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Syntactic abilities and verbal memory in monolingual and bilingual children with High Functioning Autism (HFA)

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Abstract

The aim of the current study was two-fold. First, it evaluated the influence of bilingualism on syntactic abilities and verbal memory of children with High Functioning Autism (HFA). Second, it explored the relationship between syntactic abilities and verbal memory of children with HFA and typical language development (TLD). Eighty-six monolingual Hebrew-speaking and bilingual Russian–Hebrew speaking children aged 4;6–9;2 years participated: 28 with HFA (14 monolingual and 14 bilingual) and 58 with TLD (28 monolingual and 30 bilingual). Syntactic abilities were assessed using Sentence Repetition tasks (bilingual children were tested in both languages). Verbal memory was evaluated using Forward Digit Span for verbal short-term memory and Backward Digit Span for verbal working memory. As a group, children with HFA scored lower than their TLD peers on measures of syntactic abilities and verbal memory. However, some children with HFA, monolingual and bilingual, showed intact syntactic abilities, while others scored at-risk for Language Disorder (LD). Importantly, syntactic abilities in children with HFA were not associated with their verbal memory skills. Furthermore, no differences in verbal memory were found between children with HFA who were at-risk for LD and children with no risk. Bilingualism did not influence Sentence Repetition scores when vocabulary was controlled for, and it did not affect verbal memory scores. The study demonstrated that (1) syntactic difficulties in children with HFA are not attributable to deficient verbal memory; moreover (2), regardless of languages status,

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children with HFA at-risk for LD exhibit impaired syntax similarly to those reported in the literature for children with Developmental Language Disorder. Finally, the findings show that bilingualism affects children with TLD and HFA similarly, demonstrating that bilingualism does not impede language and cognitive development in children with HFA.

Keywords
Autism, DLD/SLI, High Functioning Autism (HFA), syntax, verbal short-term memory, verbal working memory

Introduction

Autism Spectrum Disorder (ASD) is diagnosed on the basis of two symptom clusters: (a) pervasive deficiencies in social communication and social interaction, and (b) restrictive and repetitive patterns of behavior, interests or activities (DSM–5, American Psychiatric Association, 2013). Language is not part of the diagnosis and there is no consensus on the relations between language and cognitive abilities of children with ASD (Tager-Flusberg, 2016). It is estimated that 15–20% of children with ASD fail to learn even single words for communicative purposes, while approximately 50% attain fluent and functional speech (Dromi, Rum, & Goldberg Florian, 2018).

The current study explored syntactic abilities and verbal memory, including verbal short-term memory (vSTM) and verbal working memory (vWM), of monolingual and bilingual children with ASD who have non-verbal IQ within the normal range. These children are referred to in the literature as children with High Functioning Autism (hereinafter HFA) (Bishop, 2003). We assessed separate and combined effects of HFA and bilingualism on syntactic abilities and verbal memory, aiming to explore to what extent syntactic abilities are associated with verbal memory capacity in children with HFA and typical language development (TLD).

Little is known about the influence of bilingualism on syntactic abilities and verbal memory of children with HFA. Research on other populations, for example, children with Developmental Language Disorder (DLD), formerly referred to as Specific Language Impairment (SLI), shows that bilingualism is not an aggravating factor for language and memory abilities in this group (for an overview see Bird, Genesee, & Verhoeven, 2016). Bilingual children with DLD show the same pattern and extent of deficits as their monolingual peers (Meir, 2017; Paradis, Crago, Genesee, & Rice, 2003; Stavrakaki, Chrysomallis, & Petraki, 2011).

Syntactic abilities of monolingual and bilingual children are often assessed using Sentence Repetition (SRep) tasks in typical (Seeff-Gabriel, Chiat, & Dodd, 2010) and atypical populations (Armon-Lotem & Meir, 2016; Conti-Ramsden, Botting, & Faragher, 2001; Marshall et al., 2015; Novogrodsky, Meir, & Michael, 2018). SRep is a complex task: it taps into vSTM, vWM and syntactic skills. Although, it has been suggested that SRep tasks tap into both vSTM and vWM (e.g., Conti-Ramsden et al., 2001; Alloway & Gathercole, 2005), the span for meaningful sequences is twice as great as it is for unrelated sequences of words (e.g., Baddeley, Vallar, & Willson, 1987). Accurate sentence repetition is not a mere recall of phonological sequences, but it involves processing and regeneration of sentences based on morphosyntactic representations stored in the long-term memory (Potter & Lombardi, 1998). The task draws on linguistic knowledge (e.g., grammaticality, plausibility, prosody, and lexicality) (Polišenská, Chiat, & Roy, 2015). Thus, repetition of sentences of varying syntactic complexity provides insights into children's processing abilities and underlying morphosyntactic representations (Potter & Lombardi, 1998).

Syntactic abilities of children with HFA

Previous studies showed that syntactic abilities of monolingual children with HFA vary greatly. Some reported that children with HFA have intact morphosyntactic abilities (Kjelgaard & Tager-Flusberg, 2001; Novogrodsky, 2013; Novogrodsky & Edelson, 2015; Roberts, Rice, & Tager–Flusberg, 2004). For example, monolingual children with HFA perform on par with age-matched peers with TLD on comprehension of reflexive and passive constructions (de López, Schroeder, & Gavarró, 2018; Gavarró & Heshmati, 2014; Terzi, Marinis, Kotsopoulou, & Francis, 2014).

Conversely, there is evidence for problems with morphosyntax among some children with ASD (Durrleman & Delage, 2016; Durrleman, Marinis, & Franck, 2016; Rapin & Dunn, 2003). Thus, some studies on monolingual children with ASD distinguish between those with Language Disorder (henceforth, ASD+LD) and those with normal language (henceforth, ASD+NL) (Durrleman & Delage, 2016; Kjelgaard & Tager-Flusberg, 2001; Modyanova, Perovic, & Wexler, 2017; Schaeffer, 2018; Tuller et al., 2017; Whitehouse, Barry, & Bishop, 2008; Williams, Payne, & Marshall, 2013). Similar to children with DLD, children with ASD+LD have difficulties comprehending and producing different syntactic structures. These include *wh*-questions (Durrleman et al., 2016; Prévost, Tuller, Barthez, Malvy, & Bonnet-Brilhault, 2017), relative clauses (Riches, Loucas, Baird, Charman, & Simonoff, 2010), passives (Durrleman, Delage, Prévost, & Tuller, 2017), and constructions involving argument displacement (Perovic & Janke, 2013). Children with ASD+LD and children with DLD were reported to have problems repeating sentences with object *wh*-questions, object relatives, and finite argument clauses.

A recent study that tested monolingual French-speaking children with HFA aged 7;8–10;11 on a SRep task showed that the ASD+LD group performed like the DLD group. In contrast, the ASD+NL group performed like the TLD group (Silleresi et al., 2018).

Similarities in the linguistic profiles of children with ASD+LD and in children with DLD have prompted researchers to talk about the comorbidity of two disorders, possibly due to shared etiology (Bishop, 2010). Yet, some studies show that the linguistic profiles of children with ASD+LD are different from those of children with DLD, suggesting different underlying causes of impaired syntactic abilities (Prévost et al., 2017; Schaeffer, 2018). The current study aims to contribute to this discussion through an analysis of specific types of syntactic errors.

