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Syntax and Morphology in Danish-Speaking Children with Autism Spectrum Disorder

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Abstract The current study examined delays in syntax and morphology, and vocabulary, in autism spectrum disorder (ASD). Children ages 4–6 years with ASD ($n=21$) and typical development ($n=21$), matched on nonverbal mental age, completed five language tasks. The ASD group had significant delays in both syntax and morphology, and vocabulary measures, with significant within-group heterogeneity; furthermore, syntactic and morphological measures were impaired even for subgroups matched on vocabulary. Children in the ASD group without early language delay showed syntactic and morphological impairment, with intact performance on vocabulary and sentence repetition. Findings indicate that syntactic and morphological impairments are a significant concern for high-functioning children with ASD, and may be overlooked if language evaluation focuses exclusively on vocabulary.

Keywords Autism spectrum disorder · Vocabulary · Syntax · Morphology · Sentence repetition · Early language delay

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Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by impairments or abnormalities in social interaction, in language and communication, and by repetitive or restricted behaviors or interests (American Psychiatric Association 2013; World Health Organization 1992). For language and communication skills, there is significant heterogeneity, ranging from children who never acquire functional language (Gerenser 2009), to some with different levels of syntax and lexicon, to some who are verbally fluent, only experiencing pragmatic difficulties (Kim et al. 2014). Problems in early language development are often the first symptom of concern for parents (De Giacomo and Fombonne 1998). Early language abilities are of critical importance for long-term outcomes (Howlin 2005; Mayo et al. 2013).

During the 1970s, autism was considered a language disorder, and the social deficits were seen as caused by language impairments (Rutter 1970). During the 80s and 90s, the primary focus of research in ASD centered on pragmatic language difficulties, reflecting a conceptualization of social impairments as primary (Cantwell et al. 1989; see; Gernsbacher et al. 2005, for a review). However, during the last decade, there has been renewed interest in linguistic functioning in ASD, sparked in part by the possibility of meaningful etiological overlap between the language impairments in ASD and those in specific language impairment (SLI; e.g. Kjelgaard and Tager-Flusberg 2001; McGregor et al. 2012; Tomblin 2011). SLI is defined by language delay in the absence of hearing loss, brain damage, autism or other obvious causes. The difficulties of children with SLI lie especially within syntax and/or morphology, though the lexicon is also impaired (Leonard 1998). According to the most empirically supported account of

SLI, these linguistic deficits are caused by primary impairments in working memory and speed of processing (Leonard 2007).

Whether syntax and morphology are specifically impaired in ASD, relative to lexical abilities, is an important question for several reasons. First, in research studies, vocabulary tests are often used as a proxy for overall language level, e.g., when matching groups. If the vocabulary skills of children with ASD constitute a peak within their language skills, then choosing vocabulary as the matching parameter will, all things being equal, give children with ASD a disadvantage in language comprehension or production relative to the comparison sample (Mervis and Klein-Tasman 2004; Mottron 2004; Tsai and Beisler 1984), as in, for example, studies of narrative skills (Tager-Flusberg and Sullivan 1995) or metaphor comprehension (Chouinard and Cummine 2016). Secondly, in clinical practice, it is important to assess a child's language level when planning and evaluating intervention; currently, many clinicians rely heavily on vocabulary scores as an index of overall language development. If children with ASD have relatively higher scores on vocabulary tests than on measures of syntax and morphology, then this will lead to an overestimation of language level. Thirdly, the relation between lexicon, and syntax and morphology in ASD will shed light on the question regarding the overlap of linguistic abilities between children with ASD and children with SLI.

Few studies have investigated syntax and morphology in children with ASD. There is however, an emerging consensus that syntax and morphology are universally delayed in preschool-children with ASD, though not necessarily in school-aged children with ASD (Boucher 2012). The more specific question of whether syntax and morphology are specifically impaired, relative to the lexicon, has been investigated less, and findings are inconclusive. A number of studies of school children with ASD have found specific impairments in syntax and/or morphology (Bartolucci et al. 1980; Eigsti and Bennetto 2009; Howlin 1984; Perovic et al. 2013; Tager-Flusberg 1981). Other studies of school-children with ASD either did not find specific impairment within syntax or morphology (Jarrold et al. 1997), or, did not directly investigate whether syntax and/or morphology were specifically impaired compared to lexicon (Kjelgaard and Tager-Flusberg 2001; McGregor et al. 2012; Riches et al. 2010; Tager-Flusberg 2015). Kjelgaard and Tager-Flusberg (2001) tested a group of 4–14-year-old children with autism and found significant heterogeneity, with most children scoring below the normal range, but a subgroup scoring within the normal range. Compared to lexical measures, grammar scores were lower (generally by 10–15 points), but it was not investigated whether this difference between grammar and lexicon was statistically significant, and thus we do not know whether the children were *specifically* impaired within grammar, relative to their lexical abilities. Tager-Flusberg (2015) reported similar results, confirming the large variability and existence of subgroups, but did not directly compare morphosyntactic and lexical skills. McGregor et al. (2012) and Riches et al. (2010) found no specific impairments within syntax relative to IQ, though the study did not specifically compare delays in syntax versus the lexicon. In a study of Brazilian–Portuguese-Speaking Children, Fortunato-Tavares et al. (2015) found specific syntactic impairments in a group of high-functioning children with autism, relative to IQ. Again, the relationship between syntax and lexicon was not investigated directly.

