at a speaker's intended meaning. For example, it appears that with some conversational implicatures, such as relevance implicatures, a multi-step process is involved, while with others, such as scalar implicatures, the extent to which the pragmatic meaning is accessed immediately vs. whether a literal, logical interpretation is first accessed, depends on the context. However, understanding the relative timing by which pragmatic interpretations arise describes only one piece of the cognitive process. It remains unclear how individuals are able to generate pragmatic interpretations in the first place. Which underlying processes and skills enable a hearer to arrive at the pragmatic interpretation (regardless of whether the literal interpretation is activated initially or not)? Investigating the underlying processes and skills provides a more comprehensive understanding of the psychology behind communication and discourse. It can also provide insight as to why some populations, such as individuals with ASD and even in young TD children (discussed in more detail below), have difficulties with implicatures and figurative language. That is, in understanding which underlying processes are involved, we can begin to also understand what drives the failure and developmental trajectories of pragmatic competency.[7]

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[7] Imagine, for example, that ToM reasoning was found to be involved in the generation of pragmatic interpretations of scalar implicatures. As success on ToM tasks typically emerges starting around age four (Wimmer & Perner, 1983), this may then subsequently explain why young children (e.g., 4 years old and younger) have difficulties with these implicatures and why more adult-like interpretations only start to emerge at 5 years old (Papafragou and Musolino, 2003).

Relatively little empirical research has investigated the underlying processes and knowledge that enable a hearer to infer such pragmatic devices. Some types of knowledge are certainly alluded to, but do not appear to be explicitly stated, based on how the particular pragmatic device is characterized. For example, as conventional implicatures involve the encoded, conventional meanings of distinct forms (e.g., *but*), one may suspect that sufficient grammatical knowledge plays an important role in an individual's ability to reason about these implicatures. Similarly, as conversational implicatures involve the complex process of reasoning about a speaker's communicative goal and about the speaker and hearer's mutual knowledge of the different maxims that allows such implicatures to be inferred, theory of mind (TOM; i.e., the ability to reason about others' thoughts and intentions) might be considered as a potentially crucial component. Lastly, as metaphors often involve highlighting common properties of two concepts, it is reasonable to expect that metaphorical processing would involve the ability to integrate vocabulary and world knowledge (e.g., properties of light bulbs and of moons).

Among the limited empirical literature, Chiappe and Chiappe (2007) have found that when asked to **generate** metaphors (e.g., complete the utterance *Some billboards* ____ in the context of billboards being something noticeable and unattractive, p. 180), the quality of the metaphors produced by TD adults correlated with their vocabulary scores as well as their working memory capacity. Chiappe and Chiappe (2007) also found that adults' ability to **interpret** metaphors was linked to their working memory, although they did not examine the role of vocabulary ability. Janssens and Schaeken (2016) examined adults' ability to choose appropriate endings for scenarios involving conventional implicatures (i.e., *but*; e.g., *Ella has been bad but she lost her teddy bear* in the context of a mother deciding whether she should purchase a teddy bear for her daughter, p. 5) and manipulated working memory (i.e., burdening

their working memory load by having them hold in memory and reproduce the position of a matrix of dots).[8] They found that performance on conventional implicatures was not correlated with performance on the working memory task. Thus, implicatures and metaphors appear to require different skills (e.g., working memory for the latter but not the former).

To some extent, the empirical work examining potential contributors of implicature and metaphor processing appears to be consistent with their theoretical descriptions. Some contributors, such as vocabulary knowledge, that were predicted to play a role in the processing of implicatures and metaphors have been borne out in the empirical literature. On the other hand, contributors (e.g., working memory) that have not been considered in the theoretical accounts have also emerged. The underlying contributors to pragmatic reasoning, however, remain an understudied aspect of implicatures and metaphors; additionally, to what extent other knowledge such as ToM is involved is unclear based on the findings in the TD adult empirical literature.

Investigating how these pragmatic abilities are acquired in both TD children and children with ASD may be another vehicle that can address the question regarding the cognitive underpinnings of implicatures and metaphors. To some extent, TD adults are expected to have relatively intact abilities to engage in this type of reasoning. While studies such as Chiappe and Chiappe (2007) can interfere with components such as working memory capacity to determine whether it impacts reasoning about certain pragmatic language, using a similar method to investigate other skills/knowledges, such as ToM, can be difficult in TD adults, given that there is relatively little individual variability (e.g., most TD adults will pass ToM tests, Bowler, 1992;

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[8] In this example, the possible endings that the participants were asked to choose from were: a) *so Ella can have the teddy bear* or b) *so Ella cannot have the teddy bear* (Janssens & Schaeken, 2016; p. 6).

Miller, 2009). On the other hand, ToM reasoning and even general grammatical knowledge are still undergoing development in TD children and may be impaired in some children with ASD (Baron-Cohen, 1989; Kjelgaard and Tager-Flusberg, 2001; Miller, 2009; Ozonoff, Pennington, & Rogers, 1991; Steele et al., 2003). Examining whether and how children's working memory, ToM, and general grammatical skills are related to their ability to process implicatures and metaphors can reveal to what extent those areas indeed play a role in pragmatic reasoning. Similarly, examining to what extent children with ASD are able to process certain pragmatic devices (and not others) despite having deficits in related areas, such as ToM, can reveal whether those skills/deficits are indeed core to the cognitive processing of implicatures and figurative language such as metaphors. Thus, one of the goals of the study was to better understand the cognitive underpinnings to pragmatic reasoning by examining contributors to TD children and children with ASD's pragmatic skills. However, to address this question, we must first address our other question of interest – that is, the nature of pragmatic abilities in children with ASD.

Pragmatic development in TD children and children with ASD

The following section provides an overview of research that has examined TD children's and/or children with ASD's ability to comprehend different types of pragmatic language, including conventional implicatures, scalar implicatures, relevance implicatures and metaphors.

Conventional implicatures. Research on the emergence of children's understanding of conversational implicatures is limited. Janssens, Drooghmans, and Schaeken (2015) investigated TD 8- to 12-year-olds' ability to derive the contrastive meaning of utterances that involved the term *but*. In particular, children were presented with *but*-utterances (e.g., "*Sarah likes decorating the tree, but she is very clumsy"*; p. 701) in a larger story context (e.g., a family is putting up Christmas tree decorations and the character Sarah would like to help) and asked to choose the

appropriate conclusion of the story using a forced-choice task. Janssens et al. found that the children selected the appropriate response significantly above chance, with no age effects. However, when comparing their rate of selecting the appropriate pragmatic response to that of another study using a similar paradigm with adults (Janssens & Schaeken, 2013), the children nonetheless performed significantly more poorly, suggesting that even at 12 years of age, TD children's pragmatic understanding of *but* is not yet fully developed. Additionally, they found no relationship between working memory and TD children's ability to interpret conventional implicatures. It is possible that working memory does indeed play a role but is not sufficient for reasoning about conventional implicatures; rather, sufficient grammatical knowledge may also be required. However, this possibility remains yet to be explored, as Janssens et al. (2015) did not examine the linguistic abilities of the TD children. With regards to children with ASD, to the author's knowledge, no study has yet explored this population's ability to interpret conventional implicatures.

Scalar implicatures. In TD children, the ability to process scalar implicatures successfully appears to be dependent on task properties as well as on the specific scalar term investigated (Papafragou, 2006; Pouscoulous, Noveck, Politzer, & Bastide, 2007). In general, some sensitivity to these implicatures (while not completely adult-like) has been demonstrated in children by 5 years of age (Papafragou & Musolino, 2003). For example, Papafragou and Tantlou (2004) found that making the context pragmatically felicitous increased children's tendency to make pragmatic interpretations of utterances involving scalar implicatures. In the task, 5-year-olds were asked to either reward or not reward a character depending on whether the character completed a task. On the test items, the character would use a scalar term to indicate that only a portion but not the complete task was finished (e.g., responding with *I colored some*

to the question *Did you color the stars?*). If children interpreted these terms logically rather than pragmatically, then they should give the reward to such characters. However, this was not the case. Children withheld the prize at a rate significantly higher than chance, suggesting that when contexts are made somewhat more naturalistic and more felicitous, children as young as 5 years old can demonstrate knowledge about scalar implicatures.

Papafragou and Musolino (2003) similarly found that when first given training on detecting under-informativeness, TD 5-year-olds were more likely to reject a puppet's use of a weaker term to mean the stronger term (e.g., *Mickey put some of the hoops around the pole* to mean *Mickey put all of the hoops around the pole*) compared to children in a previous experiment who did not receive such training.[9] However, children continued to adopt the logical interpretation more frequently than adults. That is, despite the improvement, children's rejection rate (e.g., 52.5% for *some*) was still lower than that of the adults (e.g., 92.5%).

With regards to the ASD population, Chevallier et al. (2010) evaluated 13-year-old children with ASD's truth-value judgments of utterances containing *and* or *or*, where the use of *or* (the weaker term) implied *one but not both* while the use of *and* (the stronger term) logically and pragmatically entailed *both*. Critical items consisted of whether children judged *or*

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[9] 5 year olds were first trained to detect infelicity by having a puppet say under-informative utterances such as *this is a little animal with four legs* when describing a dog. Children were asked to determine whether the puppet described the object well and whether there might be a better way to say it. After training, children were given scenarios in which the character's performance was evaluated and as such, specificity was emphasized. An example of a test item involved Mickey being challenged to perform as well as another character on a hoop-throwing game, in which the character successfully landed three hoops. Mickey then is shown successfully landing all three hoops and Minnie is asked how did Mickey do. Because Mickey's performance is evaluated, it is more crucial to use the stronger term *all*, emphasizing that Mickey indeed got all the hoops in, rather than *some* (even though it would be logically true but could be taken to mean either all or less than all).

utterances describing items on a picture (e.g., *There is a sun or a train* when the picture contains a sun **and** a train) as true (e.g., logical interpretation) or false (e.g., pragmatic interpretation). Children with ASD did not differ from age- and language-matched TD children in the rate in which they chose the pragmatic interpretation of these items. A similar pattern was also found in adults with ASD with the scalar term *some* (Pijnacker, Hagoort, Buitelaar, Teunisse, & Geurts, 2009). Additionally, Su and Su (2015) reported that 6- and 11-year-old Mandarin-speaking children with ASD rejected the logical interpretations of utterances containing *some* at rates comparable to that of age-matched TD controls. These findings suggest that in at least a subgroup of children and adults with ASD, the ability to generate scalar implicatures is not impaired.

With regards to the question of contributing factors, Chevallier et al. (2010) found that verbal IQ scores (as measured by the British Picture Vocabulary Scales-II; Dunn et al., 1997) correlated with whether participants responded more with a logical or pragmatic interpretation of scalar implicatures, for those with ASD. In particular, individuals with lower verbal IQ tended to respond with a more logical interpretation while those with higher verbal IQ responded with a more pragmatic interpretation. As such, these findings lead to the hypothesis that general language abilities contribute to scalar implicature processing in children with ASD.

Relevance Implicatures. There has been limited developmental work regarding children's reasoning about relevance implicatures. Bernicot, Laval, and Chaminaud (2007) evaluated TD children between 6 and 10 years old in their ability to generate relevance implicatures in a forced-choice story task. For example, a character in the story might ask *Should I mow the lawn* and the other might respond with *The nephews are taking a nap*. Two possible endings of the story were then presented, one in which the inference was generated (e.g., the

character should not mow the lawn and do something else) and one in which the inference was not (e.g., the character mows the lawn). Bernicot et al. (2007) found that by 6 years of age, TD children were able to correctly select the story ending that involved the implicature meaning.

On the other hand, findings from a pilot study by de Villiers et al. (2009) suggested that processing such implicatures is impaired in children with ASD. In the task, children were presented with short scenarios involving a conversation between two individuals (e.g., boy asking his mother, *Have you packed my lunch,* with the mother responding, *Here's a dollar*) and were asked to explain the speaker meaning of the second individual (e.g., *What did the mom mean? Why did she say that?*). Compared to a group of age-matched TD children, children with ASD (between 5 and 12 years old), performed significantly more poorly. On average, the ASD group (mean age of 8 years old) performed at the level of the younger TD control group (mean age of 5 years old), at about 40% accuracy level. It should be noted that this lower accuracy found for the younger TD group is consistent with Bernicot et al. (2007), who found that when asked to provide elaborations for their forced-choice answers, which is more akin to what is being assessed in de Villiers et al. (2009), even TD 8- to 10-year-olds continued to have difficulty. Together, these findings might suggest that in comparison to the comprehension of the pragmatic device itself, meta-pragmatic knowledge of relevance implicatures emerges later for the TD population. Given that the children with ASD in de Villiers et al. (2009) were not assessed directly on their comprehension of the relevance implicatures themselves, it remains unclear to what extent their low performance is due to impairments in the ability to generate pragmatic interpretations for the implicatures or whether it is due to their inability to *explain* the pragmatic use of relevance implicatures.

In examining potential contributors, de Villiers et al. (2009) reported a positive correlation between theory of mind scores (which included performance on both first and second order false belief tests; Sullivan et al., 1994) and the children with ASD's scores for correctly describing relevance implicatures. This indicates that ToM plays a role in the pragmatic processing of relevance implicatures; however, because the implicature task involved meta-pragmatic knowledge as well, it is an open question as to whether ToM is important for the meta-pragmatics of or the actual generation of the pragmatic interpretation of relevance implicatures.

Metaphors. Metaphorical understanding has been found to undergo a protracted period of development in TD children, beginning from 4 years of age and lasting until at least 12 years of age, with some evidence of development even through adulthood (Rundbald & Annaz, 2010; Vosniadou, Ortony, Reynolds, & Wilson, 1984; also see Pouscoulous, 2014 for a review). For example, Winner, Rosenstiel, and Gardner (1976) examined 6- to 14-year-olds' ability to interpret metaphors, and found a gradual increase in their sophistication of metaphorical understanding from 6 to 12 years of age. Six-year-olds interpreted metaphors in a metonymic way (e.g., interpreting *the prison guard was a hard rock* to mean that the prison guard worked at a place with hard rocks) while 8-year-olds demonstrated primitive knowledge of metaphors, linking similarities between the two terms within a same physical modality (e.g., the prison guard was muscular). By 10 to 12 years of age, children were able to interpret metaphors beyond noting physical similarities within the same modality. This suggests that comprehension of metaphors is not an all-or-nothing process but can involve graded interpretations such that by 8 years of age, there is evidence of *some* limited form of metaphorical comprehension.

