Comprehension of “Narrow Focus” by Adolescents in the Autism Spectrum

Osnat Segal Dafna Kaplan Smadar Patael Liat Kishon-Rabin

Department of Communication Disorders, Sackler Faculty of Medicine, Tel-Aviv University, Petah Tiqwa, Israel

Keywords

Adolescents with autistic spectrum disorder · Narrow focus · Prosody

Abstract

Objective: The study compared the performance of adolescents with autistic spectrum disorder (ASD) to that of age-matched peers with typical development (TD) and cognitive language-matched peers with TD on measures of identification and comprehension of “narrow focus.” **Participants:** Forty-nine participants, 17 autistic, 17 TD peers matched for age and sex, and 15 TD children matched for expressive vocabulary participated in the study. **Method:** The Hebrew Narrow Focus Test (HNFT) was used. The HNFT includes 3 subtests. The first subtest (A) required identification of the stressed word in the sentence based on psychoacoustic abilities alone. The second (B) and third (C) subtests required understanding the meaning of focused stress in different contexts. In subtest B, the meaning of “narrow focus” was to contrast other possibilities related to the lexical-grammatical role of the stressed word in the sentence, whereas in subtest C, the meaning was to indicate a mistake. **Results:** ASD participants showed reduced performance compared to

peers across all the subtests of the HNFT, but similar performance compared to TD children in subtests A and B and better performance on subtest C. A significant correlation was found between the Raven test for assessing nonverbal intelligence and subtests B and C of the HNFT in the group of adolescents with ASD. **Conclusions:** Comprehension of narrow focus in adolescents with ASD who study in a special educational system is related to their cognitive-linguistic abilities and not to the autistic condition by itself or to its severity.

© 2017 S. Karger AG, Basel

Introduction

Prosody refers to the pitch, intensity, and durational qualities of speech [1]. These acoustic, suprasegmental changes create different prosodic features, such as intonation, lexical stress, and sentential emphasis, also termed as “narrow focus” [2–4]. Narrow focus refers to the accent/stress that falls on the accent-bearing syllable of one word in the sentence and highlights the part of information that has a special meaning [5, 6]. Studies have shown that individuals with autism spectrum disorder (ASD)

may have difficulties in the production and comprehension of prosody [7–17], and especially of affective-emotional prosody because of difficulties in understanding mental states of other people [18, 19]. However, little is known of the ability of these individuals to understand the semantic-pragmatic meaning of narrow focus [20, 21]. Furthermore, little is known of whether differences in the ability to understand the meaning of narrow focus among ASD individuals are related to autism severity or to cognitive-linguistic deficits that may accompany autism. Thus, the purpose of the present study was to assess comprehension of narrow focus in adolescents with ASD who demonstrate a range of cognitive and communication abilities.

One thought-provoking question is why individuals with ASD may show difficulties in comprehending the meaning of prosodic characteristics? The answer to this question is related to the cognitive theories that try to explain the core deficits and behaviors in autism, including abnormalities of social interaction and restricted repertoire of interests and activities [22]. These theories include the executive dysfunction (ED) hypothesis, the theory of mind (ToM), and weak central coherence (CC) [23]. The ED hypothesis suggests that individuals with ASD may have difficulties in cognitive domains including planning, attention shifting, problem solving, and working memory [24–26]. These cognitive factors may explain the core deficits of the autistic behavior, as well as difficulties in comprehension of prosodic features. The ToM, however, proposes that the basic deficit of autism involves a cognitive difficulty in inferring the mental states of others and therefore difficulties in inferring emotions and intentions of speakers through prosody [18, 19, 27]. The weak CC, on the other hand, refers to an information-processing style that includes a cognitive bias towards local rather than global processing [28, 29]. The weak CC may explain repetitive and obsessive behaviors, as well as enhanced discrimination of individual elements [30], and identification of embedded figures [31, 32]. In the linguistic domain, studies with ASD participants showed impaired ability to use the context in order to generate inferences [33] or in order to resolve ambiguous words [34]. Thus, difficulties in CC may limit the ability to comprehend the meaning of narrow focus in the context of the sentence. The present study was not designed to tease apart the three cognitive theories mentioned above, but rather to take an initial step towards understanding the influence of cognitive-linguistic abilities and autism severity on prosodic comprehension.