A recent study reported a wide variation in syntactic abilities of 18 monolingual Hebrew-speaking children with ASD, aged 8–18, on comprehension, production, and SRep (Sukenik & Friedmann, 2018). On the SRep task, most participants with HFA (14/18) scored lower than the participants with TLD, yet only 4 participants showed a profile similar to that of children with DLD (poor repetition of sentences with *wh*-movement: topicalization, object relative, and object *wh*-questions). Most participants with ASD simplified the targeted syntactic structure and made lexical errors: they added information and answered the primed questions instead of repeating them. The authors concluded that these qualitative differences between children with ASD and DLD indicate different underlying causes of syntactic deficits. Moreover, the authors reported that information previously stored in memory (i.e., from previous target sentences in the task) interfered with the new response, as evidenced by the insertion of words from previous target sentences into later responses. However, the effect of memory span of children with ASD was not addressed by Sukenik and Friedmann (2018) and is further discussed in the next section.

The role of verbal memory in syntactic abilities

Verbal memory, defined as the ability to learn, retain, and recall verbal information, is widely measured using Forward Digit Span and Backward Digit Span tasks (Richardson, 2007). Forward Digit Span task is a measure of vSTM. The task requires temporal storage of the correct order of an increasing sequence of digits and its repetition. Backward Digit Span task is considered to be an index of vWM, since it combines temporary storage and manipulation of the information: participants are required to remember the sequence of digits and repeat them backwards (Richardson, 2007).

There is no consensus on the role of verbal memory in the development of syntactic abilities in children with atypical language development. Some studies suggest that linguistic problems in children with DLD can be attributed to limitations of vSTM and vWM (Bishop, 1992; S. E. Gathercole & Baddeley, 1990). However, other studies provide counterevidence showing that limitations in vSTM and vWM do not account for vulnerability of particular grammatical morphemes such as *that* and *-ed* (Riches, 2012) and syntactic abilities observed in monolingual and bilingual children with DLD (Meir, 2017). For example, Riches (2012) tested 6-year-old children with DLD and found that Backward Color Span, which taps into vWM, was not the best predictor of children's performance on a SRep task. In contrast, a syntactic priming task tapping into long-term memory predicted performance on the SRep task for the same children. Similarly, Meir (2017) showed that even when controlling for vSTM, children with DLD scored lower than children with TLD, suggesting that vSTM is not at the core of syntactic problems in monolingual and bilingual preschoolers with DLD.

Turning to verbal memory capacity and its link to syntactic abilities in children with ASD, the findings are limited and somewhat contradictory. There are studies showing that children with ASD perform on par with their TLD peers. For example, 6- to 7-year-old children with and without ASD showed no difference in Backward Digit Span tests (e.g., Faja & Dawson, 2014). Yet, a meta-analysis comparing various executive functions in children and adolescents with ASD and TLD indicated limited vSTM and vWM (Lai et al., 2017). Studies addressing the link between syntactic abilities and memory in children with ASD are scarce, with inconclusive findings.

With respect to the association between syntax and verbal memory, poorer syntactic abilities of children with ASD were reportedly linked to deficient vSTM and vWM. For example, Durrleman and Delage (2016) reported that monolingual, French-speaking children with ASD aged 5–16 showed similar performance compared to children with DLD on a sentence completion task and a sentence production task. The clinical groups were matched for age and non-verbal IQ. To test the link between verbal memory and syntactic abilities, the authors compared the performance of children with ASD+LD and ASD+NL on measures of vSTM and vWM (Forward and Backward Digit Span were used as proxies for vSTM and vWM, respectively). The results indicated that children with ASD+LD scored lower on these verbal memory tasks than did children with ASD with intact syntactic abilities.

Conversely, there is evidence against the link between syntactic abilities and verbal memory in children with ASD. Another study on monolingual, French-speaking children with ASD aged 7–8 did not support a link between syntactic abilities and vSTM and vWM (Durrleman et al., 2017). While comprehension of passive sentences among children with ASD was poorer than that of age-matched controls, they also showed a large disparity in individual scores. Half of the children with ASD scored within the normal range and half scored at-risk for DLD. The individual differences in the comprehension of passive sentences were not related to non-verbal IQ or to any verbal memory measures, which were evaluated using Forward and Backward Digit Span tasks. Moreover, the study showed that although children with ASD, as a group, scored lower on verbal memory measures as compared to their age-matched controls, no differences on memory measures were found between children with ASD+LD and children with ASD+NL. Furthermore, Schaeffer (2018) found no link between memory capacity and syntactic abilities in monolingual Dutch-speaking participants with HFA aged 5–14. In this study, verbal memory was assessed using Forward and Backward Digit Span tasks and a nonword repetition task.

To conclude, verbal memory has been explored in children with ASD using Forward and Backward Digit Span tasks. Some studies showed shorter memory spans in children with ASD as compared to peers with TLD, others did not confirm this gap. Importantly, it is not clear whether syntactic abilities of children with ASD are linked to deficiencies in vSTM and vWM.

Syntactic abilities and verbal memory in bilingual children with ASD

As for bilingual children, previous studies found that bilinguals with TLD have lower syntactic abilities compared to monolingual children with TLD, as measured by SRep tasks (Antonijevic, Durham, & Chonghaile, 2017; Fleckstein, Prévost, Tuller, Sizaret, & Zebib, 2018; Komeili & Marshall, 2013; Meir, 2017). Yet, this negative effect of bilingualism on SRep tasks disappears when vocabulary scores are controlled for (Komeili & Marshall, 2013; Meir, 2017). Furthermore, numerous studies have shown that the use of monolingual norms for the assessment of language skills in bilingual children leads to over-diagnosis of language impairment in bilingual populations, suggesting that separate norms should be empirically derived for bilingual populations (e.g., Armon-Lotem & Meir, 2016; V. C. M. Gathercole, Thomas, Roberts, Hughes, & Hughes, 2013).

Despite the vocabulary gap between monolingual and bilingual children, bilingual children with TLD are reported to have an advantage on some complex non-verbal tasks of executive control (e.g., Bialystok, Craik, & Luk, 2012). On tests of verbal memory (vSTM and vWM), bilinguals are reported to perform on par with their monolingual peers (Engel de Abreu, 2011; Meir, 2017), or even outperform them when tested in the dominant language (Delcenserie & Genesee, 2017; Kaushanskaya, Gross, & Buac, 2014).

Now turning to studies assessing combined and separate effects of bilingualism and ASD on syntactic abilities and verbal memory, such studies are rare. A recent report by Gonzalez-Barrero and Nadig (2018) is of particular interest. The authors described separate and combined effects of ASD and bilingualism on language performance and vWM (as measured by Backward Digit Span) in children aged 6–9. The study was conducted in Canada: multilingual children spoke English, French, or Spanish or a combination of these languages. The study included 40 children: 20 monolingual children (10 with TLD and 10 with ASD) and 20 bilingual children (10 with TLD and 10 with ASD). The four groups were matched for non-verbal IQ and socio-economic status. Bilingual children were tested in both of their languages. Using a SRep task and a cut-off score of –1 SD below the mean, it was determined that some children in the monolingual and bilingual groups scored at-risk for LD (4 of 10 in the monolingual ASD group and 3 of 10 in the bilingual ASD group). These findings reiterate previous results for monolingual children with ASD; showing that some bilingual children with ASD have intact syntax, while others have impaired syntax. As for vWM, the results indicated that when children were tested in their dominant language, there was no effect of ASD, no effect of bilingualism, and no interaction between ASD and bilingualism. However, the link between syntactic abilities and vWM was not tested.