Findings on the comprehension of metaphors in children with ASD are mixed. Previous work has suggested that metaphor comprehension may be impaired in this population (Dennis et

al., 2001). For example, Happé (1993) found that some children with ASD (averaging 17 years old, ranging from 10 to 28 years of age) failed to correctly complete metaphorical expressions when presented with a list of possible endings (e.g., *The dancer was so graceful. She really was…*[a swan]). However, their failure on this task was contingent on whether they also failed on first order TOM tasks. Similarly, Norbury (2005) found that children with ASD (between 8 to 15 years of age) performed more poorly in their ability to correctly complete metaphorical utterances compared to age-matched TD controls. In contrast to Happé (1993), however, Norbury (2005) found that when accounting for semantic knowledge, the relationship between TOM and metaphorical reasoning disappeared for children with ASD, suggesting that general language abilities play a larger role at least with interpreting metaphors. This may not be too surprising as metaphors involve pointing out a particular property of one item by highlighting its similarity to another. As such, semantic knowledge about the different properties of each item is needed in order for the hearer to extract possible similarities that the speaker is highlighting and to ignore dissimilarities that are unlikely candidates.

Rundblad and Annaz (2010) also found that 5- to 11-year-old children with ASD performed significantly more poorly in producing the appropriate endings for stories involving metaphors compared to TD children matched on age and non-verbal ability. Children were presented with story contexts that encouraged metaphorical interpretations of a target sentence (e.g., A character named Stuart, who is promoting a special exhibit at a museum, is told that *There is a flood outside the museum,* due to the popularity of the exhibit). They were then asked to name what each of the main characters saw (e.g., What does Stuart see [outside the museum]?). While TD children's ability to provide correct metaphorical interpretations (e.g., a lot of people) improved across the 5 to 11 age range, children with ASD performed at floor level.

There appears, then, to be evidence suggesting that children with ASD have impairments in comprehending metaphors.[10]

Other studies, however, have reported some intact abilities in metaphorical processing in children with ASD. Melogno et al. (2012) found that 8-year-old children with ASD were able to explain sensory-based metaphors (e.g., *the moon is a light bulb*; *the house has a hat*) at levels comparable to 5-year-old TD children, but performed more poorly compared to 6-year-old TD children. Both children with ASD and TD 5-year-olds focused on function and/or perceptual similarities of the objects (i.e., the topic and vehicle) highlighted in the metaphors (a sample response for the metaphor *the moon is a light bulb* was 'The moon is yellow and the bulb is also yellow' p. 685). The TD 6-year-olds produced more elaborative responses that indicated both similarities and differences of the objects (e.g., 'It means that the moon gives light just as the bulb does, but the bulb gives light during the day, whereas the moon does it only at night' p. 685). Importantly, literal interpretations only accounted for 10.5% of children with ASD's errors. These findings, together with their ability to highlight at least function and/or perceptual similarities of the items involved in the metaphors, suggest that children with ASD have some knowledge of the communicative intent of metaphorical devices (e.g., highlighting properties of the topic and vehicle) but they may be more limited in their ability to explain its meaning.

Olofson et al. (2014) also found some ability for comprehending sensorimotor-based metaphors in children with ASD (mean age of 13 years old). Children were shown both lexicalized metaphors (e.g., *weight on my shoulder*) and their novel counterparts (e.g., *stone on my shoulders*) and asked to select a picture that best depicted the metaphor. Picture options

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[10] It is unclear, given the description of the analyses, whether children with ASD's at floor performance was due to them producing more literal interpretations or non-relevant responses.

included depictions of a metaphorical interpretation, a literal interpretation, and a distractor item. While children with ASD generally performed more poorly than the TD age-matched controls, they nonetheless performed significantly above chance on both lexicalized and novel metaphors. It should be noted that the TD children as a group had significantly higher language abilities than the children with ASD. Additionally, verbal ability (as measured by the PPVT) significantly predicted performance on novel metaphors, suggesting that, at least with novel metaphors, the poorer performance found in children with ASD may not reflect deficits in pragmatic inferencing per se, but may reflect impoverished semantic knowledge that would normally allow one to find common attributes highlighted in metaphors. Together, these results demonstrate that children with ASD show *some* abilities in processing metaphors.

In sum, the literature on TD children's pragmatic development suggests differential developmental trajectories across conventional and conversational implicatures as well as metaphors. In particular, success with scalar implicatures appears to emerge earliest (around 5 years of age), while metaphors demonstrate the most protracted development (extending to 12 years of age). Relatedly, the ASD literature suggests that children with ASD appear to demonstrate variable performance across different pragmatic types, with scalar implicatures appearing to be the least impaired and relevance implicatures the most impacted. Findings on metaphorical processing are mixed with this population.

Given that the ability to interpret different implicatures and metaphors appears to be acquired at different ages in TD population, and appears to be differentially impacted in children with ASD, there is support for the possibility that different skills/knowledge are involved for the different pragmatic devices. That is, one might expect that if the same skills or knowledge are involved (and to the same extent) for particular pragmatic devices, they should be acquired

together or should be similarly impaired. While few in number, studies that have investigated correlates to the pragmatic processing of implicatures and metaphors seem to support this notion. For example, it appears that processing of relevance implicatures relies on ToM reasoning (de Villiers et al., 2009), whereas the processing of metaphors and scalar implicatures appear to rely more on verbal IQ (Chevailler et al., 2010; Olofson et al., 2014).

However, there are a number of limitations in the current literature, which restrict any conclusions thus far. First, the number of studies that have examined these different phenomenon is still relatively small in both the TD and ASD literatures. Conventional implicatures have not been examined at all in children with ASD. Moreover, studies that have looked at potential correlates typically have focused on one contributor (c.f., Norbury, 2005, which examined both ToM and vocabulary knowledge). Thus, to what extent the different pragmatic devices involve variable skills and knowledge vs. whether they indeed all involve the same contributors, but simply have not been revealed in past studies, is unclear. Additional work examining and comparing the role of the same set of potential contributors across the different pragmatic devices is needed.

Second, past studies have focused on individual pragmatic types. Thus, it is unclear whether the differential developmental trajectories found in TD children or the differential impairments in pragmatic processing demonstrated in the ASD literature indeed reflect accurate patterns. It is possible that the patterns found across the literature are simply an outcome of different populations sampled across the studies. This is a particular concern with the ASD literature given that ASD is a highly heterogeneous disorder (Kjelgaard et al., 2001; Lenroot & Yeung, 2013; Wing, 1981). The ASD group in de Villiers et al. (2009), for example, had somewhat low verbal IQ, with a range between 63 to 94 and mean of 86. In contrast, the

individuals with ASD in Chevallier et al. (2010) had considerably higher verbal IQ, ranging between 72 to 145, with a mean of 111. Recall, the children with ASD demonstrated impairment with relevance implicatures in de Villiers et al. (2009) but intact ability to process scalar implicatures in Chevallier et al. (2010). It is possible, then, that the differential performance across implicature types is not due to something inherent to the implicatures themselves, but is due to the different language capacities of the two samples studied. In this case, if a group of children with ASD with similar verbal IQ as those in Chevailler et al. (2010) was examined, we would expect no deficits with relevance implicatures.

Another limitation is that different methodologies have been employed across the studies (e.g., forced-choice responses as in Bernicot et al., 2007; Olofson et al., 2014 and truth-value judgments as in Papafragou & Tantlou, 2004; Chevallier et al., 2010); especially with children, methodological differences can potentially lead to differences in performance (Norbury, 2005; Papafragou & Tantlou, 2004; Pouscoulous, 2014). For example, using a forced-choice task to examine TD children's ability to comprehend relevance implicatures, Bernicot et al. (2007) found that children as early as 6 years of age demonstrated understanding with this pragmatic device (i.e., the majority of the children scored 75% and higher on the task). In contrary, when the task involved open-ended questions that not only asked what a particular relevance implicature meant but also why a speaker used it, TD children performed slightly worse (between 40%-65%; de Villiers et al., 2009). Thus, it is possible that the differences found across pragmatic types in both the TD and ASD literature reflect differences in extra-pragmatic requirements involved in the tasks (e.g., memory, attention, meta-linguistic awareness) and not the pragmatic abilities of the children.

In sum, the current TD and ASD developmental literatures highlight the first aim of our dissertation. In particular, the literature is limited in that a) differences across the studies' participant samples (e.g., dissimilar verbal IQ) make it difficult to determine whether the differential performance in pragmatic processing is simply due to these sample differences or indeed reflects underlying differences among the pragmatic devices and b) use of different experimental paradigms across studies makes it difficult to determine whether the same/actual underlying pragmatic process is being assessed, and thus, whether the findings indeed reveal differential performance, or rather, are they assessing extra-pragmatic factors. The current TD and ASD developmental literatures also highlight the second aim. More specifically, similar contributors have not been examined and compared across different pragmatic types, making it difficult to determine whether same skills/knowledge are involved. A study that examines multiple types of implicatures and metaphors, utilizing a paradigm that reduces potential extra-pragmatic differences across the pragmatic types, within the same sample of children, is therefore needed to better assess the differential patterns found across the TD and ASD developmental literature and to better understand what contributes to the processing of the different pragmatic types.

The current dissertation aimed to address the following two questions: (1) what are the relative strengths and weaknesses in pragmatic processing within the same group of children with ASD and (2) what are contributors (e.g., TOM and grammatical abilities) to children's implicature processing and do they play the same role universally or are they specific to pragmatic type? To address these questions, the current dissertation examined, in comparison to age- and non-verbal-IQ-matched TD children, children with ASD's performance in their

interpretation of four pragmatic types: conventional implicatures, scalar implicatures, relevance implicatures, and metaphors.

Predictions

Based on descriptions of implicatures and metaphors. It was hypothesized that because conventional implicatures rely on the encoded meaning of a construction, children with ASD who have somewhat intact linguistic abilities should perform comparably to TD children. Similarly, while scalar implicatures fall under the broad category of conversational implicatures because there is an associated meaning (e.g., some but not all for *some*), they might be treated more akin to conventional implicatures by children with ASD, and as such, would show relatively little impairment. In contrast, relevance implicatures may depend on sensitivity to speaker intention and knowledge of the maxims, aspects that are relevant to ToM, in which children with ASD have commonly reported difficulties (Baron-Cohen, 1989; Bowler, 1992; Ozonoff, Pennington, & Rogers, 1991). As such, it was predicted that children with ASD would have more difficulty in extracting such implicatures compared to TD controls. With regards to metaphors, if it is the case that metaphorical interpretation arises similarly to that of other conversational implicatures (as proposed in the Gricean view), we might expect that children with ASD will show similar difficulties as that of relevance implicatures. Given that the theoretical descriptions do not make explicit the different skills/knowledge that are involved in the cognitive process underlying pragmatic processing of implicatures and metaphors, our predictions on the potential contributors will be guided by the empirical literature only.

Based on previous empirical findings. Predictions informed by the empirical literature, regarding which pragmatic device children with ASD were expected to show difficulties with, are similar to those informed by the theoretical descriptions. In particular, it was expected that

children with ASD will demonstrate relatively intact ability to interpret scalar implicatures (Chevailler et al., 2010; Su & Su, 2015) but will have difficulties with relevance implicatures (de Villiers et al., 2009). Given that the findings on metaphors have been somewhat mixed, it was unclear whether the children with ASD in the current study will demonstrate deficits in vs. relatively intact metaphorical processing. However, if we were to take the findings from the study that most matched the paradigm that was used in the current study (i.e., pictorial forced-choice task; discussed more below), we might expect the children with ASD to perform more poorly compared to TD controls but nonetheless above chance (Olofson et al., 2014). With regards to conventional implicatures, these have not yet been explored in children with ASD.

In terms of potential contributors, it was expected that TOM would positively correlate with performance on relevance implicatures (de Villiers et al., 2009). Success on scalar implicatures, on the other hand, would depend more on grammatical knowledge (Chevallier et al., 2010). We also predicted that while performance on metaphors would be correlated with ToM abilities (Happé, 1993), it will nonetheless be related more with language ability, in particular, vocabulary knowledge (Norbury, 2005). Lastly, while working memory has largely not been examined in the ASD and TD developmental literatures, given that it is implicated in metaphors in the TD adult literature (Chiappe & Chiappe, 2007) as well as in other areas of pragmatics (e.g., referential communication; Eigsti & Schuh, 2017), we might nonetheless expect working memory to play a role; thus, it was included as a potential contributor in the study.

Chapter 2: Methods

Participants

The pragmatic task was first piloted with 41 TD adults between the age of 18 to 21 years old (*M* = 19.53, *SD* = 0.75). All adults were native English speakers and had no reported history

of language impairments or other developmental disorders. Participants were recruited via the undergraduate participant pool at the University of Connecticut and received course credit for their participation.

Two groups of children ranging between 7 to 10 years old participated in the complete study: 12 children with ASD (*M* = 9.09 years, *SD* = 1.08) and 27 TD children (*M* = 8.88 years, *SD* = 1.35). All children were native English speakers and were recruited from the New England area. Additionally, all children were required to have a non-verbal IQ standard score greater than 70 to be included in the study. Non-verbal IQ was measured using the Weschler Abbreviated Scale of Intelligence (WASI; Weschler, 2003); children were administered the Block Design and Matrix Reasoning subtests.

All children in the ASD group had a history of ASD diagnosis from parental reports. To confirm their current ASD diagnosis, a research-reliable interviewer administered the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) to the children in the group. All children met the cut-off for ASD diagnosis (cut-off = 7; *M* = 15.45, *SD* = 4.66).