Studies on prosody in ASD have focused typically on the production of prosody. Since the first description of the autistic syndrome [35], abnormal production of prosody has been described as a core feature of autism [15–17]. Studies showed that abnormal use of prosody in participants with ASD includes monotonic or exaggerated intonation [36, 37], longer duration of utterances [38, 39], deficits in the use and control of pitch and volume [9], deficits in vocal quality [17], and improper use of stress [40]. However, not all individuals with ASD show improper use of prosody [41]. Nonetheless, expressive prosodic difficulties have been found to be persistent and to show little change over time [42, 43]. It was reported that prosodic differences are significantly related to ratings of ASD speakers' social and communicative competence [44], and that the prosody of individuals with autism created in listeners an impression of strangeness [45, 46].

In contrast to the studies that assessed production of prosody, fewer studies focused on comprehension of prosody in ASD participants [6, 17]. Some studies presented deficiencies in the comprehension of *affective* prosody [19, 47–50], while others did not [51–53]. As mentioned above, another aspect of prosody is the ability to comprehend narrow focus. Narrow focus emphasizes new and/or contrastive information [2–5]. For example, in the sentence “*PETER painted his bicycle” the subject “Peter” is emphasized in contrast to other possible operators, whereas in the sentence “Peter *PAINTED his bicycle” the predicate “painted” is emphasized in contrast to other optional actions such as “rode” [54, p 215]. Thus, the assignment of narrow focus to different lexical categories (e.g., noun, verb, adjective, adverb) results in different contrastive meanings. In other cases, for example, in the compound sentence “I wanted the *BLUE and black socks” narrow focus implies a mistake done by the addressee so that the speaker did not receive the blue socks [55].

To date, only limited data are available on the ability of ASD individuals to understand narrow focus. Furthermore, the existing research is equivocal. In one study, children with ASD performed poorly compared to peers in the task of narrow focus comprehension [21]. In this study, 31 children (24 boys) with high-functioning autism (HFA) (excluding Asperger syndrome) between the ages of 6;1 and 13;6 years and 72 typically developing (TD) controls matched on verbal mental age were tested. The children with ASD had nonverbal ability within the normal range and verbal mental age above 4 years of age. The diagnosis of autism was made by a multidisciplinary team and was based on ICD-10 [56] or DSM-IV [57] and

the Autism Diagnostic Observation Schedule [58]. The two groups of children completed a prosody assessment procedure (PEPS-C). Children with HFA showed reduced performance compared to controls on both receptive and expressive prosody tasks, including comprehension and production of intonation, affect, chunking, and narrow focus. In the receptive narrow focus task, sentences such as “I wanted CHOCOLATE and honey” were presented, followed by two pictures (e.g., chocolate and honey). The child was asked to choose which of the food items the speaker did not receive. Children with ASD showed reduced performance compared to peers matched on verbal mental age suggesting that the ability to understand the meaning of the stressed word in the sentence was not evident even when the possible effect of language abilities was controlled [21]. These results might reflect a deficit not only in narrow focus but rather a broader deficit related to ToM, executive functions, and/or integration of information as suggested by the weak CC hypothesis. In contrast, another study that assessed comprehension of narrow focus in high-functioning ASD young adults compared to TD peers did not find differences between the 2 groups [20]. In this study, 20 high-functioning male adults with ASD who had preserved cognitive and linguistic abilities, and 32 TD male adults, matched on age and verbal abilities, were tested. The participants with ASD were verbally fluent, and were either employed or in occupational training during the study. Participants’ diagnosis was confirmed using the Autism Diagnostic Observation Schedule [58]. All participants undertook a battery of auditory and prosodic tasks. These tasks included affective and pragmatic prosody recognition tasks, two psychoacoustic tasks (pitch direction recognition and pitch discrimination), and a facial emotion recognition task. Pragmatic prosody was assessed using a narrow focus task. Participants were asked to listen to sentences with narrow focus on different words and to choose for each sentence between 4 written options describing the specific meaning of narrow focus. The results showed that the ASD group performed similarly to peers on pragmatic prosody recognition and psychoacoustic tasks. A possible explanation for this outcome is related to the fact that the participants were high-functioning ASD individuals with no additional linguistic-cognitive difficulties [20]. It is also possible that participants with ASD develop comprehension of narrow focus with age.