The current study

The current study investigated syntactic abilities and verbal memory (vSTM and vWM) and the association between them among monolingual and bilingual children with and without HFA. First, we tested separate and combined effects of HFA and bilingualism on syntactic abilities. We also examined the extent to which individuals with HFA (monolingual and bilingual) are at-risk for LD. Following previous research on bilingual children with DLD, we investigated syntactic abilities in both languages of bilingual children. We also explored error patterns in children with HFA who scored at-risk for LD and discuss the characteristics of these errors with those of monolingual and bilingual children with DLD from previous studies. Second, we explored separate and combined effects of HFA and bilingualism on vSTM and vWM. Following previous studies (Meir, 2017; Paradis, 2010), we interpreted the combined effects of HFA and bilingualism by looking at interactions between HFA and bilingualism. Third, we measured the relationship between children's syntactic abilities and verbal memory (vSTM and vWM).

Method

Participants

Eighty-six children participated in the study: 28 with HFA (14 monolinguals with HFA [monoHFA] and 14 bilingual children with HFA [biHFA]), and 58 children with TLD (28 monolinguals with TLD [monoTLD] and 30 bilinguals with TLD [biTLD]). All bilingual participants were Hebrew–Russian bilinguals for whom Hebrew is the societal language and Russian is the heritage language. All children were tested on the Raven's colored progressive matrices (Raven, 1998) for non-verbal IQ. Of the initial 90 participants recruited for the study, two biHFA who spoke a heritage language other than Russian were excluded, one child was excluded due to lack of cooperation and one based on low Raven's scores (the cut-off was 70).

Background information was collected via the 'BIPAQ' parental questionnaire (Abutbul-Oz, Armon-Lotem, & Walters, 2012). Information included age of onset of societal language, length of exposure to the societal language calculated as the child's chronological age minus age of onset, and current exposure to the societal language. As a control language measure, receptive vocabulary was assessed using comprehension subtests of the Hebrew LITMUS CLT task (Altman, Goldstein, & Armon-Lotem, 2017) and the Russian LITMUS CLT task (Gagarina & Nenonen, 2017).

Children with TLD (monolingual and bilingual) had no prior parental concerns about their language milestones and did not have any diagnosed developmental disorders such as DLD, ASD, and/or ADHD, or hearing impairment, as determined by parental questionnaires. All children with TLD were attending mainstream kindergartens and schools in Israel.

Children with HFA (monoHFA and biHFA) were diagnosed prior to the study and were recruited from special education kindergartens and classes for children with ASD. Their diagnostic status was verified using the Autism Diagnostic Observation Schedule (ADOS, Lord et al., 2000) as part of the study battery.

Table 1 presents background information of the participants. A one-way ANOVA showed that the four groups did not differ on chronological age ($F(3,82) = 0.15, p = .93$) and non-verbal IQ ($F(3,82) = 1.23, p = .31$). The groups did not differ on their socio-economic status as measured by the mother's years of education; although there was a significant effect of group ($F(3,78) = 3.25, p = .03$), post-hoc pair-wise comparisons indicated that none of the pair-wise group differences reached significance ($p > .05$). The two HFA groups (monoHFA and biHFA) showed no significant differences on the severity of autism as measured by ADOS scores ($t(26) = .83, p = .42$).

Bilingual children with TLD and HFA were born to Russian-speaking parents and at the time of testing were attending educational settings (mainstream or special communication preschool/schools) in which Hebrew is the language of instruction. In Israel, compulsory education starts at the age of 5 and children attend educational settings 6 days a week from 8 a.m. till 1 p.m. (Novogrodsky & Kreiser, 2019). The two bilingual groups did not differ on age of onset of the societal language, i.e., Hebrew ($t(42) = .51, p = .61$), length of exposure ($t(42) = .09, p = .93$), and current exposure to Hebrew ($t(42)= .63, p = .53$).

In addition, we assessed children's receptive vocabulary. Bilingual children were tested in both languages. For the analysis of Hebrew receptive vocabulary skills (Table 2), we used a 2 × 2 ANOVA with Clinical Status (HFA vs. TLD) and Language Status (Monolinguals vs. Bilinguals) as independent variables. The analysis yielded a significant effect of Clinical Status ($F(3,82) = 22.96, p < .001, \eta_p^2 = .22$), a significant effect of Language Status ($F(3,82) = 5.80, p = .02, \eta_p^2 = .07$), and no significant interaction between Clinical Status and Language Status ($F(3,82) = 0.25, p = .62$). As expected, bilingual children scored lower on the societal language, meaning that vocabulary measures should be included as a covariate (see the Results section). We also analyzed

Table 1. Background information of the participants in each group.

		monoHFA (n = 14)	biHFA (n = 14)	monoTLD (n = 28)	biTLD (n = 30)
Gender (girls/boys)		0/14	3/11	18/10	16/14
Age (months)	*M*	80	83	81	80
	(SD)	(19)	(17)	(13)	(13)
	Range	54–110	60–108	63–100	60–103
Mother's education (years)	*M*	15	16	16	18
	(SD)	(2)	(4)	(2)	(3)
	Range	12–18	12–25	12–21	10–24
Age of onset of Hebrew (months)	*M*	n/a[a]	20	n/a[a]	16
	(SD)		(26)		(18)
	Range		0–80		0–60
Length of exposure to Hebrew (months)	*M*	n/a[a]	63	n/a[a]	64
	(SD)		(25)		(20)
	Range		19–108		11–98
Current exposure to Hebrew (months)	*M*		55		53
	(SD)		(14)		(14)
	Range		25–75		25–75
Raven (raw score)	*M*	20	22	23	23
	(SD)	(6)	(6)	(7)	(6)
	Range	13–32	13–36	10–34	14–36
ADOS (raw score)	*M*	12	11	n/a	n/a
	(SD)	(4)	(3)		
	Range	8–21	7–19		

[a]For monolingual Hebrew-speaking children, age of onset is 0 (i.e., from birth), since they were not exposed to any other languages, and length of exposure to societal language – Hebrew – is equal to their chronological age. n/a: not applicable.

Table 2. Receptive vocabulary skills per group.

		monoHFA (n = 14)	biHFA (n = 14)	monoTLD (n = 28)	biTLD (n = 30)
Vocabulary in Hebrew (Maximum 64)	*M*	54	52	62	58
	(SD)	6	8	4	6
	Range	38–61	34–60	43–64	38–64
Vocabulary in Russian (Maximum 64)	*M*	n/a	52	n/a	56
	(SD)		11		5
	Range		21–61		45–62

n/a: not applicable

receptive vocabulary scores in Russian for biHFA and biTLD. The results indicated no significant difference between the two groups as determined by an independent t-test for unequal variance ($t(15.18) = 1.62, p = .13$), since the Levene's Test for equality of variance detected a violation in the equality of variance.