No child in the TD group had any history of language delay or developmental disorder as indicated on parental reports. Scores on the Social Communication Questionnaire (SCQ; Rutter, Bailey, Lord, 2003) indicated that all TD children fell below the cut-off for a possible diagnosis of ASD (cut-off = 15; *M* = 2.6, *SD* = 1.89). To make comparisons to the ASD group, a subgroup of TD children matched groupwise on age and non-verbal IQ was also created (see Table 1). Care was taken to include more males than females in the TD subgroup to reflect the gender makeup of the ASD group.

Table 1 Demographic, standardized testing, and ToM scores for children with ASD, TD children (all), and TD children (subgroup)

	ASD n = 12	**TD (all)** n = 27	**TD (sub)** n = 12	**t / χ^2** [e]	***p***	***d***
Age	9.09 (1.08) 7.03-10.67	8.88 (1.35) 7.02-10.96	9.07 (1.17) 7.10-10.96	-0.05	.96	.02
Gender [a]	10 M, 2 F	17 M, 10 F	7 M, 5 F	1.82	.18	--
WASI Nonverbal IQ	101.67 (20.05) 70-132	110.24 (13.64) 84-134	103.50 (13.04) 84-125	0.27	.79	.11
CELF-5 Formulated Sentences [b]	9.42 (4.52) 2-15	10.96 (2.11) 8-15	11.33 (2.31) 8-15	0.93	.37	.38
CELF-5 Recalling Sentences [b]	10.92 (3.89) 1-13	11.24 (2.13) 8-16	11.00 (1.95) 8-14	0.03	.98	< .01
PPVT-4 [c]	105.17 (21.22) 72-137	115.52 (5.89) 92-132	111.08 (12.64) 92-130	0.83	.42	.34
2nd-order ToM reasoning [d]	3.58 (2.57) 0-7	5.89 (1.37) 3-8	5.67 (1.67) 3-8	2.35	.03	.96

[a] Person's chi-squared test
[b] Scaled scores are presented, where $M = 10$, $SD = 3$
[c] Standardized scores are presented, where $M = 100$, $SD = 15$
[d] Second-order ToM Reasoning scores range from 0-8
[e] Comparisons are made between the TD children subgroup and the ASD group

The study was approved by the Institutional Review Boards at the University of Connecticut and Yale University. Procedures were explained to all families and written informed consent was obtained from all participants and/or their guardians.

Measures

Standardized language measures. The Formulated Sentences and Recalling Sentences subtests of the Clinical Evaluation of Language Fundamentals-Fifth edition (CELF-5; Wiig, Semel, & Secord 2013) were administered to assess general grammatical abilities and verbal working memory capacity, respectively. The Peabody Picture Vocabulary Test-Fourth edition

(PPVT-4; Dunn & Dunn, 2007) was administered to serve as a measure of children's semantic knowledge.

Pragmatic measures. Participants were evaluated on their knowledge of four pragmatic devices: conventional implicatures, relevance implicatures, scalar implicatures, and metaphors. Each pragmatic device was assessed using a similar structure that involved a series of story vignettes. Use of a similar structure with story vignettes ensured minimal potential performance differences that might emerge from extra-pragmatic requirements among the four pragmatic tasks (e.g., memory, attention, meta-linguistic awareness). For each vignette, 1-2 pictures were presented to first establish the communicative context of the situation. After establishing the story context, a target sentence that elicited an implicature or additional pragmatic interpretation was presented. Participants were then shown four pictures displayed in a 2 by 2 grid and asked to select, via mouse click, the picture that best depicted the answer to a test question that involved the target pragmatic device. If the pragmatic meaning of the utterance was triggered, participants should choose the picture that depicted the pragmatic outcome. All vignettes were supported with images and auditory descriptions, such that participants were not required to read for the tasks (i.e., no text was presented). Additionally, all target utterances were presented in a neutral tone.

More specific details of the vignettes and the four possible picture options used to assess each pragmatic device follow. The descriptions of different test and control story items presented in each pragmatic task and corresponding examples are also summarized in Tables 2 and 3.

Conventional implicatures (adapted from Janssens et al., 2015). Target utterances containing the word *but* (which typically triggers a meaning of contrast) were used to evaluate children's sensitivity to conventional implicatures. For each vignette, Character A was first

introduced (e.g., *This is Sarah. Chocolate is Sarah's favorite food*; see left image in Figure 1 for example). An event involving Character A and Character B then followed (e.g., *Today at lunch, Sarah got chocolate from her friend*; see middle image in Figure 1). The target utterance was then presented (e.g., *Sarah told her friend, "I like chocolate **but** I just ate a big meal"*) while a 2 by 2 grid containing the two possible interpretations of the target utterance and two distractors/fillers was shown (see right image in Figure 1). More specifically, the four images consisted of Character A performing an action that involved (1) the **target** implicature (e.g., Sarah putting the chocolate away), (2) a **contrast** to the implicature (i.e., opposite of the implicature meaning; e.g., Sarah eating the chocolate), (3) one **distractor** (e.g., Sarah eating a sandwich), and (4) another **distractor**, (e.g., Sarah receiving her lunch). Children were asked to select the picture depicting what Character A would do next (e.g., *So, what will Sarah do next?*).

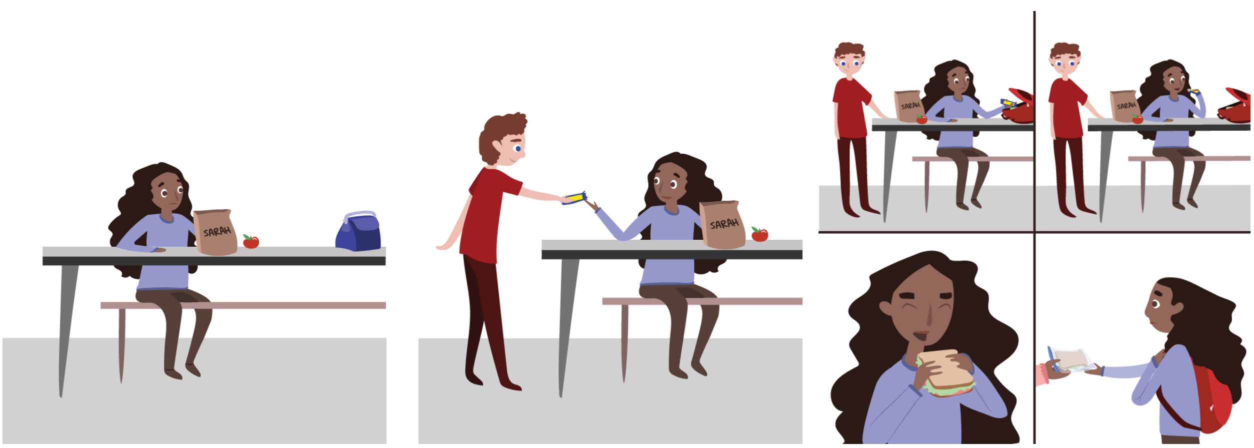

Figure 1. Example of conventional implicature item.

Five basic story plots/events were utilized: a) an eating event, b) an academic event (e.g., studying), c) a hobby event (e.g., watching TV), d) a sporting event, and e) an "unfavorable" event (e.g., one that involves engaging in an action that the character does not like, such as climbing up high on a tree). For each of the story plots/events, two vignettes were created – one

in which the target implicature involved a character engaging in the activity (e.g., *I just ate a lot of spaghetti* ***but*** *I love cake*, which implicates that the character will eat the cake) and one in which the target implicature involved a character not engaging in the activity (e.g., *I like chocolate* ***but*** *I just at a big meal,* which implicates that the character will not eat the chocolate). This was done to avoid having all target implicatures involve the character restraining from performing the activity as this may have encouraged children to use a testing strategy to succeed on the task (i.e., always pick the picture in which the character does not perform the action mentioned in the target utterance; see Janssens et al., 2015).

As further control trials, children were also presented with *but*-utterances that contained a nonsensical or unrelated second clause (e.g., *I love eating strawberries* ***but*** *I got new glasses*). Such utterances should make it more difficult to generate a relevant implicature (Janssens & Schaeken, 2013). However, if a child was using a testing strategy (e.g., simply negating the first clause without considering information from the whole utterance), then their picture selection pattern will not differ from target utterances containing both appropriate first and second clauses. A second control set of utterances containing the conjunction *and* (rather than *but*) was also included (e.g., *I love eating pizza* ***and*** *my boss gave me a lot of work*). Such utterances should not trigger the sense of contrast between the two clauses and children therefore should not reliably choose the "target" image (i.e., the image depicting the opposite event related to the first clause; in this example, it would be the character not eating the pizza and continuing to work) when presented with the four possible interpretations comparable to those used in the target *but*-utterances. The control items (nonsensical *but*-utterances and *and*-utterances) again involved events similar to the five story plots/events as described above for the sensical *but*-utterances. In sum, selection of the "target" counterpart images for either the nonsensical *but*-utterances and

and-utterances at rates comparable to that of sensical *but*-utterances would reveal that children may not have an adult-like comprehension of such conventional implicatures and may instead be using a test strategy.

Participants were presented with 10 sensical *but*-utterances, 5 nonsensical *but*-utterances, and 5 *and*-utterances, totaling 20 story vignettes for this task (see Tables 2 and 3). Order of the story vignettes were randomized across participants.

Scalar implicatures (adapted and simplified from Huang & Snedeker, 2009). To assess whether children were sensitive to scalar implicatures, five story vignettes involving various Sesame Street characters (e.g., Elmo) were administered. The five story vignette settings were as follows: (1) picking apple trees at an orchard, (2) attending a baking class that involved a carton of eggs, (3) making s'mores around a camp fire that involved a bag of marshmallows, (4) making an art project with a bag of cotton balls, and (5) attending and receiving a bag of candy at a birthday party.

For each story vignette, a narrator first described an image depicting the Sesame Street character accompanying a group of six individuals on a group activity (e.g., apple picking; see left image in Figure 2). In each of the activities, each of the six individuals (i.e., excluding the Sesame Street character) was depicted with an item (e.g., tree full of apples) that would later be the focus of the test questions. After being introduced to the particular group activity, the children were told some time has passed and that we were checking in on the group (e.g., *Oh look, half an hour has passed. Let's check in with Elmo*; see middle image in Figure 2). Following this, the narrator asked the Sesame Street character how each member of the group had progressed in the activity (e.g., *How did Billy do*?). The Sesame Street character subsequently responded with an utterance containing the scalar item (i.e., *He picked* ***some*** *of the*

apples). As the Sesame Street character responded, a 2 by 2 grid containing four images was shown: (1) one depicting the pragmatic interpretation (i.e., a tree with less than half of its' apples remaining), (2) one depicting a logically possible interpretation (i.e., a tree with all of its apples missing), (3) a distractor image (i.e., a tree with all of its original apples as well as ribbons on it), and (4) another distractor image (i.e., a tree with all of its leaves blown off; see right image in Figure 2). Children were asked to pick which image best depicted the item that belonged to the character (e.g., *What does Billy's tree look like now?*). Additional target utterances containing the quantifier *all* (e.g., *He picked **all** of the apples*) as well as utterances not involving any quantifiers (e.g., *He put the ribbons on the branches*) were included as controls and fillers, respectively. See Figure 2 for an example.

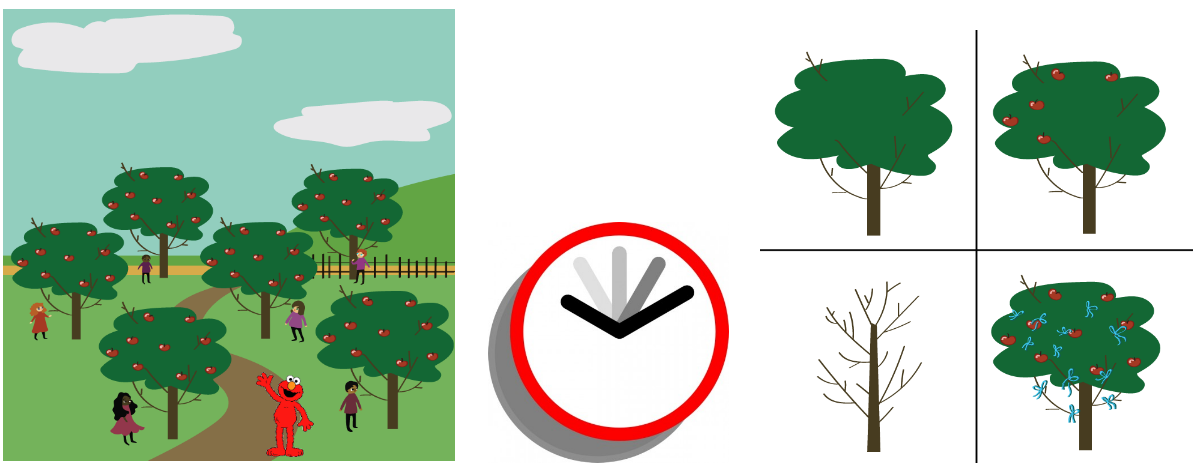

Figure 2. Example of scalar implicature item.

For each story vignette, children received two utterances containing the *some* scalar implicature, two utterances containing the quantifier *all*, and two filler utterances, totaling six utterances, one for each of the six individuals initially introduced at the start of the vignette. The

order of the utterances was randomized within each story vignette. The order of the five story vignettes was also randomized across participants.

Relevance implicatures (adapted from Bernicot et al., 2007). In these vignettes, two characters were first introduced (e.g., *Here's Sandra and her mom relaxing the living room*; see left image in Figure 3). Following this, Character A was described as asking Character B for permission/approval to engage in an activity (e.g., *Sandra says to her mom, "I have a music competition tomorrow. Can I practice the drums?"*). The target utterance was then presented (e.g., *Sandra's mom says to her, "The neighbors have already gone to bed"*) while a 2 by 2 grid containing the two possible interpretations of the target utterance and two distractors was shown (see right image in Figure 3). More specifically, the four images consisted of: (1) Character A performing the requested activity (e.g., playing the drums), (2) Character A performing another related activity (e.g., reading music sheet), (3) scene described by Character B (e.g., neighbors going to sleep), and (4) Character B performing Character A's requested activity. Children were asked to select the picture depicting what Character A would do next (e.g., *What will Sandra do next?*).

