Making inferences from text: it's vocabulary that matters

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KEYWORDS:
autism spectrum disorder, language impairment, text comprehension, inferencing, reading

WORD COUNT: 4973 (excluding references)

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Abstract

Purpose: Many children with communication disorders have reading comprehension difficulties, and in order to target interventions effectively it is important to identify which specific components of comprehension are especially challenging. The current study explored the relationship between text inferencing skill, autistic symptomatology and language phenotype.

Method: Typically developing children (*n*=32), children with autism spectrum disorders (ASD) and age-appropriate structural language skills (ALN; *n*=27), children with ASD and language impairment (*n*=15) and non-autistic children with language impairment (*n*=12) were administered the Neale Analysis of Reading Ability and responses to literal and inferential questions were analyzed.

Results: For the sample as a whole, inferencing competence was predicted by oral language skill, with autistic symptomatology not contributing significant variance. However, whilst only 12.5% of typically developing children found answering inferential questions disproportionally challenging relative to answering literal questions, one third of children with ALN demonstrated inferencing deficits, as did over 50% of children with language impairments, regardless of ASD status.

Conclusion: These results indicate that children with language impairments are most likely to find inferencing challenging, but practitioners will also need to monitor the inferencing skills of children with ASD and good language and single word reading skills.

Introduction

Literacy competence is essential for academic success (Hernandez, 2012); it is therefore cause for concern that many children with developmental disorders struggle to understand the meaning of connected text (Brown, Oram-Cardy, & Johnson, 2013; Ricketts, 2011). The Simple View of Reading (Gough & Tunmer, 1986) posits that both decoding skill and oral language abilities such as grammar and vocabulary predict reading comprehension skills for typically developing children. This model has also been successfully applied to children with Autism Spectrum Disorder (ASD) and Language Impairment (Brown et al., 2013; Ricketts, 2011). Pragmatic language skills, such as inferential understanding may also make a significant contribution for typically developing (TD) children, with inferencing skill predicting concurrent (Cain, Oakhill, & Bryant, 2004) and future reading comprehension (Oakhill & Cain, 2012), even after word reading, vocabulary knowledge, and cognitive ability have been taken into account. Little is currently known about the contribution of these skills for children with developmental disorders and this is a particularly pertinent question to the study of reading comprehension in ASD. Children with ASD vary significantly with respect to core language (grammar and vocabulary) and pragmatic language abilities. According to the Simple View, comprehension should be particularly impaired in children with ASD who also experience language impairment (the ALI phenotype, Tager-Flusberg & Joseph, 2003). The extent to which children with ASD and the ‘language normal’ (ALN) phenotype experience comprehension deficits may be determined by inferencing abilities. The present study explores the variation within ASD, relative to typical peers and peers with language impairment but not ASD, to answer both literal and inferential text comprehension questions. This participant design elucidates the role of both autistic symptomatology and language phenotype in inferencing and text comprehension.

Inferencing Deficits in Children with Language Impairment

Language impairment (LI) is characterised by persistent difficulty in the acquisition and use of spoken, written or signed language, evidenced by a reduced vocabulary, limited sentence structure and impairments in discourse (American Psychological Association, APA, 2013). There is an intimate relationship between language and literacy competence; around 50% of children with LI have impaired reading comprehension, with 15% demonstrating a ‘poor comprehender’ profile (Catts, Fey, Tomblin, & Zhang, 2002) in which reading comprehension lags behind age-appropriate word recognition.

However, the role of inferencing in comprehension difficulties is currently unknown. To date, no research has explored the ability of children with LI to make inferences from text. Instead, investigations focus on inferencing in the oral domain, with conflicting findings. Some studies report that children with language impairment struggle with both literal and inferential questions (Adams, Clarke, & Haynes, 2009; Bishop & Adams, 1992; Ellis Weismer, 1985), whilst others indicate a selective problem with inferencing (Crais & Chapman, 1987; Dodwell & Bavin, 2008; Karasinski & Weismer, 2010).

The contrasting findings may be attributable to participant characteristics. Norbury and Bishop (2002) investigated story comprehension and at a group level, the TD and LI samples did not differ in terms of literal and inferential question response accuracy. However, examination of individual data revealed that 25% of the children with LI had a disproportionate difficulty with inferencing, compared to only 11% of the control children. Error analysis revealed that those who were poor at inferencing frequently did attempt to make an inference, but that the inference made was not relevant to the surrounding linguistic context.

These data raise the question of *why* children with LI experience such difficulties. Silva and Cain (2014) assessed the picture book comprehension of 82 typically developing children aged 4-6. Both literal and inferential question response accuracy were correlated with receptive vocabulary and grammar knowledge, whilst only inferencing skill correlated with verbal working memory. In regression analysis, vocabulary knowledge was the sole predictor of both literal and inferential understanding, accounting for 8-10% of variance once age and non-verbal cognitive ability were accounted for. Likewise for adults, both vocabulary knowledge and working memory facilitate reading of a sentence which requires inferencing for comprehension (Calvo, 2004). These factors are influential as understanding of individual words is essential for comprehending connected text and will facilitate activation of associated linguistic representations, whilst working memory will assist integration of the information required to construct the inference. For example, in order to understand the phrase “He pedalled to school”, it is necessary to know that ‘pedalling’ is the movement which powers a bicycle. As vocabulary and working memory deficits are often present for children with LI (APA, 2013; Leonard et al., 2007), it is not surprising that children with LI experience impairments in literal and inferential comprehension. Such deficits may be even more pronounced in text comprehension, where decoding of text places additional cognitive demands on the processing system.