Very few studies have investigated syntax and morphology in preschool children with ASD, but they generally find syntax and morphology to be specifically impaired. For instance, Charman et al. (2003) investigated language in 134 preschool children with autism using the MacArthur Communicative Development Inventory (CDI; Fenson et al. (1994), a parental report of early language development) and found a significant delay in vocabulary, but an even more significant delay in production of phrases.

A study by Eigsti et al. (2007) investigated morphology and syntax, comparing a group of 3–6-year-old children with autism to a group of typically developing children and a group of children with intellectual disabilities, matched on nonverbal IQ and receptive vocabulary. Results showed that children with autism had less complex syntax and morphology than both control groups, measured by index of productive syntax (IPSyn; a measure of productive syntax) and mean length of utterance (MLU), indicating that their skills within syntax and morphology were specifically impaired.

Park et al. (2012) examined syntax in 3–6-year-old children. They found that in children with ASD, MLU and some of the IPSyn scores were specifically impaired relative to IQ. However, they did not investigate whether these skills were specifically impaired relative to lexicon.

In summary, some studies of school-aged children with ASD report specific impairments within syntax and morphology compared to lexicon; others do not. Studies that measured only overall language levels, without comparing syntax and morphology directly to the lexicon, reported no *specific* impairments within syntax and morphology. Studies of preschool children found specific impairments within syntax and morphology, either compared to lexicon or IQ. The conflicting findings from studies of school-age children with ASD may reflect effects of intervention (McGregor et al. 2012), characteristics of the participants, or methodological issues, such as measures used to evaluate syntax and morphology. With regard to the latter, it should be noted that McGregor et al. (2012) and Kjelgaard and Tager-Flusberg (2001) used standardized language tests, whereas

many other studies measured syntax and morphology from spontaneous language samples (e.g., Bartolucci et al. 1980; Eigsti et al. 2007; Howlin 1984).

Another difference between studies is participant characteristics. Asperger's Syndrome was historically distinguished by the absence of clinically-significant delays in cognitive level (IQ) and spoken language (American Psychiatric Association 2000; World Health Organization 1992). The studies described above included only children with Autistic Disorder, i.e., with early language delay, with the exception of Jarrold et al. (1997) and McGregor et al. (2012), who included children from the whole spectrum. This difference with regard to the included diagnostic groups may contribute to the conflicting findings. However, some children with Autistic Disorder also have cognitive skills within the normal range; and some of these children develop good language skills over time, despite their early language delay (Boucher 2012). Thus, the two diagnostic groups overlap, and indeed, the most recent diagnostic description of ASD collapses the two into a single "ASD" category (American Psychiatric Association 2013). It is important to determine whether language delays are predicted by early language delay and by IQ, rather than diagnostic status. In the study by McGregor et al. (2012), participants *without* syntactic difficulties had higher nonverbal IQs and vocabulary scores than those *with* syntactic impairment. Thus, children with lower IQ may have specific impairments of syntax and morphology, whereas children with higher IQ do not. However, this interpretation is questioned by the findings from a study of high-functioning adolescents with ASD (mean full scale IQ of 119 on the WAIS) who nevertheless displayed difficulties on a grammaticality judgment task (Eigsti and Bennetto 2009). On grammaticality judgment tests, participants must judge the grammatical correctness of a number of correct and incorrect sentences, a test that can register even subtle differences in syntactic and morphological skills (Linebarger et al. 1983). While their scores on standardized measures were in the average or high average range, participants with ASD were less sensitive to some ungrammatical structures, especially for longer sentences, and thus they had subtle, but clinically relevant impairments in syntactic and morphological abilities, despite their high IQ and lexical abilities.