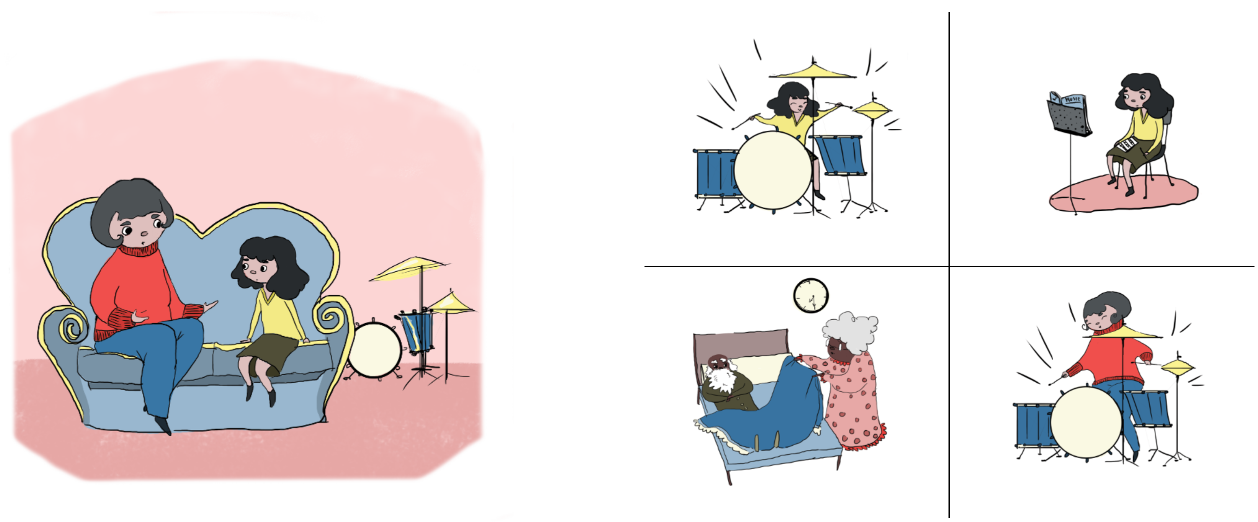

Figure 3. Example of relevance implicature item.

Five test items involved implicatures that confirmed Character's A request and another five involved implicatures that denied the request. This was done to ensure that children could not simply succeed on the task via a testing strategy (e.g., always picking the image that depicted Character A performing the requested activity). The order of the story vignettes was randomized across participants.

Metaphors (adapted from Olofson et al., 2014). In these vignettes, the narrator first described the character and story context that was depicted (e.g., *The lights in Ron's home are always broken*). A four-picture display was then shown while a metaphorical sentence was presented (e.g., *His home is a cave*; see Figure 4). The pictures depicted: (1) a metaphorical interpretation (e.g., a home that is dark); (2) a literal interpretation (e.g., an actual cave); (3) an associated metaphorical attribute (e.g., a home that had lights on but appeared cold and damp); and (4) a distractor (e.g., a tree with a hole in the middle). Children were asked to select which picture best described the previous sentence (e.g., *Which one is Ron's home?*).

Figure 4. Example of metaphor item

As a control, children were later presented with the same target utterance but now preceded with a context that supported a literal interpretation (e.g., *The bear lived in these woods for years*). The same four pictorial options were shown. In order to prevent children from perseverating on literal interpretations, a block of 10 metaphorical utterances was first administered, followed by a block of 10 literal utterances. Within each metaphorical/literal block, the vignettes were randomized across participants.

Table 2 Event and item structure of the different pragmatic types

Pragmatic Device	Num. of event types	Num. of vignettes per event type	
Conventional Implicature Total num. of items: 20	5	4	**Test**: Sensical-*but* (engagement) **Test**: Sensical-*but* (non-engagement) Control: *Nonsensical*-but Control: *And*
Scalar Implicature Total num. of items: 30	5	6	**Test**: *Some* (2) Control: *All* (2) Filler (2)
Relevance Implicature Total num. of items: 10	5	2	**Test**: Confirm request **Test**: Deny request
Metaphors Total num. of items: 20	10	2	**Test**: Metaphorical interpretation Control: Literal interpretation

Table 3 Description and example of different items presented in each pragmatic task.

Pragmatic type	Function	Example
Conventional implicature		
Sensical *but*-utterance	Test item used to determine whether subject understands implied sense of contrast	*Sarah told her friend, "I like chocolate* ***but*** *I just ate a big meal."*
Nonsensical *but*-utterance	Control item used to determine whether subject is using testing strategy (i.e., always negate first clause)	*Chris told his teacher, "I love eating strawberries* ***but*** *I got new glasses."*
And-utterance	Control item used to determine whether subject can distinguish between a conjunction that does not trigger contrastive meaning	*Haley told her friends, "I love eating pizza* ***and*** *my boss gave me a lot of work."*
Scalar Implicature		
Some-utterance	Test item used to determine whether subject understands the pragmatic implicature associated with *some*, (i.e., *some but not all*)	*Jill ate* ***some*** *of the candy.*
All-utterance	Control item used to determine subject's comprehension of a quantifier that does not involve an implicature	*Tom ate* ***all*** *of the candy.*
Filler	Filler item included so that the subject will not feel fatigued by the presentation of utterances involving just quantifiers	*Sarah ripped her bag in half.*
Relevance Implicature		
Confirming relevance implicature	Test item used to determine whether subject can determine that the additional speaker meaning involves confirming a request	*Audrey says to her dad, "My friend just came over. Can I go out and play?" Audrey's dad says to her, "You already did all your chores."*
Denying relevance implicature	Test item used to determine whether subject can determine that the additional speaker meaning involves denying a request	*Sandra says to her mom, "I have a music competition tomorrow. Can I practice the drums?" Sandra's mom says to her, "The neighbors have already gone to bed"*
Metaphor		
Metaphorical utterance	Test item used to determine whether subject can interpret additional metaphorical meaning of an utterance	*The lights in Ron's home are always broken. His home is a cave.*
Literal utterance	Control item to determine whether subjects can decode utterance presented in metaphor trials (or whether poor performance with metaphors is tied to poor deconstruction of the utterance itself)	*The bear has been living in the woods for a while. His home is a cave.*

ToM measures. A series of short vignettes, presented with pictures, that elicited explanations about characters' false belief was administered. Two first-order ToM (i.e., reasoning about others' beliefs/thoughts) stories involving a change of location were first presented followed by two second-order TOM (i.e., reasoning about individuals' reasoning about others' beliefs/thoughts) stories. See Table 4 for an example of a second-order ToM story item.

Table 4 Example of second-order ToM story item.

Jim's mother gives him a chocolate bar to share with his sister, Lucy. Jim eats some of the chocolate bar but does not want to share the rest with Lucy. He hides the chocolate bar in the cookie jar. Lucy asks where the chocolate bar is. Remember that Jim doesn't want to share the chocolate bar. So, instead of telling Lucy that he hid the chocolate bar in the cookie jar, Jim says "I left the chocolate bar in the cupboard."

Probe question 1*:* Did Jim really leave the chocolate bar in the cupboard?
Probe question 2: Did Jim tell Lucy that he left the chocolate bar in the cupboard?
Probe question 3*:* Why did Jim tell Lucy that he left the chocolate bar in the cupboard?

When Lucy leaves the kitchen, Jim decides to get more chocolate. While Jim is getting the chocolate bar out of the cookie jar, Lucy passes by the window and sees Jim getting the chocolate bar out of the cookie jar. Lucy says to herself 'Jim didn't leave the chocolate in the cupboard, he put it in the cookie jar.' Jim does not see Lucy watching him get the chocolate.

Nonlinguistic control question: Does Lucy know that Jim hid the chocolate bar in the cookie jar?

Jim's mother comes home from work. She calls Jim to the kitchen to ask him if he liked the chocolate bar. She asks 'Does Lucy know where the chocolate bar is? Jim decides to tell the truth to his mother

Second-order ignorance question*:* What does Jim say to his mother?

Memory aid*:* Now remember, Jim does not know that Lucy saw where he hid the chocolate bar

Then, Jim's mother says to Jim, 'Where does Lucy think the chocolate bar is'?

Second-order false-belief question*:* What does Jim say to his mother?

Justification question*:* Why does Jim say that?

Procedure

The study took place in a quiet room at the University of Connecticut (Storrs) or at Haskins Laboratories (New Haven, CT). Testing lasted approximately 3 to 4 hours over the course of two sessions. In the first session, children were administered the standardized measures. Following the initial visit, the standardized tests were scored and considered together with the parental reports to decide whether children met the criteria for the study (i.e., confirmed previous ASD diagnosis for the children in the ASD group and non-verbal IQ standard score equal to or greater than 70). Children who met the criteria were contacted again for the second visit, during which the pragmatic and ToM tasks were administered.

The pragmatic task was administered in a quiet room that contained two computers, a main computer that presented the story vignettes to the children and a host computer that allowed the experimenter to control the presentation of the stimuli. The participants were first seated in front of the main computer. To collect additional online sentence processing measures, the participants' eye gaze was also recorded using an eyetracker (Eyelink 1000 system). The eyetracking camera was located in front of the computer and was about 60-70 cm from the participants. Prior to presenting the pragmatic stimuli, there was a short calibration period. If calibration was unsuccessful after several trials, the session proceeded with the eye-tracker turned off. Because online processing of the pragmatic devices was not the main goal of the current dissertation, results from the eye tracking data will not be included in this document.

The presentation ordering of the different tasks was blocked in the following order: conventional implicatures, scalar implicatures, relevance implicatures, and metaphors. This ordering was used as we had some predictions regarding the eye-gaze pattern for the initial two tasks. As such, to avoid losing eye-tracking data on these particular items (e.g., due to fatigue or

restlessness in later blocks), these blocks were placed first. Participants were given a break (lasting a few minutes) between each pragmatic block. If participants were feeling particularly fatigued or fussy, a longer break was given.

The ToM task took place in a separate, quiet room. The order of the ToM task and the pragmatic tasks was counter-balanced across participants, with the exception of the adults who only participated in the pragmatics tasks.

Plan of Analysis

Pragmatic reasoning was assessed by examining the percent number of correct items (out of the total number of items). This was calculated individually for the target, control, and filler utterance types of each pragmatic task. Recall that for the scalar implicature and metaphor control/filler items, the participants should on average perform above chance (i.e., 25%) given that these utterances did not require the participants to engage in any extra-pragmatic reasoning (i.e., they needed only to decode the logical forms of the utterances to accurately choose the appropriate response). In contrast, participants' performance on the conventional implicature control items (i.e., nonsensical *but*-utterances and *and*-utterances) was expected to be below chance or at the minimum, be below performance on the test, sensical *but*-utterances. These utterances were designed such that there would be no "correct" response (as a method to determine if the participants were using a testing strategy); thus, they should not be selecting the "target" image (e.g., the image depicting negated action indicated in the first clause) at a rate above or comparable to test *but*-utterances that have a sensical target interpretation. With all test items for each of the pragmatic devices, above-chance performance would suggest that participants were interpreting the pragmatic meaning of the particular pragmatic device appropriately.

Given that our measures were proportional in nature and that almost all of the accuracy measures for the three groups (TD adults, TD children, and children with ASD) violated the test of normality, non-parametric tests were used. For the TD adults group, one-sample Wilcoxon signed-rank tests were performed to determine whether accuracy on each of the individual pragmatic tasks was significantly different than chance; effect size measure *r* was reported here, with the criteria of 0.1 being a small effect, 0.3 being a medium effect, and 0.5 being a large effect (Pallant, 2007).[11] Control, filler, and test items were analyzed separately. Following this, accuracy on only the test items of the four pragmatic devices were compared using a Friedman Test to determine whether performance varied or differed across pragmatics type.

For the TD children group, the same two analyses were performed. In addition, a series of logit regressions were conducted to examine whether the different factors (e.g., general grammatical knowledge, ToM reasoning, etc.) contributed to performance on the pragmatic tasks as predicted.[12] Logit regressions were performed separately for each pragmatic task in which the group showed variable accuracy performance. It should be noted, for ToM reasoning, that only scores on second-order ToM items were included as all children in the group passed the first-order ToM items, leaving no variability. Additionally, preliminary pairwise correlations between all variables of interest were performed to ensure that there was no multicollinearity present in the different logit regression models (i.e., correlations between variables of interest were less than +/- .70).

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[11] The formula for calculating *r* is as follows: z / sqrt(n), with n being the total number of observations.
[12] As a preview to our results, we found a different pattern of variability in the TD and ASD groups. Because this hinted at the possibility of different contributors playing a different role in the TD vs. ASD groups, we performed separate “contributor” analyses for the two groups rather than combining them into one larger sample.

For the ASD group, again, the two analyses (e.g., comparing accuracy to chance level and across different pragmatic types) were performed. However, in contrast to the TD children, logit regressions were not performed due to the small sample size. Thus, to examine the potential contributions of different factors, non-parametric correlations (i.e., Kendall's Tau) were conducted between the different factors and accuracy performance of each pragmatic type. Similar to the TD group, only second-order ToM reasoning scores were used as the children with ASD all passed first-order ToM items.

Lastly, comparisons between the ASD group and the TD subgroup, matched on age and non-verbal IQ, were made to determine to what extent the children with ASD demonstrated typical development. Pairwise Mann-Whitney U tests were conducted to compare the two groups' performance on each of the pragmatic tasks. Kendall's Tau correlations were also performed for the TD subgroup to make comparisons with the correlations found with the ASD group. Additionally, an analysis examining the errors made on the four pragmatic devices was conducted for the ASD group and TD subgroup separately. In particular, a Friedman Test comparing the proportion of errors involving the three non-target options was performed for each pragmatic device (e.g., out of all errors with metaphors, how many involved the selection of the literal competitor, other metaphorical attribute, or distractor). An item analysis comparing the groups' frequency of errors made across items for each pragmatic device was also performed. This was done to determine whether the two groups differed in the items they found difficult.