Inferencing Deficits in Children with Autism spectrum disorder

Autism spectrum disorder (ASD) is a pervasive developmental disorder characterised by impairments in social interaction and communication, plus a restricted repertoire of interests and behaviours (APA, 2013). The cognitive, linguistic and reading profiles of children with ASD vary dramatically (Nation, Clarke, Wright, & Williams, 2006) however, approximately 30% of children with ASD demonstrate a poor comprehender reading profile (Huemer & Mann, 2010; Jones et al., 2009; Nation et al., 2006). Inferencing deficits may be underpinned by theory of mind deficiencies, which may limit the ability to make inferences relating to the internal states that motivate fictional characters' behaviour. Indeed, for individuals with ASD, comprehension is poorer for texts with greater social demands (Brown et al., 2013), although mentalizing competency only contributes around 2-5% of variance in reading comprehension once language competence has been accounted for (Ricketts, Jones, Happé, & Charman, 2013).

Saldaña and Frith (2007) assessed competency making bridging inferencing, or inferences which establish connections between clauses, in this case, antecedent and outcome events. Participants read aloud a two-sentence vignette followed by a question, which was either primed by generating an inference from the preceding sentences or un-primed. The primed questions were read faster by the ASD adolescents (mean age = 14;9) and their TD peers, suggesting that both groups were activating the knowledge necessary to make the bridging inference. However, there was large variability in the ASD participants' receptive vocabulary (standard score range = 53-147), so it is uncertain whether *all* adolescents were effectively making inferences, or whether the group mean masked the difficulties of the participants with poorer language skills.

Given the relationship between inferencing skill and oral language ability for non-autistic populations, it is important that studies with ASD participants acknowledge oral language competence. This is especially pertinent considering the heterogeneity of language skill within ASD; whilst some children have deficits in receptive and expressive language, grammatical knowledge and phonological processing, others have linguistic abilities greater than age-expectations (Hus, Pickles, Cook, Risi, & Lord, 2007; Wodka, Mathy, & Kalb, 2013). These two core language phenotypes within ASD (Kjelgaard &

Tager-Flusberg, 2001) are described as language impaired (ALI; Autism, Language Impaired) and age-appropriate structural language skills (ALN; Autism, Language Normal).

Norbury and Nation (2011) explicitly assessed the influence of language phenotypes within ASD on text comprehension. Both the adolescents with ALN and those with ALI correctly answered a similar number of literal questions as their TD peers. However, the ALI group were less accurate than their peers when answering inferential questions, demonstrating a disproportionate difficulty with inferencing. The three groups were matched for non-verbal cognitive ability, and the two ASD groups did not differ in terms of symptomatology. Therefore, perhaps for children with ALN, proficient language skills offer a protective mechanism and reduce the impact of social deficits. Oral language comprehension predicted the greatest variance in inferencing competence (31.7%), with ASD status predicting only 10% of additional variance.

A similar result was reported by Jolliffe and Baron-Cohen (1999) who assessed the ability of adults with ASD to make bridging inferences. Participants read aloud a pair of sentences, the first of which described a situation and the other the outcome. They then identified the coherent connecting sentence from a choice of three. Adults with ASD were significantly less accurate than their non-autistic peers. However, adults with ASD and a history of language delay achieved significantly lower scores than adults with Asperger's syndrome, who did not have a delay in early language development (despite having similar non-verbal cognitive ability). Thus, individuals with ASD are more likely than their TD peers to find inferencing challenging and individuals with ALI may be particularly vulnerable to inferencing deficits.

Thus, research evidence suggests that individuals with developmental disorders such as LI and ASD may find inferencing more difficult than their TD peers. Yet notably studies investigating inferencing in ASD have only included typically developing peers as a comparison group (rather than peers with a different neurodevelopmental disorder), despite the parallel in the difficulties experienced by children with ALI and LI (Kjelgaard & Tager-Flusberg, 2001), including with regards to reading comprehension impairments (cf. Ricketts, 2011). It is therefore possible that the impairments of both groups are underpinned by deficits in inferencing and that these deficits are of similar severity. If so, similar intervention strategies may benefit both populations.

Additionally, previous studies have focused exclusively on adolescents and adults, who may use language to compensate for social cognitive challenges, obscuring the impact of ASD symptomatology. Thus inferencing difficulties may be especially evident for children with ASD, as literacy, language and social skills have yet to become established. Alternatively, inferencing difficulties for individuals with ASD may only emerge once task demands exceed resources, therefore children who read shorter and less complex texts will not find inferencing so challenging. Hence, the participants included in the current study were younger than those in previous research and ranged in age from 7-12 years.