Conflicting findings in the research to date thus reflect differences in participant characteristics, in what parts of language are measured, and with which methods. Some weaknesses within syntax and morphology may go unnoticed when measured with standardized language tests. Studies of syntax and morphology in children with high-functioning ASD are inconclusive. High-functioning children without early language delay, and with high IQ and advanced vocabulary skills, tend to have less impairment within syntax and morphology than children with lower IQ. However, when syntax and morphology are measured carefully, even these high-functioning children may show difficulties, and thus show specific impairments within syntax and morphology. Studies of children speaking other languages than English are sparse; to date, there have been *no* systematic studies of language in Danish-speaking children with ASD.

The primary aim of the present study was to explore syntax and morphology in a group of preschool Danish children with ASD. We predicted that children with ASD would score lower both on measures of vocabulary, and of syntax and morphology, than children with typical development, matched on nonverbal mental age, with large within-group variability. By contrasting abilities in children with and without a history of early language delay, we addressed the question of whether the language of this subgroup is impaired relative to their nonverbal mental age. We probed for differences between syntactic and morphological skills versus lexical skills for the entire ASD sample, as well as for the subgroups with and without early language delay.

Method

Participants

The participants were 21 children (16 boys, 5 girls) with ASD, age 5–6 years, and 21 children (15 boys, 6 girls) with typical development, age 4–6 years. Demographic information is presented in Table 1. The ASD and TD groups did not differ on gender, SES, or NVIQ. The groups differed in age, $F(1,40) = 14.306$, $p = .001$, with the ASD group being 8 months older (mean age 6 years, 2 months) than the TD group (mean age 5 years, 6 months). The ASD + Delay and ASD-No Delay subgroups also did not differ in gender, SES or NVIQ.

Autism Spectrum Disorder (ASD) Group

All participants with ASD were diagnosed with Childhood Autism (F84.0) using ICD-10 criteria,[1] at the ASD-diagnostic center for children aged birth to 6 years at Aarhus University Hospital in Denmark. The

[1] The main difference between ICD-10 criteria for Childhood Autism and DSM-5 criteria for Autism Spectrum Disorder is that the two first subcriteria of ICD-10, (a) deficits within social interaction, and (b) deficits within language and communication, have been collapsed into the first subcriterion of DSM-5: deficits within social-communication and social interaction. All children diagnosed with ICD-10 Childhood Autism in this study would qualify for a diagnosis of DSM-5 Autism Spectrum Disorder.

Table 1 Demographic data for typically developing (TD) and autism spectrum disorders (ASD) groups, as well as the ASD-No Delay and ASD + Delay subgroups

	TD	ASD	ASD-No Delay subgroup	ASD + Delay subgroup	*F or* χ^2	*p*	η^2	Post-hoc *t* test
n	21	21	9 (of 21)	12 (of 21)				
Male:female	15:6	16:5	8:1	8:4	0.12	0.73	0.45	
Age in months	66.0 (7.2), 54–83	74.1 (6.7), 61–82	77.6 (4.4), 69–82	71.4 (7.0), 61–82	9.94	<0.001	0.26	ASD > TD; ASD-No-Delay > ASD + Delay > TD
NVIQ[a]	111 (13), 85–135	106 (19), 80–140	114 (20), 80–140	101 (16), 80–130	2.24	0.12	0.02	
SES[b]	1.7 (1.1), 1–4	2.2 (1.3), 1–4	1.9 (1.1), 1–4	2.4 (1.4), 1–4	1.49	0.24	0.05	

Table reports *means* (*SD), range*

[a]*NVIQ* Raven's coloured progressive matrices, scaled scores

[b]*SES* Socioeconomic status (smaller numbers indicate higher SES; range: 1–5)

interdisciplinary diagnostic team is specialized and experienced in autism diagnostics, and includes a child psychiatrist, a clinical neuropsychologist, and a nurse or a daycare teacher, and in some cases, a speech language pathologist. All children were diagnosed using the Autism Diagnostic Observation Schedule—Generic (Lord et al. 2000) and the Autism Diagnostic Interview—Revised (Lord et al. 1994) or a similar structured interview evaluating social interaction, communication, and repetitive behaviors. Parents completed the Social Communication Questionnaire (Rutter et al. 2003).

Since the presence of early language delay accounts for significant variance in individual outcomes (Howlin 2005; Mayo et al. 2013), the ASD group was divided into two subgroups (Delay and No Delay subgroups) based on whether the children produced single words by age two and sentences by age three. Drawing this information from detailed clinic records, the first author determined that of the 21 children with ASD, 12 had early language delay and nine did not.

Typical Development (TD) Group

Children with typical development were recruited through daycare centers in the same geographic area. Directors of 50 daycare centers were contacted by phone and asked to distribute invitations to the parents of children aged 4–6 years who were monolingual and whom they regarded as having typical development. The teacher report of typical development was confirmed by qualitative evaluation by at least two graduate students of psychology. On the basis of these evaluations, one child was excluded from the study. All participants were monolingual speakers of Danish. The project was approved by The Danish National Committee for Research Ethics and from The Danish Data Protection Agency. All parents gave informed consent prior to participation.