Another study that assessed 27 participants with ASD with an average age of 16.8 years showed difficulties in comprehension of narrow focus compared to peers. The

ASD participants were diagnosed with HFA ($n = 14$), Asperger syndrome ($n = 10$) and Pervasive Developmental Disorders Not Otherwise Specified [57, 58]. They had verbal and performance IQs within normal limits. In this study, the participants heard a sentence with narrow focus on one of the words, and had to choose the sentence that came before it. For example, if they heard the sentence, “I want chocolate ice cream,” a sentence like “Do you want vanilla?” would have come before it [15]. It is possible that this task involved cognitive load on verbal working memory that may have influenced the results [59].

The autistic population is heterogeneous in terms of the autism severity, cognitive and linguistic abilities. Each of these factors may influence performance on comprehension of narrow focus. In particular, there is some evidence that linguistic abilities are related to prosodic comprehension. For example, prosodic comprehension measured by the PEPS-C test was correlated with linguistic measures of children with ASD [7]. It is also possible that reduced vocabulary may limit comprehension of the sentence and therefore affect comprehension of narrow focus. Other cognitive factors such as verbal mental age, nonverbal intelligence as well as the autism severity may influence performance on prosodic-comprehension tasks in individuals with ASD [22, 53]. Yet, data are missing on factors that may influence comprehension of narrow focus in adolescents with ASD.

In this context, the research questions of the present study were twofold: (1) whether adolescents with ASD identify and comprehend narrow focus similarly to TD age-matched peers, or to TD younger children, matched for cognitive-linguistic abilities, and (2) what are the associations between cognitive-linguistic measures and identification and comprehension of narrow focus. Specifically, we assessed the ability of adolescents with ASD to comprehend narrow focus using 3 subtests, each assessing a different aspect of processing and comprehension: (a) the recognition of the stressed word in the sentence, (b) inferring meaning in relation to the different grammatical role of the word carrying the “narrow focus” in simple sentences, and (c) inferring meaning in relation to the role of “narrow focus” in compound sentences, as indicating a mistake done by the addressee.

Method

Participants

The present study included 3 groups of participants: adolescents with ASD, TD adolescents and TD children.

Table 1. Descriptive characteristics of the TD adolescents, the ASD adolescents, and the TD children

	TD adolescents (<i>n</i> = 17; 13 m, 4 f)	ASD adolescents (<i>n</i> = 17; 13 m, 4 f)	TD children (<i>n</i> = 15; 6 m, 9 f)
Age, years	17.39±1.49 (15.25–20.08) *F(2, 23) = 559.28, <i>p</i> < 0.0001 Post hoc analysis (Games-Howell): <i>p</i> = 0.99 ns; <i>p</i> = 0.0001	17.62±1.46 (15.41–20.08)	8.42±0.28 (8.08–8.66)
AQ scores	–	33.76±6.32 (22–43)	–
Raven test, standard scores	128.24 (95–145) *F(2, 27) = 11.05, <i>p</i> < 0.0001 Post hoc analysis (Games-Howell): <i>p</i> = 0.1; <i>p</i> = 0.82 ns	102.35±30.11 (55–145)	106.93±8.81 (95–120)
WISC-V (verbal comprehension), score	–	69.33±17.72 (47–104)	–
Kave test (expressive vocabulary), score	44.64±2.55 (39–48) *F(2, 28) = 56.80, <i>p</i> < 0.0001 Post hoc analysis (Games-Howell): <i>p</i> = 0.1; <i>p</i> = 0.75 ns	37.64±6.37 (25–46)	36.47±1.73 (34–40)

Figures are mean ± SD (range). TD, typically developing; ASD, autistic spectrum disorder; Raven, matrix test for assessing nonverbal intelligence; m, male; f, female; AQ, autism spectrum quotient; ns, nonsignificant. * Equal variance not assumed.