The Current Study

The current study aimed to explore the influence of both autistic symptomatology and language phenotype on literal and inferential text comprehension. This was accomplished by compared the text comprehension of four groups of participants; children with ASD with and without language impairment (ALI and ALN) and non-autistic children with and without language impairment (LI and TD). Previous research has indicated that difficulties using linguistic context to resolve lexical ambiguities align with language status, rather than autistic symptomatology (Norbury & Nation, 2011). We therefore predicted that, as a group, children with ALN would have similar inferencing skills to their TD peers, whilst children with ALI and LI would not only be poorer at inferencing, but have a disproportionate difficulty answering inferential relative to literal questions. We therefore also predicted that whilst semantic knowledge (as indexed by vocabulary knowledge) and verbal working memory (as indexed by sentence repetition competence) would be significant predictors of inferencing skill, autistic symptomatology would not contribute significant variance.

Method

Participants

Ninety-eight children aged 7-12 years were recruited to the study. The protocol was approved by the Research Ethics Committee at XXX; informed, written consent was provided by all parents and verbal assent was obtained from all children.

Children with ASD (ALN n = 27, ALI n = 20) held an existing diagnosis based on DSM-IV/ICD-10 criteria from a multi-disciplinary team external to the research group and were currently in receipt of a statement of special educational need (SEN) for placement in a specialist school or unit serving children with ASD. They also met diagnostic criteria on the relevant module of the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). Autistic symptomatology was assessed for all children in the study via parental completion of the Social Communication Questionnaire (SCQ; Rutter, Bailey & Lord, 2003). Non-autistic children with LI (*n* = 19) all held an existing diagnosis of Language Impairment, had a statement of SEN and were receiving full-time special educational support. Children with ALI and LI also obtained a scaled score of six or less (10th percentile) on the Recalling Sentences subtest of the Clinical Evaluation of Language Fundamentals (CELF-4UK; Semel, Wiig, & Secord, 2003), a sensitive diagnostic marker of language impairment in both autistic and non-autistic populations (Botting & Conti-Ramsden, 2003; Conti-Ramsden, Botting, & Faragher, 2001; Riches, Loucas, Charman, Simonoff, & Baird, 2010) and a measure of verbal working memory. TD peers (*n* = 32) were recruited from local schools and did not have any reported special educational needs, nor a history of ASD or language delay.

Cognitive abilities were assessed through the Matrix Reasoning sub-test (non-verbal IQ) and the Vocabulary subtest (verbal IQ) of the Wechsler Abbreviated Scales of Intelligence (WASI; Weschler, 1999). Vocabulary knowledge was measured using the Expressive One-Word Picture Vocabulary Test (Gardner, 1990a), a picture naming task, and the Receptive One-Word Picture Vocabulary Test (Gardner, 1990b), a spoken word to picture matching task. Single word reading ability was assessed using the sight word efficiency (SWE) and phonemic decoding efficiency (PDE) subtests of the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner & Rashotte, 1999). Passage reading accuracy was assessed through the Neale Analysis of Reading Ability (NARA-II; Neale, 1997). In order to ensure that all children had sufficient reading skill for both literal and inferential comprehension to be assessed, inclusion criteria stipulated that participants must be able to read the second passage of the NARA-II with fewer than 16 word-reading errors. Five children with ALI and seven children with LI were unable to do so, reducing the sample sizes for these groups (ALI: *n*= 15, LI: *n*= 12).

All four groups were matched for chronological age (see Table 1). However, the TD and LI groups included a higher percentage of girls than the ASD groups. To ensure this did not influence task performance potential gender differences were explored. For the TD group, there were no sex differences in the baseline characteristics of age, cognitive ability, language ability, reading accuracy or SCQ score (all $t < 1.10$, $p > .150$). There were also no sex differences in these measures for the LI sample (all $t < .90$, $p > .375$).

The TD and ALN groups were matched on the cognitive, language and reading measures. As expected, both language impaired groups had significantly lower language and reading scores than the non-language impaired groups, but did not differ from one another. This is consistent with previous research indicating that the impairments in structural language abilities of children with ALI are akin to those of non-autistic children with LI (Kjelgaard & Tager-Flusberg, 2001; Loucas et al., 2008). Similar to other studies, we also found that non-verbal and verbal abilities were highly correlated (cf. Conti-Ramsden, St. Clair, Pickles & Durkin, 2012), such that children with ALI and LI tended to have lower non-verbal ability scores (cf. Dennis, Francis, Cirino, Schachar, Barnes & Fletcher, 2009). The ALN and ALI groups did not differ on two measures of autistic symptomatology, the SCQ and the ADOS, whilst the non-autistic groups attained significantly lower scores.

*****INSERT TABLE 1 HERE *****

Materials and procedure

Passage comprehension was assessed using Form 2 of the NARA-II (Neale, 1997). Participants completed a practice passage to familiarise them with the assessment and then began formal testing. For children in the early stages of reading testing began at passage 2, whereas more competent readers began at passage 3 (to avoid fatigue effects) and received full credit for the passage 2 comprehension questions. The 40 questions from passages 2-6 of the NARA were analyzed by the two authors to identify literal and inferential questions. Questions were categorised as literal if they could be answered by the child recalling information that was explicitly mentioned in the text. In contrast, if the question could only be answered by drawing an inference about something that had not been directly stated, then it was categorised as inferential. This resulted in a total of 26 literal questions and 14 inferential questions. Participants completed the test battery over two 1 hour sessions in a quiet room at their school.