Procedures and Stimuli

The children visited the university lab along with one or both parent(s) for two visits of approximately 2 h each. Four children were tested in a quiet room in their daycare center. The two visits were scheduled approximately 2 weeks apart. Participants completed a battery of tests, with breaks as needed.

Measures

Nonverbal IQ (NVIQ) Cognitive ability was assessed with the Raven's Coloured Progressive Matrices (Raven), a pattern completion test with excellent reliability and validity (Raven 2008). This widely-used test is especially well-suited for children with language difficulties, since it does not rely on linguistic skills.

Lexical Abilities The assessment of receptive vocabulary was made using the Peabody Picture Vocabulary Test, Fourth Edition (*PPVT–4*; Dunn and Dunn 2007). On this test, the child hears a spoken word and must point to the corresponding picture. The PPVT is not available in Danish; the first author developed a translation, with permission from the publisher. PPVT test items are presented as sets, 12 items per set, with sets in order of acquisition, from early to late. However, English and Danish items do not match in word frequency and typical order of acquisition. For example, the word "squash" is a relatively early item in the PPVT (item 78), but the illustrated type of squash (a crookneck squash) is not sold in supermarkets in Denmark, and is largely unknown to Danish children. On another item, "vehicle" (item 80), the only possible Danish translation is a compound word containing the word "drive"/"driving" which is very early-acquired in Danish. The publisher did not permit item substitutions. To establish valid scaling in Danish, each item in turn was examined for error rates in the TD group. Any items to which 95% (20/21) to 100% of

the TD participants responded correctly were removed from that set, such that all sets were increasingly difficult, as is the intention in the original version. Data were analyzed as raw summed scores (standard scores were not appropriate, given the above change).

Tests of Morphology and Syntax The Clinical Evaluation of Language Fundamentals, Preschool, Second Edition (CELF Preschool–2; Wiig et al. 2004) was translated into Danish by the first author, with permission from the publisher.[2] Three subtests constituting the *Language Structure index* were included: *Recalling Sentences, Sentence Structure*, and *Word Structure*. In *Recalling Sentences*, the child is given sentences of increasing syntactic complexity, and asked to repeat them aloud. This also served as a sensitive index of short-term memory capacity. *Sentence Structure* is a test of receptive syntax; the child hears a sentence and must point to the picture that best matches its meaning. *Word Structure* is a test of expressive morphology. In this sentence completion task, the child is asked to complete a sentence, provided by the experimenter, using specified prompts. Because of differences between English and Danish syntax and morphology (e.g., whether and how specific forms are used), some of the tested items were either irrelevant in Danish, or were not accurately illustrated by the illustration. The publisher did not permit substitutions of illustrations or structures. Thus, one item in the *Sentence Structure* subtest and seven items in the *Word Structure* subtest were removed from analyses. All data are presented as raw scores.

Morphology The standardized and widely-used Test of Danish Receptive Morphology [Dansk Impressiv Morfologisk test (DIM); Grønborg et al. 1987] was used as a measure of receptive morphology. This test assesses the child's ability to comprehend inflections, derivations, personal pronouns and markings. The child hears a sentence and must point to one of two possible pictures.

Socioeconomic Status Because of the robust correlation between socioeconomic status (SES) and language level (Hart and Risley 1995; Hoff and Tian 2005), groups were matched on SES using a Danish index that categorizes families into one of five social groups, based on the parents' educational level and occupation (Hansen and Andersen 2009).

Analytic Plan

Dependent variables were examined for deviations from the assumptions of normality and sphericity and were found to be normally distributed. Data were checked for outliers (individuals with scores of more than 2.5 SD from the group mean) and missing data. Scores were missing for two children with ASD from one measure—the Test of Danish Receptive Morphology—due to experimenter error; these participants did not differ from other ASD participants on any measures, and their data were otherwise included. Effect sizes were calculated with partial eta squared (η^2), which refers to the proportion of variance attributable to a given effect after partialling out non-error sources of variance (Cohen 1988).