Chapter 3: Results

As described in Chapter 2, it was expected that children with ASD would demonstrate somewhat intact ability to interpret conventional and scalar implicatures; in contrast, they were expected to display impairments in their ability to interpret relevance implicatures. While the

metaphor literature has been somewhat mixed, we nonetheless predicted that the children with ASD would perform at above chance but also less well when compared to TD children as has been found by Olofson et al. (2014) using a similar paradigm. With regards to potential contributors, it was expected that verbal working memory (i.e., CELF-5 Recalling Sentences) would play some role across the four implicatures. Given that conventional and scalar implicatures depend more on knowledge that involves the conventional meaning of constructions (although at differing degrees), grammatical knowledge (i.e., CELF-5 Formulated Sentences) was predicted to be a significant contributor. With regards to relevance implicatures, it was predicted that ToM would significantly contribute to their performance (de Villiers et al., 2009). CELF-5 Formulated Sentences scores were also entered as a way to control for children's ability to decode the logical form of the utterances. Lastly, from previous literature (Norbury, 2005), it was expected that ToM abilities and vocabulary knowledge (i.e., PPVT-4) would be significant predictors of metaphor performance. CELF-5 Formulated Sentences scores were not entered as the construction of the metaphors used in the task was relatively simply (i.e., Noun phrase is Noun phrase) and as such, there were no expectations that there will be variability in the children's ability to decode this construction.

TD Adults (Pragmatic tasks pilots)

Of the 41 individuals who participated in the task, four individuals were removed from subsequent analyses. These individuals all scored close to or lower than chance (i.e., 25% accuracy) on the test items of the Metaphor task (range = 0 to 30%). No other participants scored at or below chance on any of the other tasks. Additionally, item-analyses were performed for every control and test item. No item was answered correctly by *less* than 25% of the participants (the criterion that we used to determine if an item was too difficult), with the exception of the

control items for conventional implicatures, which was excepted; thus, all items were kept in the subsequent analyses.

Accuracy performance. Table 5 presents TD adults' accuracy on each of the pragmatic tasks. For conventional implicatures, TD adults' accuracy for control trials involving nonsensical *but*-utterances did not significantly differ from chance. In contrast, accuracy for control trials involving *and*-utterances was significantly higher than chance. It should nonetheless be noted that performance between *and*-utterances and test, sensical *but*-utterances differed significantly, with the TD adults performing with a higher accuracy on the latter type of utterances, $Z = 5.26$, $p < .001$, $r = .61$. Lastly, accuracy for the test, sensical *but*-utterances was significantly above chance.

With regards to scalar implicatures, relevance implicatures, and metaphors, TD adults performed significantly above chance on their accuracy of all control, filler, and test utterances.

Table 5 TD adults' accuracy across different pragmatic types.

Pragmatic Type	Mean	Median	Z	p^a	r^b
Conventional Implicatures					
Nonsensical *but*-utterances (control)	21.62	20.00	-1.95	.15	.23
And-utterances (control)	36.21	40.00	4.58	< .001	.33
Sensical *but*-utterances (test)	81.08	80.00	5.34	< .001	.62
Scalar Implicatures					
All-utterances (quantifier control)	96.76	100.00	5.61	< .001	.65
Fillers	99.46	100.00	5.94	< .001	.69
Some-utterances (test)	98.38	100.00	5.82	< .001	.68
Relevance Implicatures (test)	97.84	100.00	5.68	< .001	.66
Metaphors					
Literal utterances (control)	97.00	100.00	5.58	< .001	.65
Metaphorical utterances (test)	85.68	90.00	5.35	< .001	.62

Accuracy is reported as percent correct for each utterance type.
One-sample Wilcoxon signed-rank tests were performed to determine whether accuracy differed from chance (i.e., 25%).
[a] *p*-values reported have been adjusted for multiple comparisons using the Bonferroni method
[b] *r* is an effect size measure, with 0.1 being a small effect size, 0.3 medium, and 0.5 large.

Comparison of performance across pragmatic types. Focusing on the participants' performance on the test items, a Friedman test revealed that there was a significant difference in TD adults' accuracy across the four pragmatic types, χ^2 (3, N = 37) = 57.405, $p < .001$. Pairwise comparisons using Wilcoxon signed-rank tests with Bonferroni correction revealed that accuracy on conventional implicatures was significantly lower than on relevance implicatures ($p < .001$, $r = .56$) and scalar implicatures ($p < .001$, $r = .58$). Additionally, accuracy on metaphors was significantly lower than on relevance implicatures ($p < .001$, $r = .51$) and scalar implicatures ($p < .001$, $r = .51$). No other pairwise comparisons were significant.

TD children

Accuracy on pragmatics tasks. Table 6 presents TD children's accuracy on each of the pragmatic tasks. For conventional implicatures, TD children's performance on nonsensical *but*-utterances did not differ significantly from chance. With *and*-utterances, while their performance did differ from chance, it was significantly lower than their performance on sensical *but*-utterances, $Z = 3.13$, $p = .004$, $r = .43$. TD children's performance on sensical *but*-utterances was significantly above chance. With regards to scalar implicatures, relevance implicatures, and metaphors, TD children performed significantly above chance on all control, filler, and test utterances.

Table 6 TD children's accuracy across different pragmatic types.

Pragmatic Type	Mean	Median	*Z*	p^a	r^b
Conventional Implicatures					
Nonsensical *but*-utterances (control)	26.67	20.00	0.34	1.00	.05
And-utterances (control)	54.81	60.00	3.91	< .001	.53
Sensical *but*-utterances (test)	75.56	90.00	4.58	< .001	.62
Scalar Implicatures					
All-utterances (quantifier control)	95.19	100.00	4.74	< .001	.65
Fillers	96.67	100.00	4.81	< .001	.66
Some-utterances (test)	98.89	100.00	5.04	< .001	.69
Relevance Implicatures (test)	90.37	90.00	4.61	< .001	.63
Metaphors					
Literal utterances (control)	89.51	90.00	4.59	< .001	.62
Metaphorical utterances (test)	50.74	50.00	3.69	< .001	.50

Accuracy is reported as percent correct for each utterance type.
One-sample Wilcoxon signed-rank tests were performed to determine whether accuracy differed from chance (i.e., 25%).
[a] *p*-values reported have been adjusted for multiple comparisons using the Bonferroni method
[b] *r* is an effect size measure, with 0.1 being a small effect size, 0.3 medium, and 0.5 large.

Comparison of performance across pragmatic types. A Friedman test revealed that TD children differed significantly on their test item accuracy across the pragmatic types, χ^2 (3, *N* = 27) = 59.21, $p < .001$. Wilcoxon signed-rank tests with Bonferroni corrections revealed significant pairwise comparisons across all comparisons such that TD children were most accurate on scalar implicatures (*ps* < .001, *rs* between .49-.62), followed by relevance implicatures (*ps* < .001, *rs* between .48-.70), then conventional implicatures (*ps* < .01, *rs* between .43-.62), and lastly, metaphors (*ps* < .01, *rs* between .43-.61).

Contributors of pragmatic reasoning. We were interested in exploring which factors contributed to TD children's pragmatic reasoning. Table 1 presents the children's scores on standardized tests that measure general grammatical ability (i.e., CELF-5 Formulated Sentences), verbal working memory (i.e., CELF-5 Recalling Sentences), and vocabulary knowledge (i.e.,

PPVT-4) as well as second-order ToM scores. Recall that first-order ToM scores were not included in these analyses as all children performed at ceiling.

Additionally, as stated previously, we were interested in only the pragmatic types in which the group demonstrated variable performance. TD children performed at ceiling with scalar implicatures; thus, analyses were not performed for this pragmatic device. All following analyses involve only the performance on test items of the individual pragmatic type (i.e., performance on control and filler items was excluded).

Conventional implicatures. A logit regression was performed to determine whether second-order ToM reasoning, CELF-5 Formulated Sentences, and CELF-5 Recalling Sentences contributed to TD children's performance on conventional implicatures. Age was also included as a control variable. The overall model was not significantly different from a null model, $\chi^2(4) = 7.91$, $p = .09$.

Relevance implicatures. A logit regression with children's performance on relevance implicatures as the outcome variable was performed. Second-order ToM reasoning and CELF-5 Recalling Sentences scores were entered as predictor variables. Additionally, age and CELF-5 Formulated Sentences were also included as control variables. The overall model fit was significantly better than a null model, $\chi^2(4) = 10.56$, $p = .03$. Second-order ToM reasoning and CELF-5 Formulated Sentence score were found to be significant independent predictors. A one unit increase in second-order ToM score was associated with a 1.67 (95% CI, 1.14 to 2.52) increase in odds of getting a relevance implicature item correct, $p = .01$. A one unit increase in CELF-5 Formulated Sentence score was associated with a 1.35 (95% CI, 1.06 to 1.73) increase in odds of getting a relevance implicature item correct, $p = .02$

Metaphors. A logit regression was first performed with second-order ToM reasoning and PPVT-4 scores entered as predictors of children's metaphorical reasoning performance. Age was again included as a control variable. This model fit was significantly better than a null model, $\chi^2(3) = 17.20$, $p < .001$. Age was a marginally significant predictor, with every one year increase in age being marginally associated with a 1.24 (95% CI, 0.99 to 1.56) increase in odds of getting a metaphor item correct, $p = .06$. Score on the PPVT-4 was a significant predictor, with a unit increase being associated with a 1.04 (95% CI, 0.91 to 1.41) increase in odds of getting a metaphor item correct, $p = .007$.

A second logit regression model, now with the inclusion of CELF-5 Recalling Sentences scores, was also conducted. This model was also significantly better in fit than a null model, $\chi^2(4) = 25.80$, $p < .001$. With this model, age was again a marginally significant predictor, with every one year increase being marginally associated with a 1.23 increase in odds of getting a metaphor item correct, $p = .07$. In contrast to the previous model, however, score on the PPVT-4 was no longer a significant predictor, $p = .11$. Instead, score on the CELF-5 Recalling Sentences was a significant predictor, with every one unit increase being associated with a 1.22 (95% CI, 1.07 to 1.41) increase in odds of getting a metaphor item correct, $p = .004$. Lastly, it should be noted that this overall model significantly improved model fit compared to the previous model, $\chi^2(1) = 8.60$, $p < .001$.

Children with ASD

Accuracy on pragmatics task. Table 7 presents children with ASD's accuracy across the different pragmatic types. For conventional implicatures, children with ASD did not perform significantly above chance on controls (i.e., nonsensical *but*-utterances and *and*-utterances) items. With conventional implicature test items (i.e., sensical *but*-utterances), performance was

significantly above chance. However, in contrast to TD adults and TD children, children's performance on conventional test items and *and*-utterance controls did not differ significantly, $Z = 2.32$, $p = .09$, $r = .47$. Performance on all scalar implicature items (i.e.., controls, fillers, and test utterances) and relevance implicature items was significantly above chance. With regards to metaphors, while children with ASD performed significantly above chance on the literal controls, performance on metaphorical test items was not significantly above chance.

Table 7 Children with ASD's accuracy across different pragmatic types.

Pragmatic Type	**Mean**	**Median**	***Z***	p^a	r^b
Conventional Implicatures					
Nonsensical *but*-utterances (control)	23.33	20.00	-0.80	1.00	.16
And-utterances (control)	41.67	40.00	2.30	.10	.47
Sensical *but*-utterances (test)	56.67	50.00	3.08	< .01	.63
Scalar Implicatures					
All-utterances (quantifier control)	79.17	90.00	2.93	< .01	.60
Fillers	85.00	95.00	3.02	< .01	.62
Some-utterances (test)	84.17	100.00	3.05	< .01	.62
Relevance Implicatures (test)	53.33	45.00	2.85	< .01	.58
Metaphors					
Literal utterances (control)	81.48	90.00	3.13	< .01	.64
Metaphorical utterances (test)	31.67	20.00	0.55	1.00	.11

Accuracy is reported as percent correct for each utterance type.
One-sample Wilcoxon signed-rank tests were performed to determine whether accuracy differed from chance (i.e., 25%).
[a] *p*-values reported have been adjusted for multiple comparisons using the Bonferroni method
[b] *r* is an effect size measure, with 0.1 being a small effect size, 0.3 medium, and 0.5 large.

Comparison of performance across pragmatic types. A Friedman test revealed that children with ASD's test item accuracy differed significantly across the pragmatic types, χ^2 (3, $N = 12$) = 14.37, $p = .002$. Wilcoxon signed-rank tests with Bonferroni correction revealed that performance on conventional implicatures did not significantly differ from relevance implicatures ($p = 1.00$, $r = .13$) and metaphors ($p = .123$, $r = .47$); it was marginally lower

compared to scalar implicatures ($p = .076$, $r = .50$). Performance on scalar implicatures was also significantly higher compared to relevance implicatures ($p = .03$, $r = .54$) and metaphors ($p = .03$, $r = .54$). Finally, children with ASD did not perform differently on relevance implicatures compared to metaphors ($p = .573$, $r = .35$).

Contributors of pragmatic reasoning. Table 1 presents the standardized test and second-order ToM scores for the ASD group.

Given the small sample size, Kendall's Tau were performed rather than logit regressions. To control for multiple comparisons, the Bonferroni method was used. Additionally, because age was not found to be a significant correlate of any pragmatic type ($\tau_b s < .50$, $ps > .05$), partial correlations were not performed. The correlations are reported in Table 8. Overall, no significant correlations were found between the predicted contributors and any pragmatic type, with the exception of a significant correlation between accuracy on the metaphor task and second-order ToM reasoning, $\tau_b = .62$, $p = .04$.

Comparison between children with ASD and age- and non-verbal IQ-matched TD children

Accuracy measure. To determine to what extent children with ASD's performance on the pragmatic tasks differed from typical development, a subgroup of TD children matched on age, gender, and non-verbal IQ was created as a comparison group (see Table 1). Pairwise Mann-Whitney U comparisons with Bonferroni corrections were performed on both groups' test item performance for each pragmatic type (see Figure 5). TD children performed significantly better than children with ASD on conventional implicatures ($U = 121$, $p = .02$) and relevance implicatures ($U = 122$, $p = .01$). Groups did not differ in their performance on scalar implicatures ($U = 93$, $p = .56$) and on metaphors ($U = 97.5$, $p = .58$).