Results

Passage Reading Ability

To determine whether the four groups of participants were of similar passage reading ability, four one-way ANOVAs were conducted (Table 2). For both passage complexity and the number of questions administered there was a significant main effect of Group, with post-hoc analysis determining that the TD and ALN groups (who did not differ) read more complex passages and attempted more questions than the ALI and LI groups (who did not differ). Accordingly there were significant group differences in NARA accuracy and comprehension standard scores, with the TD and ALN groups attaining significantly higher scores than their ALI and LI peers. Thus, across the reading measures the two non-language impaired groups did not differ, but attained significantly higher scores than the two language impaired groups, who did not differ.

*****INSERT TABLE 2 HERE *****

Literal and Inferential Understanding

To account for individual differences in the number of comprehension questions administered and for the different number of literal and inferential questions, the raw accuracy scores were transformed into a percentage of the total questions administered for each question type. As the TD and ALN groups were of similar reading accuracy and comprehension ability they were compared to determine whether there were any differences in comprehension relating to question type. A 2 (group; TD vs ALN) x 2 (question type; literal vs. inferential) repeated measures ANOVA was conducted on percentage accuracy scores. As illustrated by Figure 1, there was a main effect of Condition, $F(1, 57) = 19.98$, $p < .001$, $\eta_p^2 = .26$, with literal questions answered more accurately than inferential questions. However, there was not a main effect of Group, $F(1, 57) = .01$. $p = .932$, nor was there a Condition x Group interaction, $F(1, 57) = .70$, $p = .408$.

Likewise, the LI and ALI groups attained similar reading scores, so a 2 (group) x 2 (question type) repeated measures ANOVA was conducted on these groups' percentage accuracy scores. As illustrated by Figure 1, there was a main effect of Condition, $F(1, 25) = 16.77$, $p < .001$, $\eta_p^2 = .40$, with literal questions answered more accurately than inferential questions. In addition, there was a main effect of Group, $F(1, 25) = 5.08$, $p = .033$, $\eta_p^2 = .17$; the ALI children answered fewer questions accurately relative to their LI peers. However, there was not a Condition x Group interaction, $F(1, 25) = .75$, $p = .394$.

*****INSERT FIGURE 1 HERE *****

To investigate which factors predict inferencing skill simultaneous multiple regression analysis was conducted. Six predictor variables were entered into the model: chronological age, WASI matrix reasoning raw score (non-verbal IQ), vocabulary knowledge, CELF recalling sentences (as an index of verbal working), single word reading accuracy and SCQ score (as an index of ASD symptomatology). The strong correlation between expressive and receptive vocabulary raw scores ($r = .87$, $p < .001$) justified the use of a vocabulary composite (created by averaging the two raw scores). Likewise, the correlation between TOWRE SWE and PDE raw scores ($r = .78$, $p < .001$) justified the use of a single word reading composite (created by averaging the two raw scores). The total model was significant, $F(6, 59) = 12.64$, $p < .001$, and explained 51.80% of the variance in the percentage of inferential questions correctly answered. Both vocabulary knowledge and verbal working were significant predictors of inferencing competence, whilst age, non-verbal IQ, single word reading ability and SCQ score did not contribute significant variance (see Table 3).

*****INSERT TABLE 3 HERE *****

Inferencing Deficits

Figure 1 indicates that children within the language impaired groups may have a disproportionate difficulty with inferencing, which is not so evident for the non-language impaired children. To explore this further an ‘inferencing ability’ score was created by dividing the percentage of correct inferential answers by the percentage of correct literal answers (cf. Norbury & Bishop, 2002). A score of 1 indicates that the child answered inferential questions as accurately as literal questions. The TD group achieved a mean inferencing ability score of .91, with a SD of .19. Thus, scores falling below .72 were >1SD from the TD mean and considered to be indicative of a disproportionate difficulty with inferencing.

Four TD children (12.50%) scored below this level, relative to 33.33% (*n* = 9) of children with ALN, 53.33% (*n* = 8) of children with ALI and 58.33% (*n* = 7) of children with LI. Chi square analysis determined the non-autistic (TD+LI) and autistic (ALN+ALI) groups did not differ, χ^2 (1, N=86) = 1.69, *p* = .193. However, the children with language impairment (LI+ALI) were significantly more likely than their peers without language impairment (TD+ALN) to have a specific difficulty with inferencing, χ^2 (1, N=86) = 8.01, *p* = .005.

Discussion

This study investigated the extent to which autistic symptomatology and language competence contribute to text inferencing competence. Uniquely we compared the inferencing skills of children with ASD and different language phenotypes to both typically developing peers and non-autistic peers with language impairment. This enabled us to determine whether there were similar sources of reading comprehension deficits across developmental disorders. The key finding is that the greatest predictor of inferencing skill was verbal skill, although children in all three clinical groups were more likely than their TD peers to experience specific deficits in inferencing.

Does Inferencing Skill Align with Language Ability or ASD Diagnosis?