To examine syntactic abilities of children with ASD, including those with and without early language delay, analyses compared group differences (ASD vs. TD) for five language measures focused on lexical, syntactic, and morphological skills: translated versions of the PPVT, and the *Recalling Sentences, Sentence Structure*, and *Word Structure* subtests of the CELF; and the DIM. Because of group differences in chronological age, this variable was included as a covariate in all group comparisons, which were run as MANCOVAs. For those tests yielding significant main effects of group, follow-up *t* tests were used to assess subgroup differences. To test whether syntax and morphology in ASD were specifically impaired, relative to the lexicon, we formed subsets ($n = 15$) of the ASD and TD groups, matched on PPVT scores, by excluding the lower-scoring ASD and the higher-scoring TD participants. These subgroups did not differ in NVIQ. Scores on the four syntactic and morphological measures were analyzed using MANCOVA with age as a covariate. A second planned analysis compared syntactic and morphological abilities for the TD group and two subsets of the ASD group: those participants with early language delay (ASD + Delay; $n = 12$) and without such delay (ASD-No Delay; $n = 9$); we anticipated greater impairment in the language-delayed subgroup. A MANCOVA compared language scores among the ASD + Delay, ASD-No Delay, and TD groups, with age as a covariate. For this analysis, scores were transformed into

[2] The similarities between Danish and English grammar made a relatively direct translation viable. The main morphological differences are that Danish does not have present progressive and third person marking, but does mark nouns for gender. As such, items testing present progressive and third person marking were removed. The publisher prohibited the inclusion of any additional items, so the CELF did not include items measuring gender marking on nouns; this marking is acquired very early. An additional difference is that Danish has no rules for copula contraction; thus, items testing this structure were also removed. The translated version thus measures nearly all the relevant Danish morphemes. As for syntactic differences between Danish and English, in some Danish sentences (e.g., those introduced by an adverbial phrase), the verb precedes the subject. In the subtest Sentence Structure, there were no cases of this "inverted" word order, and thus all translations were straightforward. Only one item was removed from Sentence Structure, due to semantic differences. Altogether, the translated version was thought to be useful for measuring morphosyntactic knowledge of Danish.

Table 2 Language scores for groups with typical development (TD) and autism spectrum disorder (ASD)

	TD ($n=21$)	ASD ($n=21$)	F	p	η^2
PPVT	98.6 (9.3), 83–113	89.1 (15.2), 57–109	18.59	0.001	0.13
CELF-SS	18.8 (2.1), 11–21	15.0 (4.5), 7–21	20.90	0.001	0.24
CELF-WS	14.9 (1.6), 11–17	11.2 (3.9), 3–17	32.05	0.001	0.28
CELF-RS	29.8 (4.2), 19–36	21.4 (11.0), 3–36	21.70	0.001	0.21
DIM [a]	47.8 (2.3), 42–51	39.8 (11.1), 11–51	23.29	0.001	0.22

Table reports *means* (*SD), range*. Age is included as a covariate in all tests; results were similar with PPVT score as a covariate. Note that scores are presented as raw rather than standard scores

PPVT peabody picture vocabulary test-4; *CELF* clinical evaluation of language fundamentals, preschool edition; *SS* sentence structures; *WS* word structures; *RS* recalling sentences; *DIM* Danish receptive morphology

[a]Two children with ASD, one with delay, one without, are missing DIM scores, due to experimenter error

z-scores to permit analysis of group by language measure interactions.

Finally, we examined individual differences in the patterns and types of errors via an exploratory qualitative analysis of performance on the *Word Structure* and *Recalling Sentences* subtests.

Results

Entire Sample, TD vs. ASD

Results of analyses comparing the entire ASD sample to the TD sample, with age as a covariate, indicated significant differences on all five language measures; data are shown in Table 2. As a group, the children with ASD had significantly lower scores on all language measures than their NVIQ-matched peers.

PPVT-Matched Subsets

The analysis of vocabulary-matched subsets ($n=15$) of the ASD and TD groups revealed significant differences on the Danish Morphology test, $F(1,27)=11.68$, $p=.002$, $\eta^2 = 0.30$. Data are shown in Table 3. As for the CELF, there was a significant difference for performance on the *Word Structures* subtest, $F(1,27)=8.67$, $p=.007$, $\eta^2 = 0.24$. Group differences did not reach significance for the *Sentence Structures* subtest, $F(1,27)=3.34$, $p=.08$, $\eta^2 = 0.11$, nor for the *Recalling Sentences* subtest, $F(1,27)=1.19$, $p=.29$, $\eta^2 = 0.04$. This analysis indicates significant syntactic and morphological delays in young children with ASD, over and above lexical knowledge, relative to a group of typically developing children matched for NVIQ and for lexical level. However, there was large within-group heterogeneity.