Tasks

Syntactic abilities. Shortened versions of the Hebrew and Russian LITMUS Sentence Repetition task (SRep-30) (Marinis & Armon-Lotem, 2015) were administered. The tasks contain 30 of the 56 stimuli from the original LITMUS Hebrew and Russian SRep task (Meir, Walters, & Armon-Lotem, 2016). The Hebrew LITMUS SRep-30 task included SVO sentences with obligatory and optional prepositions, biclausal sentences with coordination, object *wh*-questions, oblique *wh*-questions, object relatives, oblique relatives, conditionals, and biclausal sentences with conjunctional phrases. The Russian LITMUS SRep-30 task included SVO sentences with obligatory and optional prepositions, SOV sentences, direct object *wh*-questions, oblique *wh*-questions, subject relatives, object relatives, and conditionals.

Verbal memory. The Hebrew Forward Digit Span (FWD) and the Hebrew Backward Digit Span (BWD) adapted from the Wechsler Intelligence Scale for Children (Wechsler, 1991) were used to assess vSTM and vWM. Children were tested in the societal language, i.e., Hebrew, because previous studies evaluating children's verbal memory in both languages found no differences between the performance of monolingual and bilingual children in this language (Meir, 2017).

Procedure and coding

Informed parental consent was obtained for each child prior to participation. The study was approved by the Institutional Review Board of Haifa University and by the Israeli Ministry of Education.

Each participant was tested individually in a quiet room in the preschool/school or at home. The Hebrew and Russian LITMUS SRep-30 tasks and the Hebrew FWD and BWD tasks were pre-recorded for consistency of presentation and were presented via a computer screen. The child heard each stimulus only once and was instructed to repeat it verbatim.

Russian and Hebrew SRep-30 tasks. The children's repetitions of the sentences were considered correct if the target syntactic structure was correctly reproduced. Lexical substitutions were scored as correct (e.g., uncle/man, soup/food, cooked/made). This scoring method is advantageous for evaluating syntactic abilities without penalizing for vocabulary errors (Marinis & Armon-Lotem, 2015). The proportion of correctly repeated sentences was calculated, and detailed error analysis was conducted, based on Meir et al. (2016).

FWD and BWD. The children were asked to repeat digit sequences orally. Test items consisted of two lists of digits administered for each length, beginning with a length of two digits, and increasing in length by one digit following successful repetition of at least one list of digits of a given length. The task was discontinued when the child failed at two consecutive digit sequences of the same length. The longest list length correctly repeated for each span (FWD and BWD) was noted.

Statistical analysis

Data analysis was carried out using SPSS Statistics, Version 25.0. Two-way ANOVAs were applied on syntactic abilities in Hebrew and on verbal memory (vSTM and vWM) in order to estimate separate and combined effects of Clinical Status (HFA vs. TLD) and Language Status (Monolinguals vs. Bilinguals). Combined effects of Clinical Status and Language Status were determined by interactions between the two variables. To evaluate the magnitude of each factor, effect sizes were determined by partial eta squared (η_p^2). To probe syntactic abilities in Russian, we compared the two bilingual groups (biHFA and biTLD) using independent *t*-tests. The equality of variance was tested using Levene's Test: if the equality of variance was violated, we reported *t*-values and *p*-values with corrected degrees of freedom.

Results

The results section is structured as follows. First, we present the analysis for syntactic abilities of Hebrew and Russian. We analyzed the performance of children with HFA in terms of the presence/absence of LD (as determined in the section below) and looked into their error patterns. Second, we present findings for verbal memory. Finally, we tested the associations between syntactic abilities and verbal memory. Descriptive statistics for performance on syntactic and verbal memory abilities are presented in Table 3.

Syntactic abilities in monolingual and bilingual children with and without HFA

Syntactic abilities in Hebrew. Our first research question aimed to evaluate independent and combined effects of bilingualism and HFA on syntactic abilities. We analyzed scores on the Hebrew SRep-30 task (Table 3) using a 2 × 2 ANOVA with Clinical Status (HFA vs. TLD) and Language Status (Monolinguals vs. Bilinguals) as independent variables. The analysis yielded a significant effect of Clinical Status ($F(1,81) = 57.61$, $p < .001$, $\eta_p^2 = .42$) and a marginal effect of Language Status ($F(1,81) = 5.60$, $p = .055$, $\eta_p^2 = .04$), with no significant interaction between the two variables ($F(1,81) = 0.62$, $p = .434$). The observed significant effect of Clinical Status indicated that children with HFA (monoHFA and biHFA) scored lower than children with TLD (monoTLD and biTLD) did. The effect of Language Status was marginal: bilingual children had slightly poorer performance as compared to their monolingual peers. Yet, the effect of Clinical Status was robust (compare the effect of HFA and bilingualism: $\eta_p^2 = .42$ and $\eta_p^2 = .04$). The lack of significant interaction indicates that bilingualism affects biHFA and biTLD similarly.

Since there were group differences in receptive vocabulary scores (see section Participants above), we re-analyzed the Hebrew SRep-30 scores using an ANCOVA with Clinical Status (HFA vs. TLD) and Language Status (Monolinguals vs. Bilinguals) as independent variables and receptive vocabulary scores in Hebrew as a covariate. The results indicated that the effect of Clinical Status remained significant ($F(1,80) = 30.70$, $p < .001$, $\eta_p^2 = .28$), whereas the effect of Language Status disappeared ($F(1,82) = 0.58$, $p = .45$). This is an important finding suggesting that once vocabulary knowledge is controlled, bilingual and monolingual children perform similarly on the SRep task. Furthermore, the interaction between Clinical Status and Language Status remained insignificant ($F(1,80) = 0.00$, $p = .95$).

Table 3. Participants' performance on the tasks.

		monoHFA (n = 14)	biHFA (n = 14)	monoTLD (n = 28)	biTLD (n = 30)
Syntactic abilities in Hebrew	*M*	0.63	0.58	0.96	0.85
(Hebrew LITMUS SRep-30)[a]	(SD)	0.24	0.26	0.06	0.15
	Range	0.03–0.93	0.17–0.93	0.83–1.00	0.43–1.00
Syntactic abilities in Russian	*M*	n/a	0.66	n/a	0.87
(Russian LITMUS SRep-30)[b]	(SD)		0.30		0.11
	Range		0.23–0.97		0.63–1.00
vSTM (FWD)[b]	*M*	3.43	2.92	4.11	4.17
	(SD)	1.02	0.76	0.88	1.46
	Range	2–6	2–4	2–6	3–9
vWM (BWD)[b]	*M*	2.79	1.85	3.21	3.07
	(SD)	1.31	1.72	0.92	1.07
	Range	0–6	0–5	2–6	2–6

[a]One bilingual child with HFA refused to perform the tasks in Hebrew.
[b]One bilingual child with HFA and one bilingual child with TLD refused to perform the SRep-30 task in Russian. n/a: not applicable

Syntactic abilities in Russian. We compared total scores on the Russian SRep-30 task across the biHFA and the biTLD groups (Table 3). The results showed that the biHFA group scored significantly lower as compared to their biTLD peers, as determined by the t-test for unequal variance ($t(13.37) = 2.47$, $p = .03$, Cohen's $d = .93$). This gap in the Russian SRep task between the groups cannot be attributed to lower vocabulary scores in children with HFA, since both groups obtained similar scores on receptive vocabulary in Russian.