Previous research indicates that both adolescents and adults with ASD have difficulty making inferences from connected text and that inferencing is particularly challenging for individuals with ASD and concomitant language difficulties (Jolliffe & Baron-Cohen, 1999; Norbury & Nation, 2011). We found that this was also the case for *children* with ASD; those with ALI found inferencing more challenging than their TD and ALN peers. Furthermore, whilst both vocabulary knowledge and verbal working memory accounted for variance in inferencing skill, autistic symptomology was not a significant predictor. However, before concluding that autistic symptomatology is not associated with inferencing skill it is important to consider the individual-level data. Whilst only 12.5% of TD children had a specific difficulty with inferencing, one third of the ALN sample and over 50% of the ALI sample did. This suggests that children with ASD are more likely than their TD peers to find inferencing challenging, although difficulties are increasingly prevalent in children with language impairments. This assertion is supported by our inclusion of a non-autistic LI comparison group; 58% of these children exhibited a specific inferencing deficit.

Our results suggests that the importance of oral language competence for inferencing is partially driven by verbal working memory, which will enable the reader to remember content, aiding integration of information. Vocabulary knowledge it also important, as understanding of the words in the text will facilitate comprehension of the text as a whole, in addition to understanding of the administered questions. From a practical perspective, this suggests that interventions targeting vocabulary knowledge may facilitate inferencing skill, potentially aiding reading comprehension. Indeed, Nash and Snowling (2006) found that teaching new words to children with poor vocabulary knowledge resulted in an increase in inferential text comprehension accuracy. Such interventions will most usefully target both autistic and non-autistic children with language impairments, although the inferencing skills of children with ALN may require additional monitoring relative to their TD peers.

In addition, it is noteworthy that the ALI group found both literal and inferential comprehension more challenging than their LI peers. Perhaps during the construction phase of comprehension both groups of children are activating vocabulary knowledge and generating propositions to a similar extent, but the ALI group struggle to integrate the information into a global and coherent model. Impaired awareness of the context could impact upon both literal and inferential understanding, further reducing the availability of an accurate situational model of the text. Thus, children with ALI may require more specific reading comprehension instruction than their LI peers.

Considerations

It is noteworthy that the regression model only accounted for 52% of the variance in inferencing skill. It is therefore important to consider other potential contributory factors, such as grammatical knowledge. Many sentences include cohesive devices (such as ‘but’, ‘until’ and ‘though’), and these often invite the reader to generate an inference aiding integration of information (Cain & Nash, 2011). Indeed, for typically developing children, performance on receptive grammar tasks correlates with inferencing skill, although it is not a significant predictor when vocabulary knowledge is taken into account (Oakhill & Cain, 2012; Silva & Cain, 2014). In addition, inferencing specific skills such as the ability to retrieve the correct premise information from the text, to recall the relevant item from the knowledge base, to integrate the information in the text and existing knowledge, and to generate a context relevant inference are likely to be influential (Cain, Oakhill, Barnes, & Bryant, 2001). The additional factors which predict inferencing skill for both typical and atypical populations requires further study.

It will be also be important for future research to identify the stage in the process at which inferencing becomes problematic, and whether there are qualitative differences in inferencing for children with ALI and LI. Potentially, they are generating inferences on-line, but have difficulty formulating appropriate responses to comprehension questions. Alternatively, difficulties may occur during the on-line process, for example remembering the information read, making the link between units of information or constructing a mental model of the information. Further research employing on-line reading paradigms (like those of Saldaña & Frith, 2007) or utilising eye-tracking technology (cf. Brock, Norbury, Einav & Nation, 2008) will provide this insight.

Conclusion

This study demonstrates that the text inferencing ability of children with ASD is intimately associated with oral language skill (cf. Jolliffe & Baron-Cohen, 1999; Norbury & Nation, 2011) and that there are commonalities between the deficits experienced by both autistic and non-autistic children with LI. It is therefore important that language phenotypes within ASD are identified, both in research and for educational practice. It is proposed that interventions will most usefully target vocabulary knowledge (Nash & Snowling, 2006), followed by specific inferencing skills (McGee & Johnson, 2003; Yuill & Oakhill, 1988). The effectiveness of such interventions for different language phenotypes within ASD, and for non-autistic children with language impairment, are a priority for future research.

Acknowledgements

This research was funded by a Reid Scholarship from Royal Holloway University of London. We would like to thank all of the children who took part in this study, as well as their parents and schools; this research would not have been possible without you.

References

Adams, C., Clarke, E., & Haynes, R. (2009). Inference and sentence comprehension in children with specific or pragmatic language impairments. *International Journal of Language & Communication Disorders, 44*(3), 301-318. doi: 10.1080/13682820802051788

American Psychological Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-V)*. Arlington, Va, USA: American Psychiatric Association.

Bishop, D., & Adams, C. (1992). Comprehension problems in children with specific language impairment: Literal and inferential meaning. *Journal of Speech and Hearing Research, 35*(1), 119-129.