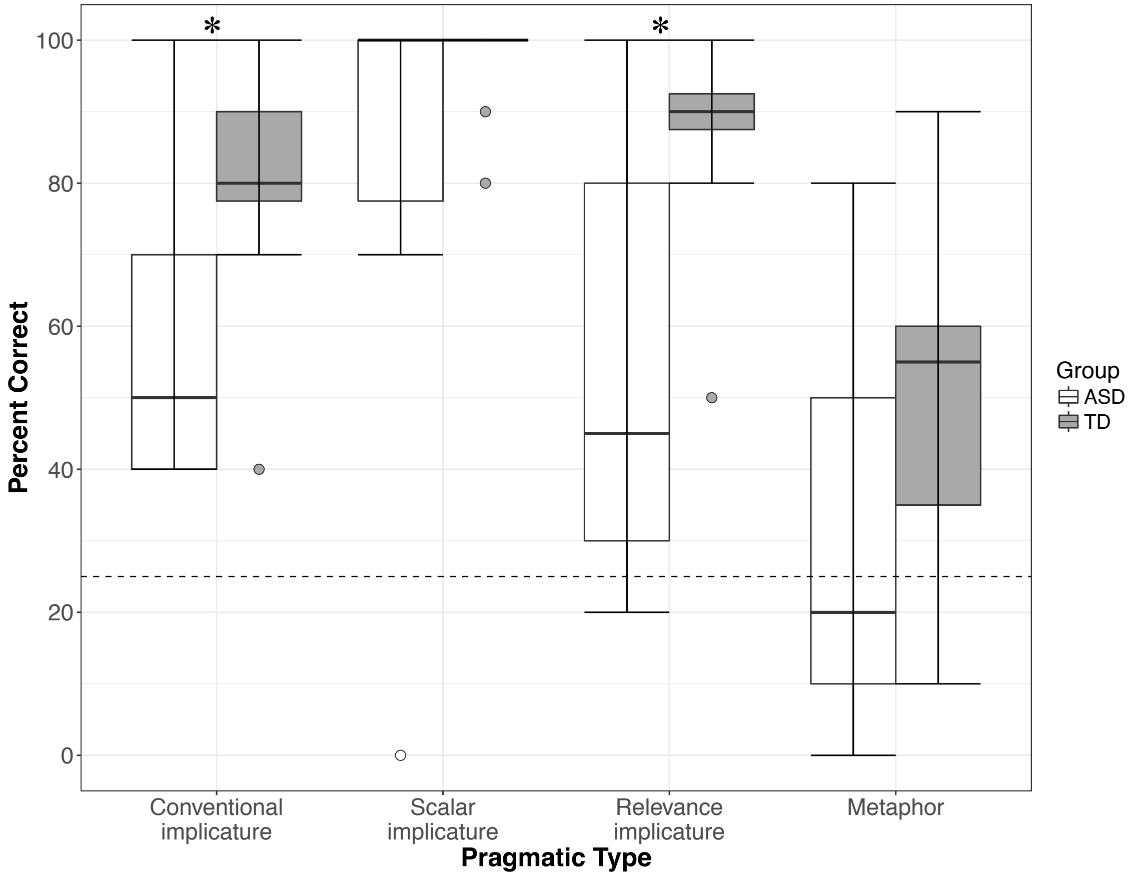

Figure 5. Performance across pragmatic types between children with ASD and TD children matched on age, gender, and non-verbal IQ.

With regards to examining factors that contribute to performance on the individual pragmatic tasks, Table 8 includes correlations for the TD children subgroup. Similar to the children with ASD, the only significant correlation found was between TD children's performance on metaphors and second-order ToM reasoning, $\tau_b = .48$, $p = .04$.

Table 8 Kendall Tau's correlation coefficients between the pragmatic tasks and potential contributors

	CELF-5 Formulated Sentences	CELF-5 Recalling Sentences	2nd-order ToM	PPVT-4
ASD group				
Conventional implicatures	.15	.16	.33	--
Scalar implicatures	-.02	-.15	.14	--
Relevance implicatures	.13	.00	.02	--
Metaphors	--	.43	.62*	.26
TD subgroup				
Conventional implicatures	.20	-.09	.15	--
Scalar implicatures	.11	.00	-.06	--
Relevance implicatures	.23	-.09	.42	--
Metaphors	--	.17	.48*	.42

* $p < .05$

Note, we conducted a correlation between PPVT-4 score and performance on metaphors. Correlations with PPVT-4 score and the other pragmatic tasks were not performed as we had specific ad-hoc predictions regarding the relationship between PPVT-4 and metaphors but not for the other pragmatic tasks. Similarly, because we did not expect CELF-5 Formulated Sentences to play a role in metaphorical reasoning, a correlation between the two was not conducted. The latter two steps were taken to limit the number of correlations being performed with an already small sample size.

Error analysis. We examined the errors that the children in each group made on the pragmatic types and discovered a number of similarities. With errors on conventional implicatures, children with ASD demonstrated a preference in their response, $\chi^2(2) = 11.81$, $p = .003$. Pairwise comparisons using Wilcoxon signed-rank tests with Bonferroni correction revealed that children with ASD tended to select the option that involved the opposite of the implicature meaning (e.g., if the implicature meaning was that Sarah would not eat the chocolate, the opposite option would be Sarah **eating** the chocolate) at a higher rate (M = 64.85% of errors, SD = 27.82%) compared to the two distractors (M = 22.42%, SD = 17.96% and M = 10.91%, SD = 15.57%), ps < .05. A similar pattern emerged with the TD children, $\chi^2(2) = 14.22$, $p < .001$.

The contrasted implicature meaning (M = 70.00%, *SD* = 34.96%) was selected at a higher rate than both distractors (*M* = 6.67%, *SD* = 16.10% and *M* = 16.67%, *SD* = 33.33%), *p*s < .05.

With errors on relevance implicatures, children with ASD did not prefer one type of response, $\chi^2(2) = 2.12$, *p* = .35. That is, they selected the competitor option (i.e., either performing or not performing the requested action, depending on the relevance implicature type; *M* = 36.86% of errors, *SD* = 29.05%), and the two distractors (*M* = 27.41%, *SD* = 29.92% and *M* = 29.88%, *SD* = 25.72%) at similar rates. For TD children, it initially appeared that they did have a preference in their response, $\chi^2(2) = 6.22$, *p* = .04. However, pairwise comparisons did not reveal significant differences in their rates of selecting the competitor option (*M* = 56.67%, *SD* = 46.37%), and the two distractors (*M* = 2.22%, *SD* = 6.67% and *M* = 41.11%, *SD* = 47.02%), *ps* > .05. Moreover, it should be noted that the overall rate of errors for this type of implicatures were relatively low for the TD children (see Figure 5).

When making errors on metaphors, children with ASD demonstrated a preference in their response, $\chi^2(2) = 9.43$, *p* = .009. Pairwise comparisons using Wilcoxon signed-rank tests with Bonferroni correction revealed that children with ASD tended to select the literal option (*M* = 62.03% of errors, *SD* = 35.03%) at a significantly higher rate than the distracter (*M* = 9.54%, *SD* = 22.19%), *p* = .03. However, the rate of selecting the literal option was only marginally higher than the rate of selecting the option involving a related metaphorical attribute, (*M* = 28.42%; *SD* = 28.72%), *p* = .062. TD children also demonstrated a preference, $\chi^2(2) = 21.27$, *p* < .001; however, the TD children selected the literal option (*M* = 87.80%, *SD* = 10.31%) at significantly higher rates compared to both the distractor (*M* = 1.67%, *SD* = 5.77%) and the related metaphorical attribute option (*M* = 10.53%, *SD* = 10.55%), *ps* < .001.

Next, a test of equal proportions, comparing the number errors made by the ASD group vs. TD subgroup, was performed for each test item for each pragmatic type. Similarities between the two groups were again revealed. For conventional implicatures, the groups did not differ on the number of errors made on any test item, *ps* > .05. The lack of group difference was also found for relevance implicature test items, *ps* > .05, and for metaphor test items, *ps* > .05. This suggests that for conventional implicatures, relevance implicatures, and metaphors, no particular test item was disproportionately harder for children with ASD when compared to TD children (or vice versa). The level of challenge posed by a particular test item was the same for both children with ASD and TD children.

Chapter 4: Discussion

There were two goals of this dissertation. The first was to clarify the relative weaknesses and strengths of children with ASD's pragmatic abilities. While previous studies focusing on individual pragmatic devices suggested that children with ASD show differential impairments (e.g., intact reasoning about scalar implicatures but impaired reasoning about relevance implicatures; Chevailler et al., 2010; de Villiers et al., 2009), it remained an open question as to whether this variability simply reflected heterogeneity of the samples recruited across the different studies or whether it indeed reflected differential pragmatic abilities in children with ASD. To address this question, we examined four different pragmatic devices (i.e., conventional, scalar, and relevance implicatures as well as metaphors) within the same group of children. The second goal concerned investigating potential contributors that enable children to process these individual pragmatic devices. To address this question, we examined to what extent children's performance on the individual pragmatic devices was related to their performance on areas such

as working memory, ToM, general grammatical knowledge, and vocabulary knowledge. We discuss our findings for each of the two goals below.

Variability in pragmatic abilities

For both our TD children and children with ASD, variable performance across the four pragmatic devices was found. TD children performed best on scalar implicatures, followed by relevance implicatures, then conventional implicatures, with poorest performance on metaphors. It should be noted, that despite demonstrating variable performance, the TD children nonetheless performed above chance across the four pragmatic types. This suggests that the TD children do indeed have some knowledge on how these pragmatic types should be interpreted; what varies is how skilled they are in reliably extracting the pragmatic meanings of these devices.

This pattern of findings is consistent with those already reported in the TD developmental literature. In particular, the pragmatic device with which the TD children in the current study demonstrated the best performance, scalar implicatures, has also been found to be one of the earlier implicatures to be acquired (Papafragou & Musolino, 2003). The next pragmatic device that the TD children in the study performed well in was relevance implicatures, which also appear to be acquired relatively early (i.e., by 6 years of age as found in Bernicot et al., 2007). Conventional implicatures and metaphors, which demonstrate more protracted development (Janssens et al., 2015; Rundbald & Annaz, 2010; Winner et al., 1976), were also the two pragmatic devices that the TD children in the current study had the most difficulty with. Thus, our finding of variable pragmatic abilities within the same group of TD children replicates the pattern exhibited across the previous TD literature that have examined the pragmatic devices individually.

For children with ASD, we again see variability; however, this variability was manifested differently from that of the TD children. In particular, the children with ASD, like the TD children, performed best on scalar implicatures. However, in contrast to the TD children, children with ASD's performance on conventional implicatures, relevance implicatures, and metaphors did not differ. It should be noted that we had a relatively small sample for our ASD group and thus may be underpowered given the multiple pairwise comparisons that were performed and controlled for. Examining the general trend in the ASD group's performance nonetheless revealed a different pattern of variability – in particular, we see best performance with scalar implicatures, followed by conventional implicatures, then relevance implicatures, with the poorest performance on metaphors. Additionally, unlike the TD children, the children with ASD performed above chance on all three implicatures but not on metaphors, suggesting a deficit in the latter pragmatic device. Thus, for the ASD group, they appear to have the least difficulty with devices that have been described as having the implicature meaning conventionally encoded (i.e., conventional implicatures) or associated (i.e., scalar implicatures) with its form (Grice, 1989) and the most difficulty with those that might require more sensitivity to speaker knowledge and intention (i.e., relevance implicatures and metaphors).

Not only was variability in the ASD group demonstrated relative to the different pragmatic devices (i.e., within group) but also in the degree of impairment when compared to a subgroup of TD children matched on age and non-verbal IQ (i.e., across group). Once again, children with ASD demonstrated relatively intact abilities to reason about scalar implicatures. In contrast, children with ASD performed more poorly compared to the TD subgroup on conventional implicatures and relevance implicatures. Examining the errors that the children made with these pragmatic devices, we find that the ASD group and TD subgroup exhibited

similar error patterns with conventional and relevance implicatures. These error patterns, together with their above-chance but lower rate of accuracy compared to the TD subgroup, suggest that the children with ASD may not be showing atypical processing of these implicatures. Instead, it appears that they may be simply less reliable or skilled at processing such implicatures. Finally, with metaphors, both groups demonstrated comparable performance; however, there was large variability in performance for both groups. Additionally, while the TD children demonstrated above chance performance, children with ASD's performance did not differ from chance. Examining their errors with this pragmatic device, both groups presented with similar error patterns, with a tendency to select the literal option. Together, this suggests that metaphors are not only disproportionally hard for children with ASD but are difficult for even TD children as well. However, children with ASD may nonetheless have relatively more difficulty with this device.

In sum, both within and across group variability was found in children with ASD's ability to process different pragmatic devices. They appeared to have little trouble interpreting scalar implicatures, consistent with our predictions as well as with what Chevallier et al. (2010) and Su and Su (2015) have previously found (see also Pijnacker et al., 2009 with adults with ASD). On the other hand, they appear to have some difficulties with relevance implicatures, again consistent with our hypotheses and findings from de Villiers et al. (2009).

With metaphors, we had predicted that the children with ASD would demonstrate some difficulty with this pragmatic device but would nonetheless perform above chance (as has been found in Olofson et al., 2014). However, the children with ASD in our study appeared to have the most difficulty with metaphors, as this was the only pragmatic device on which the group performed at chance. There are a few reasons for why our findings might have differed from

Olofson et al. (2014). First, while the children in our study ranged from 7 to 10 years old, the children in Olofson et al. ranged between 7 to 22 years of age, with a mean age of 12 years old. Thus, not only did Olofson et al. investigate a larger age range, their children were, on average, older than those that participated in the current study. As metaphorical processing can undergo a protracted period of development (Vosniadou et al., 1984; Winner et al., 1976), it is not completely surprising, then, that the older children with ASD in Olofson et al. would demonstrate better competency with metaphors than the children with ASD in the current study. Additionally, their task involved additional contextual support (e.g., including a longer story and more images to establish the characters and context), which previously have been found to improve performance on metaphors (Pouscoulous, 2014 for a discussion).[13] Moreover, other studies have reported impairments in metaphorical processing among children with ASD (Happé, 1993; Norbury, 2005; Rundblad & Annaz, 2010). Thus, while our finding was inconsistent with our initial hypothesis and findings from Olofson et al. (2014), it is indeed consistent with other studies in the ASD literature.