HFA and language disorder

Subsequently, we focused on the individual data with the main aim to assess children's performance relative to empirically-derived cut-off points for monolingual and bilingual children (Armon-Lotem & Meir, 2016)[1] for both SRep Tasks (Figure 1(a) and (b)).[2] The results indicated that 86% of monoHFA children (12 of 14) scored in the LD range and only 14% (2 of 14) showed intact syntactic abilities. As for biHFA children, the picture was different: only 29% (4 of 14) scored in the LD range for bilingual children, i.e., below the cut-off points in the two languages. The majority of biHFA children showed intact syntactic abilities in one of their languages: 5 children showed performance above the cut-off point in Russian, 1 child showed performance above the cut-off point in Hebrew, and 4 children showed performance above the cut-off in both languages.

Performance of children with HFA with and without language disorder across different syntactic structures. We further compared the performance of monoHFA and biHFA children with Language Disorder (+LD) and with normal language (+NL) on the different syntactic structures in Hebrew (Table 4) and in Russian (Table 6). The subgroup of monoHFA+NL showed consistently high performance across most of the syntactic structures. The only

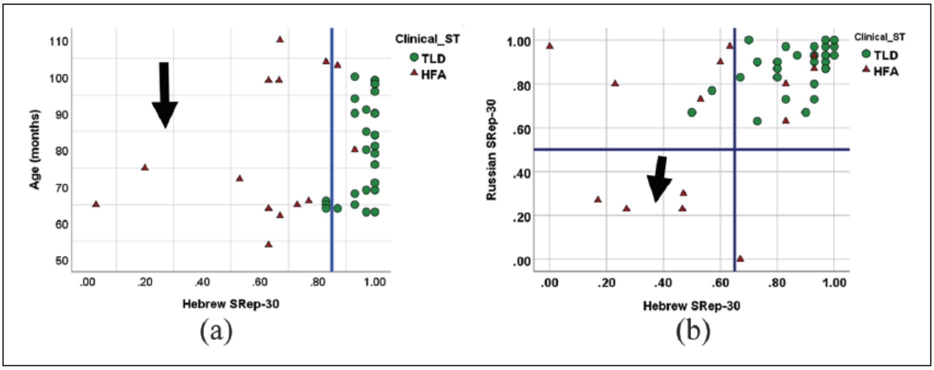

Figure 1. Syntactic abilities in HFA groups (monolingual and bilingual). (a) Performance of monolingual children below the *monolingual* cut-off point in Hebrew.[a] (b) Performance of bilingual children below the *bilingual cut-off point* in Hebrew and in Russian.[a]
[a] For monolingual children, we used age as a dummy variable to plot syntactic abilities; for bilingual children, syntactic abilities skills in both Russian and Hebrew were plotted, and for two children who refused to perform one of the SRep tasks, we used a dummy score '0'.

Table 4. Performance of children with HFA with Language Disorder (HFA+LD) and without Language Disorder (HFA+NL) across different syntactic structures in Hebrew.

	monoHFA+NL (*n* = 2)	monoHFA+LD (*n* = 12)	biHFA+NL (*n* = 9)[a]	biHFA+LD (*n* = 4)
1. SVO + free prepositions	1.00 (0.00)	0.83 (0.33)	0.89 (0.24)	0.75 (0.17)
2. SVO + obligatory prepositions	1.00 (0.00)	0.92 (0.29)	0.96 (0.11)	0.83 (0.19)
3. VSO	1.00 (0.00)	0.69 (0.39)	0.56 (0.33)	0.25 (0.17)
4. Object wh-questions	1.00 (0.00)	0.39 (0.28)	0.63 (0.35)	0.17 (0.19)
5. Oblique wh-questions	1.00 (0.19)	0.47 (0.30)	0.59 (0.36)	0.17 (0.19)
6. Object relatives	1.00 (0.00)	0.69 (0.44)	0.81 (0.34)	0.42 (0.32)
7. Oblique relatives	1.00 (0.00)	0.72 (0.40)	0.67 (0.37)	0.17 (0.19)
8. Biclausal sentences	0.83 (0.24)	0.67 (0.38)	0.78 (0.33)	0.42 (0.32)
9. Conditionals	0.67 (0.00)	0.39 (0.19)	0.67 (0.33)	0.17 (0.19)
10. Biclausal with conjunctional phrases	0.50 (0.24)	0.06 (0.13)	0.41 (0.43)	0.08 (0.17)

[a]One bilingual child with HFA refused to perform the SRep-30 in Hebrew.

structures that seemed to present difficulties were conditional sentences and biclausal sentences with conjunctional phrases (Table 4). The subgroup of monoHFA+LD scored significantly lower than the subgroup of monoHFA+NL did on various structures (Table 4). These included object and oblique *wh*-questions, object and oblique relatives, conditionals, and biclausal sentences with conjunctional phrases (all comparisons at $p < .05$).

Similarly, the comparison of the subgroups of biHFA+NL and biHFA+LD (Table 4) revealed significant group differences on various structures: object *wh*-questions, oblique

Table 5. Most frequent error patterns of children with HFA who scored at-risk for Language Disorder (+LD) across different syntactic structures in Hebrew (% of total errors).

	monoHFA+LD (n = 12)	biHFA+LD (n = 4)
1. SVO+free prepositions	Sentence fragment (50%)	Sentence fragment (29%)
2. SVO+obligatory prepositions	n/a	n/a
3. VSO	SVO (63%)	Sentence fragment (78%) SVO (22%)
4. Object *wh*-questions	Sentence fragment (41%) Subject *wh*-question (41%)	Sentence fragment (70%) Subject *wh*-question (30%)
6. Oblique *wh*-questions	Preposition omission (44%)	Subject/Object omission (40%) Preposition omission (20%)
7. Object relatives	SVO (18%) Sentence fragment (18%) Coordination (18%) No response (18%)	Other (57%)
8. Oblique relatives	SVO (30%) Subject relative (30%) No response (30%)	Sentence fragment (30%) SVO (30%) Subject relative (20%)
9. Biclausal sentences	Sentence fragment (67%) Conjunction omission (25%)	Sentence fragment (71%)
10. Conditionals	Sentence fragment (45%) Conjunction omission (23%) Auxiliary omission (14%)	Sentence fragment (60%) Coordination (20%)
11. Biclausal with conjunctional phrases	Sentence fragment (22%) Conjunction omission (72%)	Sentence fragment (36%) Conjunction omission (27%) Coordination (18%)

wh-questions, oblique relatives, conditionals, and biclausal sentences with conjunctional phrases (all comparisons at $p < .05$).

It should be noted that both groups of children with HFA and LD showed high performance on simple Subject Verb Object sentences (SVO) with free and obligatory prepositions.

In order to better understand the characteristics of grammatical difficulties in monoHFA and biHFA children who scored at-risk for LD, we analyzed their error patterns (Table 5). They produced sentence fragments and showed simplification of complex structures (e.g., they repeated object *wh*-questions using simple SVO structures, or subject *wh*-questions).