Botting, N., & Conti-Ramsden, G. (2003). Autism, primary pragmatic difficulties, and specific language impairment: can we distinguish them using psycholinguistic markers? *Developmental Medicine and Child Neurology, 45*(8), 515-524. doi: 10.1111/j.1469-8749.2003.tb00951.x

Brock, J., Norbury, C., Einav, S., & Nation, K. (2008). Do individuals with autism process words in context? Evidence from language-mediated eye-movements. *Cognition, 108*(3), 896-904. doi: 10.1016/j.cognition.2008.06.007

Brown, H., Oram-Cardy, J., & Johnson, A. (2013). A meta-analysis of the reading comprehension skills of individuals on the Autism Spectrum. *Journal of Autism and Developmental Disorders, 43*(4), 932-955. doi: 10.1007/s10803-012-1638-1

Cain, K., & Nash, H. (2011). The influence of connectives on young readers' processing and comprehension of text. *Journal of Educational Psychology, 103*(2), 429-441. doi: 10.1037/a0022824

Cain, K., Oakhill, J., Barnes, M., & Bryant, P. (2001). Comprehension skill, inference-making ability, and the relation to knowledge. *Memory and Cognition*, *29*(6), 850-859.

Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology, 96*(1), 31-42. doi: 10.1037/0022-0663.96.1.31

Calvo, M. (2004). Relative contribution of vocabulary knowledge and working memory span to elaborative inferences in reading. *Learning and Individual Differences, 15*(1), 53-65.

Catts, H., Fey, M., Tomblin, J., & Zhang, X. (2002). A longitudinal investigation of reading outcomes in children with language impairments. *Journal of Speech, Language, and Hearing Research*, *45*, 1142-1157.

Conti-Ramsden, G., Botting, N., & Faragher, B. (2001). Psycholinguistic markers for Specific Language Impairment (SLI). *Journal of Child Psychology and Psychiatry, 42*(6), 741-748. doi: 10.1111/1469-7610.00770

Conti-Ramsden, G., St. Clair, M., Pickles, A., & Durkin, K. (2012). Developmental trajectories of verbal and nonverbal skills in individuals with a history of SLI: From childhood to adolescence. *Journal of Speech, Language and Hearing Research*. doi: 10.1044/1092-4388(2012/10-0182)

Crais, E., & Chapman, R. (1987). Story recall and inferencing skills in language/learning-disabled and nondisabled children. *Journal of speech and hearing disorders, 52*(1), 50-55.

Dennis, M., Francis, D., Cirino, P., Schachar, R., Barnes, M., & Fletcher, J. (2009). Why IQ is not a covariate in cognitive studies of neurodevelopmental disorders. *Journal of the International Neuropsychological Society, 15*(03), 331-343. doi: 10.1017/S1355617709090481

Dodwell, K., & Bavin, E. (2008). Children with specific language impairment: an investigation of their narratives and memory. *International Journal of Language & Communication Disorders, 43*(2), 201-218. doi: 10.1080/13682820701366147

Ellis Weismer, S. (1985). Constructive comprehension abilities exhibited by language-disordered children. *Journal of Speech and Hearing Research, 28*(2), 175-184.

Gardner, M. (1990a). *Expressive One-Word Picture Vocabulary Test (Revised): Manual*. Novato, CA: Academic Therapy Publications.

Gardner, M. (1990b). *Receptive One-Word Picture Vocabulary Test (Revised): Manual*. Novato, CA: : Academic Therapy Publications.

Gough, P., & Tunmer, W. (1986). Decoding, reading, and reading disability. *RASE: Remedial & Special Education, 7*(1), 6-10. doi: 10.1177/074193258600700104

Hernandez, D. (2012). Double Jeopardy: How Third-Grade Reading Skills and Poverty Influence High School Graduation: The Annie E. Casey Foundation.

Huemer, S., & Mann, V. (2010). A comprehensive profile of decoding and comprehension in Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 40*(4), 485-493. doi: 10.1007/s10803-009-0892-3

Hus, V., Pickles, A., Cook, E., Jr., Risi, S., & Lord, C. (2007). Using the Autism Diagnostic Interview--Revised to increase phenotypic homogeneity in genetic studies of autism. *Biological Psychiatry, 61*(4), 438-448. doi: 10.1016/j.biopsych.2006.08.044

Jolliffe, T., & Baron-Cohen, S. (1999). A test of central coherence theory: linguistic processing in high-functioning adults with autism or Asperger syndrome: is local coherence impaired? *Cognition, 71*(2), 149-185. doi: 10.1016/s0010-0277(99)00022-0

Jones, C., Happé, F., Golden, H., Marsden, A., Tregay, J., Simonoff, E., . . . Charman, T. (2009). Reading and arithmetic in adolescents with autism spectrum disorders: Peaks and dips in attainment. *Neuropsychology, 23*(6), 718-728. doi: 10.1037/a0016360

Karasinski, C., & Weismer, S. (2010). Comprehension of inferences in discourse processing by adolescents with and without language impairment. *Journal of Speech, Language, and Hearing Research, 53,* 1268-1279. doi: 10.1044/1092-4388(2009/09-0006

Kjelgaard, M., & Tager-Flusberg, H. (2001). An investigation of language impairment in autism: Implications for genetic subgroups. *Language and Cognitive Processes, 16*(2-3), 287-308. doi: 10.1080/01690960042000058

Leonard, L., Ellis Weismer, S., Miller, C., Francis, D., Tomblin, J., & Kail, R. (2007). Speed of processing, working memory, and language impairment in children. *Journal of Speech, Language, and Hearing Research, 50*(2), 408-428. doi: 10.1044/1092-4388(2007/029)

Lord, C., Risi, S., Lambrecht, L., Cook, E., Leventhal, B., DiLavore, P., . . . Rutter, M. (2000). The Autism Diagnostic Observation Schedule—Generic: A Standard Measure of Social and Communication Deficits Associated with the Spectrum of Autism. *Journal of Autism and Developmental Disorders, 30*(3), 205-223. doi: 10.1023/a:1005592401947

Loucas, T., Charman, T., Pickles, A., Simonoff, E., Chandler, S., Meldrum, D., & Baird, G. (2008). Autistic symptomatology and language ability in autism spectrum disorder and specific language impairment. *Journal of Child Psychology and Psychiatry, 49*(11), 1184-1192.