Table 3 Language scores for PPVT-matched subsets with typical development (TD) and autism spectrum disorder (ASD)

	TD ($n=15$)	ASD ($n=15$)
PPVT	94.5 (7.5), 83–109	95.8 (8.1), 86–109
CELF-SS*	18.3 (2.3), 11–21	16.0 (4.2), 7–21
CELF-WS*	14.7 (1.7), 11–17	12.7 (3.3), 5–17
CELF-RS	28.3 (3.6), 18–32	26.9 (6.9), 9–36
DIM	47.3 (2.5), 42–51	44.3 (7.0), 33–51

Table reports *means* (*SD), range*. Age is included as a covariate in all tests. All scores are presented as raw rather than standard scores

PPVT peabody picture vocabulary test, fourth edition; *CELF* clinical evaluation of language fundamentals, preschool; *SS* sentence structure; *WS* word structure; *RS* recalling sentences; *DIM* Danish receptive morphology

*$p<.05$

TD, ASD-No Delay, and ASD + Delay

An analysis of the TD group and the two subgroups of ASD, the ASD-No Delay group and the ASD + Delay group, using z-scores in a repeated-measures MANCOVA, indicated a significant main effect of group on the language measures, $F(2,38)=37.55$, $p<.001$, $\eta^2 = 0.66$. Data are shown in Table 4. There was no main effect of language measure, $F(4,152)=0.55$, $p=.70$, $\eta^2 = 0.01$, and no group X measure interaction, $F(8,152)=0.89$, $p=.53$, $\eta^2 = 0.05$. Each of the three groups differed from each other: ASD + Delay versus ASD-No Delay, $p<.001$; ASD + Delay versus TD, $p<.001$; ASD-No Delay versus TD, $p=.04$. Planned comparisons of the ASD-No Delay versus TD groups revealed significantly lower scores for the ASD-No Delay group on the *Word Structure* subtest, $F(1,27)=5.25$, $p=.03$, $\eta^2 = 0.16$ (see Table 4). Differences for the DIM, PPVT, *Recalling Sentences* and *Sentence Structure* measures were not significant. These results suggest that early language delay is a significant risk factor for ongoing delays in vocabulary, syntax, and morphology, but that even children without a history of language delay show significant impairments in morphology relative to TD controls.

ASD + Delay vs. ASD-No Delay

An exploratory analysis compared scores on language measures for the ASD + Delay versus ASD-No Delay groups. These results indicated significant group differences for the PPVT, $F(1,18)=5.98$, $p=.03$, $\eta^2 = 0.25$, and

Table 4 Language scores for typical development (TD), ASD-No Delay and ASD + Delay subgroups

	TD ($n = 21$)	ASD-No Delay ($n = 9$)	ASD + Delay ($n = 12$)	F	p	η^2	Group t test
PPVT	98.6 (9.3), 83–113	100.1 (7.6)	80.9 (14.4), 57–97	13.07	<0.001	0.44	TD, ASD No-Delay > ASD + Delay
CELF-SS	18.8 (2.1), 11–21	17 0.8 (2.4), 13–21	12.8 (4.6), 7–21	13.72	<0.001	0.43	TD > ASD + Delay
CELF-WS	14.9 (1.6), 11–17	13.7 (2.0), 10–17	9.4 (4.1), 3–16	18.94	<0.001	0.51	TD > ASD-No-Delay, ASD + Delay
CELF-RS	29.8 (4.2), 19–36	31.2 (3.5), 25–36	14.1 (8.5), 3–30	33.50	<0.001	0.65	TD, ASD-No-Delay > ASD + Delay
DIM[a]	47.8 (2.3), 42–51	47.3 (6.1), 33–51	34.4 (10.6), 11–49	22.47	<0.001	0.56	TD, ASD-No-Delay > ASD + Delay

Table reports *means* (*SD), range*. Age is included as a covariate in all tests; results were similar with PPVT score as a covariate. Note that all scores are presented as raw rather than standard scores

PPVT peabody picture vocabulary test, fourth edition; *CELF* clinical evaluation of language fundamentals, preschool; *SS*: sentence structure; *WS* word structure; *RS* recalling sentences; *DIM* Danish receptive morphology

[a]Two children with ASD, one with delay, one without, are missing DIM scores, due to experimenter error

Recalling Sentences, $F(1,18) = 20.04$, $p < .001$, $\eta^2 = 0.53$, measures. Differences did not reach significance for *Sentence Structures,* $F(1,18) = 3.51$, $p = .08$, $\eta^2 = 0.16$, Danish Morphology, $F(1,18) = 3.35$, $p = .08$, $\eta^2 = 0.16$, and *Word Structure*s, $F(1,18) = 2.63$, $p = .12$, $\eta^2 = 0.13$. Because *Recalling Sentences* has a strong short-term memory component, these data suggest that short-term memory skills may differentiate between children with ASD who do versus do not show early language delays.