We further compared the performance of biHFA children with and without LD on the Russian SRep-30 (Table 6). Comparisons of the two subgroups showed that biHFA+LD scored significantly lower than did biHFA+NL on all targeted structures ($p < .05$) (Table 7).

Finally, we analyzed error patterns in the subgroup of biHFA+LD in Russian. The results showed the same pattern that emerged in Hebrew: children omitted obligatory

Table 6. Performance of biHFA with Language Disorder (HFA+LD) and without Language Disorder (HFA+NL) across different syntactic structures in Russian.

	biHFA+NL (*n* = 9)[a]	biHFA+LD (*n* = 4)
1. SVO+free preposition	0.93 (0.15)	0.67 (0.00)
2. SVO+obligatory preposition	0.89 (0.24)	0.33 (0.27)
3. SOV	0.89 (0.17)	0.33 (0.27)
4. Biclausal with coordination	0.96 (0.11)	0.25 (0.17)
5. Biclausal with subordination	0.85 (0.24)	0.33 (0.38)
6. Object *wh*-questions	0.78 (0.24)	0.33 (0.27)
7. Oblique *wh*-questions	0.89 (0.17)	0.25 (0.17)
8. Subject relatives	0.89 (0.24)	0.08 (0.17)
9. Object relatives	0.59 (0.40)	0.00 (0.00)
10. Conditionals	0.81 (0.18)	0.00 (0.00)

[a]One bilingual child with HFA refused to perform the SRep-30 task in Russian.

Table 7. Most frequent error patterns of children with HFA who scored at-risk for Language Disorder across different syntactic structures in Russian.

	biHFA+LD (*n* = 4)
1. SVO+free preposition	n/a
2. SVO+obligatory preposition	Sentence fragment (50%) Preposition omission (38%)
3. SOV	Case error (43%)
4. Biclausal with coordination	Sentence fragment (44%) Conjunction omission (33%)
5. Biclausal with subordination	Conjunction omission (38%)
6. Object *wh*-questions	Sentence fragment (63%)
7. Oblique *wh*-questions	Omission of subject or object (38%)
8. Subject relatives	SVO (75%)
9. Object relatives	SVO (45%) Other (27%)
10. Conditionals	Sentence fragment (50%) Conjunction omission (42%)

parts of the primed sentence and simplified complex syntactic structures into more simple ones. For example, as in Hebrew, in Russian they repeated target object relative clause structures as SVO structures.

To summarize, monoHFA and biHFA children showed similar syntactic profiles: some children scored at-risk for LD, some showed intact syntactic abilities. The types of errors and significant difficulties with certain structures suggest that the characteristics of the syntactic difficulty of these two subgroups are similar to those observed in monolingual and bilingual children with DLD. This is taken up in the Discussion section.

Verbal memory spans (vSTM and vWM) in monolingual and bilingual children with and without HFA

The analysis of verbal memory (vSTM as measured by FWD and vWM as measured by BWD) yielded significant effects of Clinical Status (for FWD: $F(3,81) = 13.34$, $p < .001$, $\eta_p^2 = .14$ and for BWD: $F(3,81) = 8.86$, $p < .001$, $\eta_p^2 = .10$). Yet, there was no significant effect of Language Status for FWD ($F(3,81) = 0.72$, $p = .40$) and no effect of language status for BWD ($F(3,81) = 3.83$, $p = .054$). No significant interaction between Clinical Status and Language Status was found (for FWD: $F(3,81) = 1.15$, $p = .29$ and for BWD: $F(3,81) = 2.05$, $p = .16$). The effect of Clinical Status indicated that children with HFA had smaller verbal spans (vSTM and vWM) as compared to their peers with TLD. However, no differences were observed between biHFA and monoHFA children, as shown by no significant effect of Language Status and no significant interaction between Language Status and Clinical Status.

Since bilingual children scored lower than monolingual children did on the receptive vocabulary scores, we re-analyzed the FWD and BWD scores using an ANCOVA with Clinical Status (HFA vs. TLD) and Language Status (Monolinguals vs. Bilinguals) as independent variables and receptive vocabulary scores in Hebrew as a covariate. The effect of Clinical Status did not disappear for vSTM ($F(4,81) = 5.27$, $p = .02$, $\eta_p^2 = .06$) when receptive vocabulary scores were controlled for. However, this effect disappeared for vWM ($F(4,79) = 1.36$, $p = .25$). The effect of Language Status and the interaction between Clinical Status and Language Status remained insignificant for vSTM ($F(4,80) = 0.09$, $p = .77$, $F(4,80) = 1.98$, $p = .16$, respectively) and for vWM ($F(4,79) = 1.90$, $p = .17$, $F(4,79) = 3.23$, $p = .08$, respectively).

The relationship between syntactic abilities and verbal memory in monolingual and bilingual children with HFA

At the group level, children with HFA showed lower syntactic abilities as compared to their TLD peers. However, the group measures did not reflect the high heterogeneity within this population. In the current study, some children with HFA, both monolingual and bilingual, showed intact syntactic abilities, whereas others were impaired. Our third research question addressed the associations between syntactic abilities and verbal memory. In the group of children with HFA, language measures were interrelated: syntactic abilities strongly correlated with receptive vocabulary ($r(28) = .903$, $p < .001$). In addition, the two tasks tapping into verbal memory were interrelated: there were significant correlations between vSTM and vWM ($r(28) = .648$, $p < .001$) (Table 8). However, no correlations were detected between memory spans (vSTM and vWM) and syntactic abilities (Table 8; see also Appendix A). In addition, age correlated only with non-verbal IQ ($r(28) = .558$, $p < .001$), while it did not correlate with any of the language measures (Hebrew expressive vocabulary and Hebrew SRep) or with any of the verbal memory measures (vSTM and vWM) (see Table 8).

Exploring the relationship between verbal memory measures and morphosyntax across monolingual and bilingual children with HFA, we additionally ran separate correlational analyses for monoHFA and biHFA children (see Appendices B1 and B2). Yet,

Table 8. Pearson correlation analysis for monolingual and bilingual children with HFA (n = 28).

	Age	Non-verbal IQ	vSTM	vWM	Hebrew receptive vocabulary	Hebrew SRep-30
Age						
Non-verbal IQ	.558**					
vSTM	.125	.192				
vWM	.195	.200	.647**			
Hebrew receptive vocabulary	.171	.233	–.035	.205		
Hebrew SRep-30	.259	.250	.179	.243	.903**	

*Correlation was significant at the .05 level (2-tailed).
**Correlation was significant at the .01 level (2-tailed).

no significant correlations were detected between verbal memory (vSTM and vWM) and morphosyntactic abilities in either group.

We further compared the performance of children with HFA+LD and HFA+NL on verbal memory. Both subgroups showed similar performance on vSTM ($t(25) = .02, p = .99$) and vWM ($t(25) = .91, p = .37$).

Finally, we ran binominal regression analyses with LD as a dependent factor and vSTM and vWM as independent variables to assess whether verbal memory skills can predict LD status of children with HFA. The results indicated that the model was not significant. Neither vSTM ($\beta = .43$, SE = .59, Wald $\chi^2(1) = .61, p = .44$), nor vWM ($\beta = .42$, SE = .36, Wald $\chi^2(1) = 1.39, p = .24$) predicted LD status of children with HFA.