Lastly, we found that the children with ASD appeared to also have some difficulty with conventional implicatures. There has yet to be empirical work examining conventional implicatures in this population; however, based on Grice's description of conventional implicatures, which appeared to describe such implicatures as ones that rely more on structural/grammatical knowledge, we had expected children with ASD to demonstrate relatively little, if not the least, difficulty with this type of implicature. This was especially the case given

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[13] In designing the metaphorical task, we had hoped to included more contextual information akin to Olofson et al. (2014). However, we were constrained by the types of metaphors we were investigating (e.g., concrete metaphors in the *NP is NP* form) and by trying to make the task as comparable to the ones investigating the other pragmatic devices as much as possible.

that the ASD group did not differ from the TD subgroup on any of the standardized language measures. This might suggest that interpretations of conventional implicatures may not simply involve grammatical/structural knowledge. Given the limited empirical work (both in the ASD and TD literatures) on conventional implicatures, it is unclear, when examining accuracy alone, why children with ASD would have difficulty with this pragmatic device and what factors beyond grammatical/structural knowledge is responsible for the poorer performance. However, examining our findings on what potentially contributes to the processing of these different pragmatic devices might provide some insight to this question. Thus, we will revisit this issue after the discussion on what skills/knowledge were found to contribute to performance across the different pragmatic devices.

Overall, despite differing in precisely how it was manifested, both TD children and children with ASD demonstrated variability in their pragmatic skills. While potentially not surprising in and of itself, this finding suggests that all pragmatic devices are not made equal. That is, knowledge about one aspect of the social-communicative use of language does not necessarily enable one to engage in all aspects of the social-communicative use of language. What is particularly interesting is that we find variability even within a single pragmatic language type. In particular, we find that the ability to reason about one type of implicature (e.g., scalar implicatures) is not necessarily transferable to other kinds of implicatures (e.g., conventional implicatures). Rather, it appears that different types of implicatures are acquired at piecemeal. This variability within implicatures provides further support to the notion of distinct subcategories within the larger category of implicatures. A question, then, is why is it the case that knowledge about a particular implicature (or more generally a particular pragmatic device)

not transferrable to another? Is it that there are differences across pragmatic devices with regards to the underlying knowledge/skills involved? We turn to this question next.

Contributors to pragmatic reasoning

As presented in Chapter 1, one of our original goals was to examine potential correlates to children with ASD's pragmatic performance. Due to the small sample size, we were limited in the types of analyses we were able to perform with the ASD group. However, the TD group demonstrated enough variability with three of the four pragmatic types and thus, we were nonetheless able to explore the question in the TD sample. We first discuss our preliminary findings with the ASD group followed by a more detailed discussion of findings with the TD group.

Preliminary analyses with the ASD group revealed little relationship between performance on the different pragmatic devices and the different contributors of interest. The only exception was the relationship between metaphorical processing and 2^{nd}-order ToM reasoning. The relationship between ToM and metaphorical processing has been previously found in Happé (1993). However, from Happé (1993), it appeared that 1^{st}-order ToM reasoning was sufficient for children with ASD to succeed on metaphors. In contrast, all of the children with ASD in our current study passed 1^{st}-order ToM tests but nonetheless struggled with metaphors. This divergent pattern of results may be attributed to the differences in the tasks. First, our task included more items (ten compared to five in Happé, 1993). Additionally, while we had a different set of forced-choice options for each story item, participants in Happé (1993) were given a list of six possible responses and asked to use them to complete the five metaphorical sentences. Thus, it was possible for the children to use a process of elimination to match the responses to their appropriate metaphorical utterances. In other words, the task utilized

in the current study may have been more difficult but may nonetheless have been better at assessing children's metaphorical understanding (by limiting test-taking strategies). Our finding is further supported by Norbury (2005), who found that children who passed 1st-order ToM performed poorly on metaphors whereas those who passed 2nd-order ToM tests performed comparable to TD controls. However, as we did not compare the role of semantic knowledge vs. ToM, we were not able to assess whether Norbury's (2005) findings were replicable for the ASD group.[14] Lastly, it should be noted that while we did not find many of the predicted relationships between the pragmatic devices and the different contributors in our ASD group, we caution against interpreting this to mean that those contributors do not play any role in the processing of the different pragmatic devices. Our sample size was small and we were extremely underpowered given the number of relationships we were interested in examining. Future work utilizing a larger sample will be needed in order to better address the question regarding potential contributors of pragmatic reasoning in children with ASD.

We turn next to what was revealed by the analyses focusing on the TD children. With regards to relevance implicatures, we found ToM reasoning, in particular 2nd-order ToM reasoning, to play an important role in TD children's ability to interpret such implicatures. This was consistent to our predictions and findings presented in de Villiers et al. (2009). Additionally, to compare the role of other predictors that might enable processing of other implicatures, working memory and general grammatical knowledge were included as predictors as well. However, we only found general grammatical knowledge (along with ToM) to be a unique predictor of relevance implicature performance. This contrasts somewhat to de Villiers et al.

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[14] Unlike Norbury (2005), we did not find a correlation between performance on metaphors and PPVT-4 scores, although this may again be because we were underpowered.

(2009), as they did not find performance on relevance implicatures to be correlated with verbal IQ. However, it should be noted that the reported correlation between relevance implicature performance and verbal IQ in their study was .60; additionally, it was marginally significant. It is possible that they were underpowered, as they only included 10 children in their analysis, and thus this relationship was not revealed. Regardless, our findings suggest that both general grammatical knowledge and ToM play important and unique roles in TD children's ability to interpret relevance implicatures.

With regards to metaphors, we predicted that both ToM and vocabulary knowledge would correlate with performance on metaphors, with the latter playing a more important role. The pattern exhibited in the TD children was only somewhat consistent with this. More specifically, while we initially did find vocabulary knowledge to be a predictor of children's performance, another model, where working memory was additionally included, revealed only working memory to be a predictor. Moreover, ToM was not revealed as a predictor in either of our models. Our findings somewhat parallel that of Norbury's (2005), in that with the inclusion of vocabulary skill, ToM did not appear to contribute to metaphorical reasoning. However, as Norbury (2005) did not examine the contribution of working memory (in comparison to vocabulary knowledge), it is unclear whether their results would have also paralleled ours as well. We hesitate to interpret this pattern of findings to suggest that vocabulary knowledge is not necessary in metaphorical processing. It seems likely that to successfully extract the feature that is being highlighted between the topic and vehicle in metaphors, one would certainly need to have some knowledge about both the topic and vehicle. However, successfully interpreting metaphors may require more than the individual knowledge about the topic and vehicle; rather, the ability to compare and contrast, to extract the relevant feature(s), which would involve

working memory, may be required in addition to the knowledge about the topic and vehicle. Indeed, working memory has been found to correlate with the interpretation of metaphors in TD adults (Chiappe & Chiappe, 2007). Thus, it is possible that vocabulary knowledge is a necessary but insufficient contributor to metaphorical reasoning, with working memory playing a more important role.

Lastly, with regards to conventional implicatures, we found neither general grammatical knowledge, working memory, nor ToM to predict TD children's performance on such implicatures. The lack of influence from working memory on conventional implicatures is consistent with what has been previously found in both TD children (Janssens et al., 2015) and TD adults (Janssens & Schaeken, 2016). This has been taken as evidence for the automaticity of how conventional implicatures are triggered, in contrast to conversational implicatures which would require the addressee to take into account and compute how an utterance fits with the different conversational maxims (Moeschler, 2012). That is, it has been argued that because of the automaticity of the process (e.g., accessing the contrastive meaning of *but* by default immediately), there is very little working memory involved (Janssens & Schaeken, 2016). What is puzzling, then, is the lack of contribution of general grammatical knowledge to its processing, given that one would think that competency with coordinating conjunctions (which would fall under grammatical knowledge) would be relevant here. As there is very little empirical research on conventional implicatures, we can only speculate as to what other factors might be contributing to TD children's performance with these implicatures. One possibility is that a certain threshold of inhibitory control is needed for success on this particular task. In asking what the character in the story will do next, the participants needed to extract from the conventional implicature (e.g., *I like chocolate but I just ate a big meal*) that the option related to the first

clause (e.g., eat chocolate) should be suppressed or negated in order to arrive at the appropriate answer (e.g., save chocolate for later). As inhibitory control has been found to improve between early childhood (i.e., mean age of 7 years old) and middle childhood (i.e., mean age of 11 years old) (Williams, Ponesse, Schachar, Logan, Tannock, 1999) in TD children, a dearth of inhibitory control may explain the poorer performance exhibited in the current study as well as in Janssens et al. (2015).

Inhibitory control may also be a relevant construct to explain why the children with ASD performed more poorly on conventional implicatures compared to the TD controls. If success on conventional implicatures such as those involving *but* involves inhibitory control, it is possible that the children with ASD's poorer performance may be linked to inhibitory control impairments that have also been reported in this population (Christ, Holt, White, & Green, 2007). That is, it is possible that children with ASD's impairments in inhibitory control may prevent them from suppressing or negating the first clause of the *but* utterance and thus, from selecting the appropriate response. The type of errors that they made with conventional implicatures seems to support this possibility, as they had a preference of incorrectly selecting the response that was the opposite of the implicature meaning (i.e., the response depicting the outcome of the event involved only in the first clause). For example, in the case of *I like chocolate, but I just ate a big meal,* the children with ASD tended to select the option depicting the character eating the chocolate (rather than putting the chocolate away). It is of course possible that the children with ASD were only paying attention to the first clause of the utterance (and thus were choosing the inappropriate response). However, given that they performed at chance for control, non-sensical *but* utterances (demonstrating that they notice the anomaly of such utterances) and performed above chance for test, sensical *but* utterances, it appears that the

children were indeed paying attention to the full utterance and were distinguishing between the two types. The ability to distinguish between non-sensical and sensical *but* utterances together with the pattern of errors that they made with these items suggest that the children with ASD may indeed have some difficulty in suppressing the information presented in the first clause to arrive at the correct response. Future work assessing directly the potential relationship between conventional implicatures and inhibitory control is needed.

It appears, then, that different sets of skills/knowledge are involved in the processing of the different pragmatic types. While ToM appears to be important for devices such as relevance implicatures, it does not appear to play a role for conventional implicatures or metaphors. We did not examine the relationship between ToM and scalar implicatures directly. However, given that children in both groups performed generally well on these implicatures despite showing variable performance on 2^{nd}-order ToM, this would suggest that higher-order ToM may not be necessary for one to extract the pragmatic meaning of such implicatures. However, our study cannot rule out the possibility that 1^{st}-order ToM might nonetheless play a role, as children from both groups all passed 1^{st}-order ToM tasks. In other words, it is possible that TD children and children with ASD demonstrated relatively good performance with scalar implicature because they had already mastered 1^{st}-order ToM. Another possibility is that success on 1^{st}-order ToM and scalar implicatures relies on a shared mechanism but that 1^{st}-order ToM itself has minimal causal effect on scalar implicature processing. Future studies examining a younger age group, where there may be more variability in both 1^{st}-order ToM reasoning and scalar implicature reasoning, are needed to assess these possibilities.

One key point regarding our measure of ToM should be addressed. In particular, the ToM measure used in this study assessed children's knowledge about other's false belief, a common

measure used in the developmental literature (Miller, 2009; Sullivan et al., 1994) as well as in the literature examining children with ASD's pragmatic deficits (e.g., Happé, 1993; Norbury, 2005). However, ToM involves more than false belief reasoning; it can also encompass an individual's knowledge about other's intentions and goals. As such, while we did not find children's false belief reasoning to be related to their reasoning about conventional implicatures, scalar implicatures, nor metaphors, it is possible that these devices do involve other aspects of ToM that was not captured by our measure here.

For example, on the surface, conventional implicatures should rely more heavily on structural language knowledge than knowledge about the speaker's intention in comparison to conversational implicatures. However, we did not find success on such implicatures to be related to children's structural language knowledge. While we have speculated lower-level processing deficits (e.g., inhibitory control) as a potential contributor to the poorer performance of conventional implicature in both TD children and children with ASD, it is the nonetheless possible that an aspect of ToM, not captured here by the false belief tests, was playing a role. The lack of relationship between children's processing of conventional implicatures and their structural language knowledge might have hinted at the possibility that conventional implicatures do require more ToM knowledge than initially thought. In particular, conventional implicatures may still require some knowledge about the speaker's intention/goal – information that is not made available in the linguistic signal alone. For example, in the instance of using *but* in *I'll love to have dessert* ***but*** *I just ate a big meal*, one may nonetheless need some knowledge about the speaker's intention in highlighting that there is a contrast between one's love for dessert and one being full after eating a big meal. The speaker may be trying to use this contrast with the goal of indicating to the hearer that due to this incompatibility, s/he will not be partaking in dessert. In

other words, processing of conventional implicatures may require knowledge about the speaker's purpose in highlighting the contrast. This type of ToM knowledge may not have been captured in the measure that was used in the study and thus, ToM was not revealed to be a contributor.

An analogous argument could be made for scalar implicatures, which have features in common with conventional implicatures (i.e., implicature involves a lexicalized or associated form/construction). To process scalar implicatures, one might require knowledge about the speaker's goal/aim in using a particular construction/form (e.g., using *some* to highlight *some but not all*). Similar to conventional implicatures, it did not appear that scalar implicatures were influenced by the children's (false belief) ToM skills. However, if it is the case that both conventional implicatures and scalar implicatures involve a component of ToM not captured by the measures used in the current study – namely a speaker's goal/aim – we might have expected performance on the two implicature types to be comparable. If lack of knowledge regarding speaker goal/aim was contributing to the poorer performance on conventional implicatures, then we should expect it to contribute to poor performance on scalar implicatures as well. We did not find this to be the case – rather, scalar implicatures appeared to be relatively easy for both TD children and children with ASD to interpret. While it could be argued that conventional implicatures do indeed involve some form of ToM that was simply not captured in our study, such arguments will also need to account for the relative ease children have with scalar implicatures.