Qualitative Differences

A qualitative analysis of the *Word Structure* subtest revealed a similar overall pattern of errors across the three groups. The same items tended to pose difficulties for all three groups, most pronounced in the ASD + Delay group, and more pronounced in the ASD-No Delay than in the TD group. The types of errors were also similar. For instance, one of the most difficult items, across groups, was an item testing irregular past tense, *fell*. The most typical error was to produce another form of the verb, either the perfect tense, *have fallen*, or the present tense, *fall*. However, in all three groups, some children gave no response, or gave a very different answer, e.g., *is in the tree* (ASD + Delay), *is lying down* (ASD-No Delay), or, *does not fall* (TD). Another difficult item tested the objective masculine pronoun *him*. Across groups, participants produced *her*, the pronoun with female marking (all groups), with neuter marking, *it* (TD), the subjective instead of objective pronoun, *he* (ASD-No Delay), or a related word, e.g., *the male* (TD) or *the boy* (ASD + Delay). Across groups, some children gave no response, though the proportion was greatest in the ASD + Delay group. In sum, across groups, the patterns as well as the types of errors were similar, though more frequent in the ASD + Delay group, less in the ASD-No Delay group, and the least in the TD group. These results are more consistent with a pattern of general delay, than with a sharply atypical course of acquisition of morphology in ASD.

The qualitative analysis of the scores on the Sentence Repetition test revealed somewhat larger qualitative group differences, but with wide variability in performance within each group. Children across all groups made more errors as sentence length increased, and produced omissions, substitutions, and additions. In general, there were fewer grammatically correct substitutions in the ASD + Delay group, and with more omissions and substitutions that rendered responses ungrammatical.

Discussion

This study compared the language abilities of young Danish children with ASD with or without a history of early language delay, to children with a history of typical development, ages 4–6 years. The groups were matched on IQ, gender, and socioeconomic status. Language abilities from a number of domains were examined: receptive vocabulary (*PPVT*); expressive morphology (*Word Structure* subtest); receptive syntax (*Sentence Structure* subtest); sentence processing and short-term memory (*Recalling Sentences* subtest); and receptive morphology (*DIM*).

When controlling for age, the two groups differed significantly in syntactic and morphological, and lexical skills, though with wide variability in the ASD group. Furthermore, using two approaches to equate groups on lexicon abilities, analyses indicated that the ASD group continued to show relative impairments on multiple measures of syntax and morphology, suggesting that syntactic and morphological impairments in ASD reflect difficulties beyond the lexical level. Still, there was wide variability in the ASD group, with some children showing no morphological impairments.

To further examine language abilities, the ASD group was divided into two subgroups, with and without early

language delay. The ASD + Delay group and TD groups differed on all morphosyntactic measures: expressive morphology (*Word Structures*); receptive syntax (*Sentence Structures*); sentence processing and short-term memory (*Recalling Sentences*); and receptive morphology (*DIM*). The ASD-No Delay group differed from the TD group on expressive morphology.

This analysis suggests two conclusions: first, the ASD subgroups had substantially heterogenous impairments, with the ASD + Delay subgroup showing severe and broad language impairments, and differing from the TD group on every measure. Secondly, even the ASD-No Delay subgroup exhibited significant deficits in expressive morphology, relative to the TD group.

An ancillary finding was that the ASD + Delay group showed deficits in vocabulary (*PPVT*) and sentence processing and short-term memory (*Recalling Sentences*) language measures relative to their ASD-No Delay counterparts. While these results are tentative, given the small group sizes, they indicate that short-term memory may distinguish those whose early language is delayed from those who have no such early delays, and therefore suggest that short-term memory could play an important role in such delays. Evidence for this interpretation was reported in a study showing that sentence repetition skills distinguished between children with ASD with and without language impairment (Harper-Hill et al. 2013).

The present findings add to a growing literature on structural language differences in ASD. The finding that syntax and morphology were specifically impaired in the entire group of children with ASD is consistent with several previous studies (Bartolucci et al. 1980; Eigsti et al. 2007; Howlin 1984; Tager-Flusberg 1981). These studies used spontaneous speech samples, and thus may have confounded syntactic and morphological differences with a deviant communicative style; however, the present study reports similar findings using structured tests. In other previous studies, high-functioning children with ASD had standardized language test scores that were within the normal range (Kjelgaard and Tager-Flusberg 2001; McGregor et al. 2012). However, in these studies, measures of syntactic and morphological abilities were not compared to lexical ones, leaving it unclear whether syntax and morphology were intact, or were impaired relative to high lexical skills. The present finding, where groups were equated on lexical level, suggests that even high-functioning children with ASD show a broad range of performance, with many showing substantial syntactic and morphological impairments and a few showing superior skills.