Discussion

The current study evaluated syntactic abilities and verbal memory (vSTM and vWM) and the association between these two abilities among monolingual and bilingual children with and without HFA. First, we assessed separate and combined effects of HFA and bilingualism on syntactic abilities. In order to evaluate the heterogeneity of syntactic abilities in children with HFA, we explored children's individual profiles by assessing their scores relative to at-risk for DLD performance and error patterns. Second, we assessed separate and combined effects of HFA and bilingualism on verbal memory (vSTM and vWM). Finally, we explored the relationship between syntactic abilities and verbal memory (vSTM and vWM) in monolingual and bilingual children with HFA. This comparison contributes to the ongoing debate of the role of verbal memory among children with atypical language development.

Separate and combined effects of bilingualism and HFA on syntactic abilities

The findings showed a negative effect of bilingualism and a negative effect of HFA on syntactic abilities. As a group, children with HFA scored lower than those with TLD. This was observed in both Hebrew (the societal language) and in Russian (the heritage language of the bilingual children). Furthermore, bilingual children scored lower on syntax as compared to their monolingual peers. This is in line with previous studies showing that bilingual children score lower on SRep tasks when compared to monolingual peers (Antonijevic et al., 2017; Fleckstein et al., 2018; Komeili & Marshall, 2013; Meir, 2017; among many others). Yet, similarly to previous research (Komeili & Marshall, 2013; Meir, 2017), our study showed that the negative effect of bilingualism disappeared once vocabulary scores were controlled for. These findings suggest that poor performance on tasks assessing syntactic abilities in bilingual children is driven by smaller vocabulary size.

However, turning to the effect of HFA, although the effect size of HFA was diminished when vocabulary scores were controlled for (compare $\eta_p^2 = .42$ vs. $\eta_p^2 = .28$), the negative impact of HFA did not disappear. This suggests that although vocabulary size affects syntactic abilities, the low performance of children with HFA cannot be entirely explained by their smaller vocabulary sizes. This is in line with previous findings on children with DLD. For example, children with DLD are reported to perform lower on morphosyntax in comparison with younger vocabulary-matched controls (Briscoe, Bishop, & Norbury, 2001; Riches, 2012). It is thus suggested for both populations that reduced lexical abilities do not fully explain difficulties with syntactic structures.

Finally, looking at the combined effects of bilingualism and HFA, our study shows that bilingualism similarly affects children with TLD and HFA and it is not an aggravating factor among children with HFA.

Individual performance of monolingual and bilingual children with HFA on syntax

In order to explore individual scores of monolingual and bilingual children with HFA, we applied empirically-generated norms for monolingual and bilingual children (see Armon-Lotem & Meir, 2016). The use of separate norms for monolingual and bilingual children has been shown to diminish rates of over-diagnosis of language disorders in bilingual populations.

The analysis of individual profiles of children with HFA showed that some children with HFA have intact syntactic abilities, while others score at-risk for LD. This has been previously demonstrated for monolingual children with HFA (Durrleman & Delage, 2016; Kjelgaard & Tager-Flusberg, 2001; Modyanova et al., 2017; Schaeffer, 2018; Tuller et al., 2017; Whitehouse et al., 2008). These results highlight varying language profiles within the group of children with HFA (Novogrodsky, 2015). The novelty of the current study is the findings of heterogeneity of syntactic skills for bilingual children with HFA: some children scored in the LD range for bilingual children, while others showed intact syntactic abilities: 5 in Russian, 1 in Hebrew, and 4 in both languages. Interestingly, we showed that most monoHFA children were at-risk for LD based on SRep task performance. A simple explanation for this finding is the random sample of the current study. However, we would like to suggest two other possibilities to explain the distribution discrepancy between monolingual and bilingual children with HFA. One is that bilingualism might serve as a compensatory mechanism for children with HFA as suggested for bilingual children with typical (Engel de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012) and atypical language development (Armon-Lotem, 2010; Cleave, Bird, Trudeau, & Sutton, 2014). It has been previously suggested that learning one language can bootstrap the acquisition of the second language, especially in sequential bilingual children (for more detail see Paradis, 2010).

A different explanation is the widely reported over-representation of bilingual children in special education due to the unbalanced distribution of language skills across their two languages and inadequacy of monolingual norms in the assessment of bilingual children (Zhang, Katsiyannis, Ju, & Roberts, 2014). Bilingual children are often evaluated in the societal language using monolingual norms. Thus, their scores are more likely to be lower, which is a common cause for referring them to special education programs. This is also evident in our study: bilinguals scored lower than monolinguals. Future studies should include monolingual and bilingual children with HFA from mainstream education programs as well, not only from special education programs as was the case in the current study. This would allow to explore distribution rates of monolingual and bilingual children with HFA across special and mainstream education settings and further explore the idea of bilingual advantage.

While some children with HFA show intact syntactic abilities, some monolingual and bilingual children with HFA who score at-risk for Language Disorder show problems with complex syntax, e.g., problems with object relatives and object *wh*-questions. Error patterns of monolingual and bilingual children with HFA+LD are similar to those of monolingual and bilingual Hebrew–Russian speaking children with DLD (Meir et al., 2016; Novogrodsky & Friedmann, 2006). The current findings are in agreement with those of Silleresi et al. (2018), who found an overlap in linguistic profiles of children with ASD at-risk for LD and of children with DLD. However, there is also evidence that children with HFA who score at-risk for LD differ from children with DLD. For example, a recent study on monolingual Hebrew-speaking children with ASD performing at-risk for DLD showed that error profiles of children with ASD bore fundamental differences from those of children with DLD (Sukenik & Friedmann, 2018). The authors showed that participants with ASD not only simplified syntactic structures, but they also made substitution errors, perseverations, added information, and answered the primed questions instead of repeating them (Sukenik & Friedmann, 2018). It is important to note that some children with HFA in the current study also answered primed *wh*-questions, instead of repeating them; yet, this error pattern was observed in only a few children. We believe that a possible explanation for the difference between the two studies has to do with the coding schemes. In the current study, the coding scheme did not penalize participants for the types of errors presented by Sukenik and Friedmann (2018). Only the repetition of primed syntactic structure was coded, which is suggested to be advantageous for evaluating children's syntactic abilities (Marinis & Armon-Lotem, 2015). While Sukenik and Friedmann's (2018) coding scheme emphasized specific ASD traits (e.g., perseveration), the current study focused on syntactic abilities.

The distinction between two subgroups of children with ASD in both monolingual and bilingual populations is valuable for discussing the etiology of the impairment. Previous research suggested that the etiologies of children with ASD and children with DLD overlap, which raised the question as to whether DLD and autism are part of the same continuum (Bishop, 2010). The results of our study support the idea of two different etiologies. The fact that some children with HFA develop intact morphosyntactic skills is indicative that autism and DLD have different underlying causes. The overlap in linguistic profiles in children with HFA+LD and children with DLD might indicate that some children with HFA have a comorbid language disorder (Tager-Flusberg, 2006). A remaining question for future studies is, to what extent does this overlapping phenotype represent the neurological etiology of both populations? Yet, it is important to note that this overlap is observed within the domain of language and is not a general cognitive difficulty, as discussed in the next section.