McGee, A., & Johnson, H. (2003). The effect of inference training on skilled and less skilled comprehenders. *Educational Psychology, 23*(1), 49-59. doi: 10.1080/01443410303220

Nash, H., & Snowling, M. (2006). Teaching new words to children with poor existing vocabulary knowledge: a controlled evaluation of the definition and context methods. *International Journal of Language & Communication Disorders, 41*(3), 335-354.

Nation, K., Clarke, P., Wright, B., & Williams, C. (2006). Patterns of reading ability in children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 36*(7), 911-919. doi: 10.1007/s10803-006-0130-1

Neale, M. (1997). *Neale Analysis of Reading Ability - Revised (NARA-II)*. Windsor, UK: NFER.

Norbury, C., & Bishop, D. (2002). Inferential processing and story recall in children with communication problems: A comparison of specific language impairment, pragmatic language impairment and high-functioning autism. *International Journal of Language & Communication Disorders, 37*(3), 227-251. doi: 10.1080/13682820210136269

Norbury, C., & Nation, K. (2011). Understanding variability in reading comprehension in adolescents with Autism Spectrum Disorders: Interactions with language status and decoding skill. *Scientific Studies of Reading, 15*(3), 191-210. doi: 10.1080/10888431003623553

Oakhill, J., & Cain, K. (2012). The precursors of reading ability in young readers: evidence from a four-year longitudinal study. *Scientific Studies of Reading, 16*(2), 91-121. doi: 10.1080/10888438.2010.529219

Riches, N., Loucas, T., Charman, T., Simonoff, E., & Baird, G. (2010). Sentence repetition in children with specific language impairment and autism: a study of linguistic factors affecting recall. *International Journal of Language & Communication Disorders, 45*, 47-60.

Ricketts, J. (2011). Research review: Reading comprehension in developmental disorders of language and communication. *Journal of Child Psychology and Psychiatry, 52*(11), 1111-1123. doi: 10.1111/j.1469-7610.2011.02438.x

Ricketts, J., Jones, C., Happé, F., & Charman, T. (2013). Reading comprehension in Autism Spectrum Disorders: The role of oral language and social functioning. *Journal of Autism and Developmental Disorders, 43*(4), 807-816. doi: 10.1007/s10803-012-1619-4

Rutter, M., Bailey, A., & Lord, C. (2003). Social Communication Questionnaire (SCQ). Los Angeles, CA: Western Psychological Services.

Saldaña, D., & Frith, U. (2007). Do readers with autism make bridging inferences from world knowledge? *Journal of Experimental Child Psychology, 96*(4), 310-319. doi: 10.1016/j.jecp.2006.11.002

Semel, E., Wiig, E., & Secord, W. (2003). *Clinical Evaluation of Language Fundamentals (CELF-4 UK)*. London, UK: Harcourt Assessment.

Silva, M., & Cain, K. (2014). The relations between lower and higher level comprehension skills and their role in prediction of early reading comprehension. *Journal of Educational Psychology*. doi: 10.1037/a0037769

Torgesen, J., Wagner, R., & Rashotte, C. (1999). *Test of Word Reading Efficiency* Austin, TX: Pro-Ed.

Wechsler, D. (1999). *Wechsler Abbreviated Scales of Intelligence (WASI)*. San Antonio, TX: Harcourt Assesment.

Wodka, E. L., Mathy, P., & Kalb, L. (2013). Predictors of phrase and fluent speech in children with autism and severe language delay. *Pediatrics*. doi: 10.1542/peds.2012-2221

Yuill, N., & Oakhill, J. (1988). Effects of inference awareness training on poor reading comprehension. *Applied Cognitive Psychology*, *2*(1), 33-45. doi: 10.1002/acp.2350020105