The role of working memory, as operationalized by the CELF-5 Recalling Sentences task, also appeared to differ across pragmatic devices. It appears to be important for metaphors but less so for conventional implicatures and relevance implicatures. Variable working memory but relatively little variable scalar implicature performance again hints that working memory

may not play a vital role in the processing of this latter type of implicature. Some caution should be taken however. While the CELF-5 Recalling Sentence task is sensitive to correctly identifying clinical populations, it is less specific in its ability to detect variations within the typical population. It is possible that variations in working memory do in fact play a role on scalar implicatures but such variations were simply not capture by the task. Future work should utilize a working memory measure that captures variations in both typical and atypical populations.

The lack of contribution from working memory on the processing of relevance implicatures, in particular, was somewhat surprising. Under the Gricen view, such implicatures, in contrast to conventional implicatures where the implicature arises by default, need to be worked out by the hearer. The hearer will need to reason that in order for an utterance such as *You already did all your chores* (in response to *Can I go out and play*?) to satisfy the conversational maxims (i.e., relation), the speaker must have intended something beyond what has been explicitly said. The hearer might then try to determine what that additional, relevant intended speaker meaning might be (e.g., that one can indeed go and play). If it is indeed the case that relevance implicatures need to be worked out in such a manner (e.g., multiple-step process that involves coordinating between speaker's intentions with what s/he explicitly said, while searching for additional interpretations, etc.), then one might predict working memory to play a role, which was not found. It is possible that working memory is involved but the working memory load involved is relatively small or not particularly taxing (i.e., a working memory load that can be easily handled by the children) and thus its relationship with relevance implicatures was not revealed in the study. In contrast, metaphors were found to be predicted by working memory. Under the Gricean view, the interpretation of metaphors involves similar steps as other implicatures. Therefore, it might be puzzling as to why one type of pragmatic device was found

to be predicted by working memory while another was not. It should be noted that interpreting metaphors also requires the hearer to compare and contrast the topic and vehicle simultaneously while searching for the particular feature(s) that the speaker may be highlighting. This may involve a more working memory taxing process compared to the process involved with relevance implicatures – thus, explaining why we found working memory to contribute to the processing of metaphors but not relevance implicatures. This of course remains speculative as Grice's original description of implicatures was not meant to be a *cognitive* description of how hearers come to interpret these pragmatic devices. Additional work examining how the manipulation of working memory load impacts relevance implicatures vs. metaphors is needed. Performance on the CELF-5 Recalling Sentences involves some language competency as well thereby making it difficult to distinguish the unique roles of language and working memory. Manipulating both verbal working memory and non-verbal working memory in future work will better illuminate their relative roles for relevance implicatures and metaphors. Further work should also aim to uncover and make explicit the cognitive steps involved in the processing of each of these pragmatic types in order to better understand the role of working memory relative to these devices.

We expected language ability to play some role in each of these pragmatic devices as individuals would of course need to first have sufficient linguistic knowledge to decode the linguistic signal in order to then be able to extract the additional speaker meaning. What we were particularly interested in, though, was whether more specific language skills could sufficiently support some types of pragmatic reasoning when compared to other potential contributors. This does not appear to have been borne out. Out of the four pragmatic devices, we had hypothesized that conventional implicatures would be the one that would be most likely supported by just

linguistic structural knowledge. We did not find general grammatical skill to be a significant predictor for success with these implicatures. While vocabulary knowledge was found to play a role in metaphorical processing, it was not sufficient to support success on these items as working memory appeared to play a more important role. Similarly, general grammatical knowledge was not the only predictor of performance on relevance implicatures as we also found ToM to be a predictor. This suggests again that language skill in and of itself does not enable successful pragmatic reasoning of this type. Rather, *both* general grammatical knowledge and ToM together appear to be important for the processing of relevance implicatures. For now, it remains unclear what the exact nature of general grammatical language's contribution is (beyond the decoding of the linguistic stimuli). It could be that general grammatical language is a tool that aids in one's ability to track the different steps involved when reasoning about relevance implicatures. It should also be noted that general grammatical knowledge was measured via the CELF-5 Formulated Sentences subtest. In this task, children were asked to describe a picture when given a word. While early items involve relatively direct links between the word (e.g., *washing*) and the picture (e.g., an image depicting a girl by the sink washing her hands), the relationship between the provided word and picture becomes somewhat more opaque in the later items (e.g., the word *until* with a corresponding image depicting a girl doing her homework while her baseball teammates wait by the door) and may require the children to make more gap-filling inferences (e.g., the teammates are waiting for girl to finish her homework → implies that girl cannot leave for baseball practice unless she is done with her homework → generate a sentence such as *Until she finishes her homework, she can't go to baseball practice*). It is possible that it is this ability to make these appropriate gap-filling inferences, as captured by the CELF-5 Formulated Sentences score, that is related to success on relevance implicature and not

necessarily grammatical knowledge per se. Work that directly assesses the role of inferencing abilities vs. grammatical knowledge will be needed to evaluate this hypothesis.

Summary and implications

In sum, we found that both TD children and children with ASD demonstrated variable ability in their pragmatic reasoning, with scalar implicatures appearing to be easiest to interpret and metaphors being the hardest. This replicates the variability that has been found in the literature focusing on the individual pragmatic types. Moreover, we found that the different devices appear to rely on a different set of skills/knowledge, which may explain the pattern of variability that we see in the children with ASD. While the findings regarding contributors came mostly from the TD children's data, if we were to look at the set of findings pertaining to the contributors as a whole, it would appear that the pragmatic devices that children with ASD had the most difficulty with (i.e., relevance implicatures and metaphors) were also ones that appear to involve ToM, an area that is commonly reported to be impaired in ASD (Baron-Cohen, 1989; Bowler, 1992; Ozonoff, Pennington, & Rogers, 1991). What about TD children, who showed less skill with conventional implicatures and metaphors? We speculate that, here, the variability found in TD children is less driven by social-cognitive factors such as ToM but rather by lower level processing factors such as working memory (which has been found to predict metaphors) and inhibitory control (which we consider as potentially relevant for success on conventional implicatures involving *but*). Our findings suggest that the variability exhibited by TD children and children with ASD arise from different sources. However, we were only able to investigate contributors in the TD children and could not, because of low power, compare directly whether the same contributors found in the TD children were also found in the ASD children. Additional

work directly comparing the contributors of TD children vs. children with ASD's pragmatic reasoning is still needed.

Together these findings suggest that "pragmatics" should not be thought of as a monolith and certainly, children do not acquire pragmatics in such a way. While we describe pragmatics broadly as how language is used in communication, there are many different aspects involved. In the context of our study, knowledge that people can intend more than what they explicitly state or that both speaker and hearer will make contributions that only further the goal of the conversation may not be sufficient for one to succeed on all types of implicatures. Instead, children need to also sufficiently acquire the sets of skills/knowledge specific to the different implicature types. In other words, it does not appear that there is one uniform "implicature" process – rather, how an implicature is interpreted will differ by type and the process may be made of different pieces of cognition (e.g., ToM and general language abilities for relevance implicatures). Our findings also suggest that we should not view pragmatics to be uniformly impaired in children with ASD. They indeed appear to show some skill with certain types of pragmatic language (e.g., scalar implicatures). This variability in pragmatic deficits further supports the notion that the ability to understand and engage in the pragmatic use of language is not simply an all or nothing process.

In trying to address our two questions, we also gained some insight into the field of pragmatics more broadly. In particular, the variability in performance and the different role contributors play across the pragmatic devices together support the idea that there are indeed distinct pragmatic types. Metaphors, more specifically, appear to be distinct from implicatures. Both TD children and children with ASD demonstrated difficulty with this pragmatic device but what was particularly interesting was that this was the only pragmatic type in which the children

with ASD performed at chance. The notion that metaphors are distinct from the other implicatures differs from Grice's (1989) description of figurative language as a type of implicature that arises from the quality maxim. It is of course possible that metaphors are indeed quality implicatures and that quality implicatures are for some reason harder than the other implicature types to interpret, thus explaining the difficulty children had with metaphors. To assess this possibility, future work comparing performance on metaphors and other quality implicatures is needed as we did not investigate the latter in the current study.

The relative ease that both groups of children showed with scalar implicatures in comparison to relevance implicatures, in conjunction with the difference that ToM appears to play between the two implicatures, further supports the argument of there being two subcategories of implicatures (i.e., generalized vs. particularized) within the larger category of conversational implicatures. Recall that generalized conversational implicatures, such as scalar implicatures, involve implicatures that are typically associated with a form/construction (e.g., use of *some* is often associated with the implicature *some but not all*). In contrast, particularized conversational implicatures, such as relevance implicatures, do not involve any form/construction from which they are associated with; rather, they depend heavily on the features of the context/discourse and knowledge regarding speaker knowledge and intention. This distinction between generalized vs. particularized implicatures appear to be supported by our findings. In particular, ToM contributed to the processing of relevance implicatures but less so for scalar implicatures, paralleling the description which suggests that different amounts of speaker knowledge/intention are involved between these two types of implicatures. Additionally, given the more lexical nature of generalized conversational implicatures, we might predict that accessing such implicatures should be easier than accessing particularized conversational

implicatures. That is, the interpretation of the former type may be more directly accessible (e.g., retrieve the implicature associated with the form) compared to the latter type (e.g., integrate contextual information and speaker knowledge to determine the implicature interpretation). Again, this was borne out in our findings. Both TD children and children with ASD had little difficulty interpreting scalar implicatures in comparison to relevance implicatures, providing further support for the notion that there are two subcategories of implicatures within the category of conversational implicatures.

What remains puzzling, however, is the nature of conventional implicatures and why they appeared to be more difficult to interpret compared to conversational implicatures. We presented some speculation for why children might perform more poorly on these implicatures, largely speculating lower level processing deficits (e.g., inhibitory control) as a contributor. We also considered the possibility that conventional implicatures require a different aspect of ToM that was not assessed in the study; however, we also noted that such an argument would require the consideration and elaboration on the difference in performance found between scalar and conventional implicatures. As our study is one of the very few that have examined conventional implicatures, additional work is needed to clarify the source for children's difficulty with these implicatures as well as what factors enable children to process them.

In general, our findings on relevance and scalar implicatures are consistent with Grice's (1989) descriptions of these implicatures. We provide empirical support for the notion that within conversational implicatures, there appears to be further subtypes that rely on different types of knowledge and differ on the ease to which they can be readily interpreted. On the other hand, open questions regarding to what extent metaphors and conventional implicatures fit with their theoretical descriptions remain.

Limitations and open questions

While we were able to address our two aims in this study, there were also limitations that should be investigated in future research. First, the sample size for our ASD group was small. We were limited in the type of analyses we were able to perform that would have helped inform some of our questions. The small sample size also meant that we were underpowered for the analyses that we were able to conduct. Thus, we should be somewhat cautious regarding the null results found within this group. Future work involving a larger group of children with ASD will better help address and clarify our research questions.

Second, there were some methodological limitations. While we tried to minimize task differences across the different pragmatic devices, there inevitability were some variations across the tasks. For example, conventional and relevance implicatures were assessed with individual story items (e.g., each *but* utterance involved their own separate story context). In contrast, each scalar implicature was not assessed by an individual story but rather fell into one of five larger, overarching stories (i.e., for each story, two scalar implicature, filler, and control items were assessed). The conventional and relevance implicature tasks required the children to adopt knowledge about the context more often than the scalar implicature task. This may have made the former two tasks more cognitively demanding than the latter task and we indeed find that for both groups, children had less difficulty with scalar implicatures compared to conventional and relevance implicatures. We are unable to completely rule out the possibility that the variability in performance found across the different tasks resulted from the differences in the tasks. As the TD children and children with ASD demonstrated somewhat different patterns of variability, this suggests to us that at least some part of the variability is not explained by simple cross-task differences. If the variability is driven solely by task differences, we might have expected that

children with ASD to demonstrate a similar pattern of variability to the TD children, which was not the case.

Another methodological limitation was that the overall pragmatic task was blocked without counterbalancing the individual blocks.[15] As the metaphorical block was presented last, it is arguable that fatigue rather than inherent difficulty with metaphors lead to children's poorer performance on this task. It should be noted that children generally performed well on the literal controls, which were presented after the metaphorical items, suggesting that poorer performance cannot be completely accounted for by fatigue effects. Future work may try to target fewer pragmatic types such that more comparable tasks could be designed and implemented; additionally, counter-balancing the different tasks should also be incorporated into the overall design.

Lastly, we have only begun to investigate some of the contributors that enable children to reason about the different pragmatic devices. Investigations concerning how other contributors, such as inhibitory control and potentially other executive functioning skills, might influence implicature understanding will be needed in future work. This may help clarify to what extent reasoning about different pragmatic devices involves social-communicative functions as well as more low-level processes. Additionally, while we have identified some contributors, it remains an open question as to how these contributors come together to allow children to reason about pragmatics. Thus, future work should examine additional contributors as well as the time course to which these contributors come to play during the processing of these devices.

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[15] This was originally designed as to way to ensure that we were able to capture the best eye-tracking data (in case there was fatigue for later tasks) for those implicatures we had particular hypotheses regarding the time-course in how they might be processed online.

In conclusion, our study demonstrated that the variability in pragmatic abilities found previously across samples in the TD and ASD literature is similarly found within individuals as well. Moreover, we were able to bring novel insight to the pragmatics literature by not only revealing what might contribute to individuals' ability to reason about pragmatics but also by showing that different pragmatic devices require different sets of skills/knowledge. These findings inform the ASD literature by demonstrating that pragmatic impairments are indeed not universal and by revealing what might be the underlying sources responsible for the particular pragmatic difficulties they do demonstrate. These findings also inform the developmental literature by demonstrating that pragmatics is not acquired as a whole but rather at piecemeal. Different pragmatic devices undergo different developmental trajectories and how these trajectories proceed may depend on the development of the different knowledge/skills involved for the particular pragmatic device. Lastly, these findings inform the pragmatics literature more broadly by demonstrating some empirical support for how traditionally these pragmatic devices are thought to be defined and organized.

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