Verbal memory and its association with syntactic abilities

The results for verbal memory (vSTM and vWM) indicated that monolingual and bilingual children with HFA had lower vSTM and vWM scores than their TLD peers. Importantly, our study demonstrated that bilingualism is not an exacerbating factor for memory skills of children with HFA, as discussed above for syntactic abilities.

The current study showed a significant difference in verbal memory capacity between children with HFA and children with TLD, in line with previous research (Lai et al., 2017). Deficient verbal memory has been suggested to be a key source of linguistic difficulties in children with DLD (Bishop, 1992; S. E. Gathercole & Baddeley, 1990). Thus, it is plausible to think that lower performance on syntax among children with HFA would be associated with low verbal memory capacity. However, previous studies report conflicting results on the links between verbal memory and syntactic abilities in these children (Durrleman & Delage, 2016; Durrleman et al., 2017; Schaeffer, 2018). The current results did not confirm associations between any of the verbal memory measures and syntactic abilities, supporting no link between verbal memory and syntactic abilities. Furthermore, following the analyses in Durrleman and Delage (2016) and Durrleman et al. (2017), we compared children with HFA+NL and HFA+LD on vSTM and vWM. Both types of analysis indicated that poor syntactic abilities cannot be attributed to deficiencies in vSTM and vWM.

Limitations

Although the study shed light on the heterogeneity of syntactic profiles in monolingual and bilingual children with HFA, the study has some limitations that should be addressed in future studies. First, SRep tasks were used as a proxy of syntactic abilities. SRep tasks are widely used for assessing children's morphosyntactic abilities (for a review, see Marinis & Armon-Lotem, 2015), yet SRep tasks are complex: they involve phonological, lexical-semantic, and morphosyntactic processing as well as speech production. Future studies should compare production and comprehension tasks in order to determine the nature of syntactic difficulties in children with HFA.

Secondly, our study provided evidence on syntactic skills and verbal memory of bilingual children with HFA. It showed no detrimental effect of bilingualism on any measures of verbal memory (vSTM and vWM), i.e., bilinguals performed similarly to monolinguals regardless of their clinical status. Yet, it is known that language skills of bilingual children vary between their two languages (Kohnert, 2010). Some bilingual children might show an enhanced performance in their dominant language as compared to their weaker language on measures of verbal memory. Thus, it is plausible to suggest that bilingual advantage was not observed in the current study because children were tested on verbal memory in the societal language (Hebrew). This advantage might be found when children are tested in both languages and their span in the dominant language is considered. Future studies should test verbal memory abilities of bilingual children with HFA in both of their languages.

Finally, the children with HFA (monolingual and bilingual) in the current study were recruited from special education programs. It is plausible to suggest that due to the lack of appropriate assessment tools and norms for bilingual children that they are over-represented in special education programs (e.g., Bedore & Peña, 2008). Thus, future studies should include monolingual and bilingual children with HFA from partial and full inclusion programs as well.

Conclusions

To conclude, the study found that syntactic skills in children with HFA vary regardless of children's language status. Some children with HFA show intact syntactic skills, while others show impared syntactic abilities. Problems with specific syntactic phenomena indicate impaired grammatical representation for some children with HFA, similarly to children with DLD (Marshall, Marinis, & van der Lely, 2007). The current study provides new evidence that syntactic difficulties in children with HFA (monolingual and bilingual) are not linked to verbal memory, in agreement with previous suggestions (Durrleman et al., 2017; Schaeffer, 2018).

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Notes

1. Based on Armon-Lotem and Meir (2016), empirically-generated cut-off points for the new, shorter versions of Hebrew and Russian SRep-30 were obtained.
2. Armon-Lotem and Meir (2016) reported 100% sensitivity and 87% specificity for monolingual Hebrew-speaking children and 100% sensitivity and 89% specificity for bilingual children on the Hebrew SRep-56 task. They reported 81% sensitivity and 81% specificity for the Russian SRep-56 task.

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Appendix A

Individual scores of HFA participants on the experimental tasks.

Participant	LD / NL	Language Status	SRep-30 (Hebrew)[b]	SRep-30 (Russian)[b]	FWD[c] (Hebrew)	BWD[d] (Hebrew)
1	LD	Bilingual	0.17	0.27	3	0
2	LD	Bilingual	0.27	0.23	2	2
3	LD	Bilingual	0.47	0.30	4	4
4	LD	Bilingual	0.47	0.23	3	3
5	LD	Monolingual	0.03	n/a	3	2
6	LD	Monolingual	0.20	n/a	5	6
7	LD	Monolingual	0.53	n/a	3	2
8	LD	Monolingual	0.63	n/a	3	2
9	LD	Monolingual	0.63	n/a	2	0
10	LD	Monolingual	0.63	n/a	3	2
11	LD	Monolingual	0.67	n/a	4	3
12	LD	Monolingual	0.67	n/a	3	3
13	LD	Monolingual	0.67	n/a	3	3
14	LD	Monolingual	0.73	n/a	3	3
15	LD	Monolingual	0.77	n/a	3	3
16	LD	Monolingual	0.83	n/a	4	3
17[a]	NL	Bilingual		0.97		
18	NL	Bilingual	0.23	0.80	3	0
19	NL	Bilingual	0.53	0.73	2	0
20	NL	Bilingual	0.60	0.90	3	2
21	NL	Bilingual	0.63	0.97	3	0
22[1]	NL	Bilingual	0.67		2	0
23	NL	Bilingual	0.83	0.63	2	2
24	NL	Bilingual	0.83	0.80	3	5
25	NL	Bilingual	0.93	0.93	4	3
17	NL	Bilingual	0.93	0.87	4	3
27	NL	Monolingual	0.87	n/a	3	3
28	NL	Monolingual	0.93	n/a	6	4

[a]Missing data.
[b]Based on Armon-Lotem and Meir (2016), empirically-generated cut-off points for the new, shorter versions of Hebrew and Russian SRep-30 were obtained. Bilingual children were classified as LD if they showed performance below the cut-off in both languages. The shaded cells represent performance below the cut-off point.
[c]We used cut-off points for FWD for monolingual and bilingual children based on Armon-Lotem and Meir (2016). The shaded cells represent performance below the cut-off point.
[d]No cut-off points are available for this population in Hebrew.

Appendix B1

Pearson correlation analysis for monoHFA ($n = 14$).

	Age	Non-verbal IQ	vSTM	vWM	Hebrew receptive vocabulary
Age					
Non-verbal IQ	.611*				
vSTM	.198	.102			
vWM	.193	–.102	.767**		
Hebrew receptive vocabulary	.390	.369	–.185	–.228	
Hebrew SRep-30	.330	.208	.090	–.071	.872**

Appendix B2

Pearson correlation analysis for biHFA ($n = 14$).

	Age	Non-verbal IQ	vSTM	vWM	Hebrew receptive vocabulary
Age					
Non-verbal IQ	.503				
vSTM	.066	.429			
vWM	.263	.510	.499		
Hebrew receptive vocabulary	.015	.186	.108	.532	
Hebrew SRep-30	.238	.327	.261	.460	.920**