Strikingly, the ASD-No Delay subgroup scores showed intact performance on sentence repetition (the *Recalling Sentences* subtest), despite significantly lower performance on another grammatical CELF subtest, *Word Structure*. The *Recalling Sentences* subtest is correlated with syntactic skills in typically developing children (Kidd et al. 2007) and in Specific Language Impairment (Conti-Ramsden et al. 2001; Stokes et al. 2006). However, this subtest differs from *Word Structure* and *Sentence Structure*, which are direct measures of morphology and syntax, respectively, as it also involves short-term memory and phonological output processes (Clay 1971). In the present study, the ASD-No Delay subgroup showed intact performance on sentence repetition, but impaired knowledge of Danish morphology. It is therefore unlikely that the sentence repetition task indicates completely intact syntactic and morphological knowledge. Rather, this high-functioning group of children may display *enhanced* short-term memory, allowing them to repeat sentences within the short-term memory span without full comprehension or grammatical knowledge (Clay, 1971). This kind of short-term memory ability could be relevant for echolalia, a common finding in ASD, where affected individuals repeat words or sentences spoken by others (e.g. Prizant 1983). Interestingly, the children with the strongest sentence repetition performance also had the most advanced comprehension skills, and did not present with immediate echolalia in their spontaneous speech. Thus, their sentence repetition did not appear to be fully automatic or echolalic.

The present finding of intact sentence repetition skills in the non-language-delayed ASD group sheds light on other studies reporting sentence repetition as a measure of syntax, such that grammatical impairments may be masked by enhanced short-term memory skills. For example, in McGregor et al. (2012), the estimate of syntactic ability was derived from two tests of syntax of which the *Recalling Sentences* subtest was one. Thus, advanced short-term memory skills in these high-functioning children may have artificially boosted the summed syntax score, and masked syntactic difficulties. That said, the children in the ASD-No Delay group clearly included children with less language impairment than the ASD + Delay group, with some of the children being unimpaired.

The finding of intact sentence repetition skills also informs the discussion about the overlap between ASD and SLI (e.g., Riches et al. 2010). The current findings suggest that intact sentence repetition in high-functioning ASD may mask syntactic and morphological impairments. In contrast, children with SLI typically show impaired sentence repetition abilities; the current results suggest that language deficits in these diagnoses may reflect distinct processing mechanisms.

The current study had several limitations. First, the study was limited by the lack of normed tests of Danish. Translated versions of the English-language tests required eliminating some inappropriate items, and thus analyses used raw rather than age-normed scores. This

assumes that development is linear, an assumption likely to be incorrect. Second, results were limited by matching; because of the heterogeneity of the ASD group in age, NVIQ, and receptive vocabulary, they could not be matched with their TD peers in all three variables, and were similar in NVIQ only. As such, age was entered as a covariate in all analyses, and *PPVT* scores were equated in two statistical approaches (using a *PPVT*-matched subgroup, and covarying *PPVT* scores). The ASD group was significantly older (by 7 months on average), a difference that should give this group a relative advantage in language tasks. That group differences were nonetheless apparent is informative. Finally, the study was cross-sectional, with limited ability to investigate developmental patterns or features that may predict levels of syntax and morphology.

The finding that sentence repetition was enhanced relative to other grammatical skills in the ASD-No Delay subgroup warrants further research within this area. Future research could longitudinally investigate sentence repetition skills and short-term memory in children with ASDs, to evaluate the developmental consequences of these early abilities as well as the potential overlap between children with ASD and SLI.

The finding of syntactic and morphological impairments in ASD has implications for research as well as clinical practice. Lexical measures such as the *PPVT* and its British equivalent, the British Picture Vocabulary Scale (Dunn et al. 2009), are widely used for matching purposes. These findings suggest that matching on lexicon alone may result in an overestimate of the language level in ASD. These results indicate that a test of receptive vocabulary is not a good proxy for overall language level in ASD, and should be complemented by tests of syntax and morphology.

In conclusion, we found that children with ASD as a group showed impaired syntactic and morphological abilities, and that even the subgroup of children with no early language delay and with intact performance on vocabulary and sentence repetition had some difficulties within syntax and morphology that may be overlooked if they are not tested thoroughly.

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Compliance with Ethical Standards

Author Contributions Study conception and design: Brynskov, Eigsti, Krøjgaard, Bohn; Acquisition of data: Brynskov, Jorgensen, Lemcke; Analysis and interpretation of data: Brynskov, Eigsti; Drafting of manuscript: Brynskov; Critical revision: Brynskov, Eigsti.

Conflict of interest All authors declare that they have no conflicts of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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