Table 1

Participant Ages and Standard Scores

Variable	TD (SD) n=32	ALN (SD) n=27	ALI (SD) n=15	LI (SD) n=12	*F* value	*p* value
Chronological age (Years)	10.22[a] (1.01) 8.72–	10.37[a] (1.80) 7.18–	10.95[a] (1.35) 8.32-12.95	10.34[a] (1.44) 8.11-12.50	.93	.432
Gender: Male / Female	17 / 15	26 / 1	11 / 4	6 / 6	χ^2 = 20.33	< .001
WISC matrix reasoning NVIQ (T-score)	53.56[a] (7.09)	53.56[a] (9.20)	47.40[ab] (10.27)	44.25[b] (8.30)	5.13	.003
Language skill:						
WASI vocabulary VIQ (T-score)	58.78[a] (9.25)	53.63[a] (12.54)	36.92[b] (7.62)	44.17[b] (11.29)	15.77	< .001
Expressive one-word picture vocabulary test (Standard score)	113.09[a] (11.24)	114.88[a] (16.13)	84.40[b] (12.07)	91.76[b] (12.94)	24.67	< .001
Receptive one-word picture vocabulary test (Standard score)	110.61[a] (9.22)	110.78[a] (18.45)	75.93[b] (11.52)	89.08[b] (16.97)	27.21	< .001
CELF Recalling Sentences (Scaled score)	10.25[a] (2.36)	10.14[a] (2.87)	4.00[b] (3.14)	4.27[b] (2.33)	29.93	< .001
Reading accuracy:						
TOWRE SWE (Standard score)	108.67[a] (10.47)	102.69[a] (12.41)	82.29[b] (17.89)	79.17[b] (18.00)	22.18	< .001
TOWRE PDE (Standard score)	111.14[a] (14.31)	107.65[a] (12.72)	86.07[b] (16.53)	87.38[b] (13.16)	17.31	< .001
Autistic symptomatology:						
SCQ	3.52[a] (2.38)	19.00[b] (7.38)	20.93[b] (9.35)	12.50[c] (4.87)	35.44	<.001
ADOS (Total)	—	10.50[a] (2.93)	12.40[a] (3.63)	—	2.08	.141

Values with the same superscript do not differ when p < .05

Note: When performance was above ceiling, a score one point above the standardisation ceiling was awarded. This applied to four children (three TD, one ALN) for the expressive vocabulary test and two children (one TD, one ALN) for the receptive vocabulary test. When assessment performance was below floor, a score one point below the standardisation ceiling was awarded and this applied to one ALI child for the expressive vocabulary test. This conservative procedure was implemented by Nation et al. (2006).

Table 2

NARA-II Administration Details

	TD Mean (SD)	ALN Mean (SD)	ALI Mean (SD)	LI Mean (SD)	*F*	*p*
Most complex passage read (highest=6)	5.53[a] (.76)	5.22[a] (1.26)	3.47[b] (1.41)	3.17[b] (1.27)	21.11	< .001
Number of questions administered (max = 40)	36.25[a] (6.10)	33.78[a] (10.01)	19.73[b] (11.26)	17.33[b] (10.14)	21.11	< .001
NARA accuracy (Standard score)	111.25[a] (11.36)	109.11[a] (12.50)	83.80[b] (13.39)	84.25[b] (12.28)	28.73	< .001
NARA comprehension (Standard score)	98.88[a] (8.53)	97.78[a] (11.92)	76.47[b] (7.92)	81.08[b] (9.23)	26.26	< .001

Values with the same superscript do not differ, all p > .65

Table 3

Regression Analysis Predicting Inferencing Skill

	β	*t*	*p*	Zero-order correlation	Semi-partial correlation
Chronological age	1.03	.56	.577	.29	.05
Non-verbal ability	.109	.23	.823	.43	.02
Vocabulary knowledge	.498	2.63	.011	.72	.23
Verbal working memory	.391	2.19	.033	.69	.19
Single word reading	.059	.31	.759	.52	.03
Autistic symptomatology	-.093	.38	.706	-.28	-.03

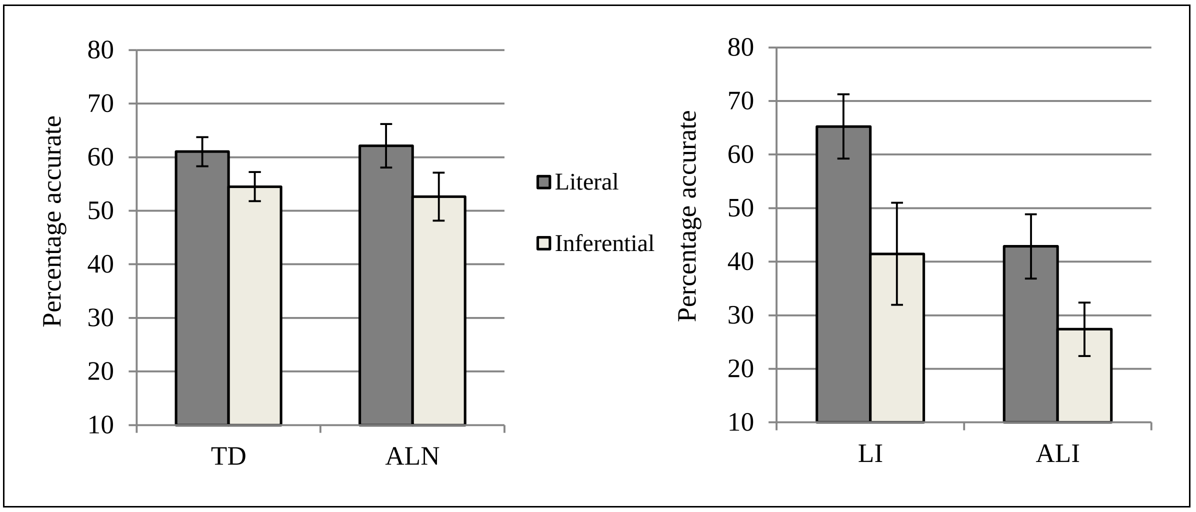

Figure 1 *Percentage of Correct Responses for Literal and Inferential Questions. Error bars Represent Standard Error.*