Adolescents with ASD

This study included 17 adolescents (13 males) with ASD with no comorbid psychiatric disorders according to medical records and psychiatric assessment. The age range of the ASD participants was between 15.4 and 20 years (mean = 17.62, SD = 1.46). The participants were assessed by psychiatric specialists and were diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) [57] criteria for autistic disorder. All adolescents were diagnosed with autism. The main caregiver of all participants completed the autism spectrum quotient (AQ) questionnaire [60]. The AQ assesses a combination of autistic features including social skills, communication, imagination, attention to details, and attention shifting. The AQ has been found to predict a diagnosis of ASD in a clinical sample [61, 62]. The AQ shows high interrater and test-retest reliability [60], and its norms have been replicated in independent samples in the UK [62], in a Dutch sample [63] in several Japanese samples [64] and in Hebrew-speaking samples [65]. All participants scored above 26 points (mean = 33.76, SD = 6.32) on this questionnaire, which was previously reported as a sensitive cutoff point [60, 61, 64] that distinguishes the TD population from those diagnosed with ASD [65]. All ASD participants were interviewed in a pretest conversation phase by 2 certified communication disorder clinicians with special interest in language development and disorders. All adolescents with ASD showed fluent use of spoken language with diverse sentence types and grammatical forms. All participants studied at a special school for children with ASD. The school was a regional educational facility for students with autism between the ages of 10 and 21 who live in Tel Aviv-Yafo.

The demographic details as well as the results of background tests are presented in Table 1. The background tests included: (a) verbal IQ (WISC-V), (b) the “Kave” Hebrew expressive vocabulary test [66], and (c) the Raven Progressive Matrices test for assessing abstract-analytical nonverbal intelligence [67].

TD Groups

Two additional groups of TD adolescents and children served as controls: (1) 17 adolescents (13 males) aged between 15.2 and 20 years (mean = 17.38, SD = 1.49) were matched to the adolescents with ASD by sex and age, and (2) 15 children (6 boys) aged between 8.0 and 8.6 years (mean = 8.42, SD = 0.28). This age group was matched to that of the ASD participants by cognitive-linguistic measures, i.e., Raven test results and expressive vocabulary as shown in Table 1. The reason for matching according to expressive vocabulary was due to an absence of standardized tests in Hebrew for assessing receptive vocabulary in children above 8 years of age. Typical development of the participants was confirmed by parents' questionnaires. Informed consent to participate in this study was obtained from the parent and the participant.

Test Materials

The Hebrew Narrow Focus Test (HNFT) was developed for the purpose of the present study. The test includes 40 everyday simple sentences (subtests A and B) and 20 everyday simple sentences with a compound noun/verb/adjective (subtest C). The sentences were chosen by 5 speech and language pathologists (SLPs) out of 150 possible sentences based on word familiarity and frequency. Only sentences in which all words were judged as very frequent and familiar were selected. The 5 clinicians also judged the sentences as adequate for both elementary school-aged children and adults. A series of pretests confirmed a developmental change in performance on the HNFT. Fifteen 8- to 9-year-olds were able to identify narrow focus without any difficulty. However, the ability to comprehend the meaning of narrow focus (subtests B and C) increased with age. Fifteen 10- to 11-year-olds comprehended narrow focus in simple sentences (subtest B) similarly to adults (unpublished data). However, comprehension of narrow focus in simple compound sentences (subtest C) was better in young adults compared to adults.

Fig. 1. Group results in percent correct responses on subtest A: identifying the word carrying narrow focus in the sentence.

Subtest A assessed the ability to identify the word carrying narrow focus. The subtest includes 5 different 4-word sentences with a similar syntactic structure: subject, predicate, object, and adjective (e.g. “I *EAT a red apple”). Narrow focus is assigned to one of the words in the sentence, so that each sentence appears 4 times in the test with a different word carrying “narrow focus,” totaling 20 sentences. In this subtest the listener has to identify the word carrying “narrow focus” among 4 written alternatives.

Subtest B assesses the ability to infer the meaning of narrow focus as eliminating other alternatives related to the lexical-grammatical role of the word carrying narrow focus. Similar to subtest A, this subtest also includes 5 different 4-word sentences with the same syntactic structure of subject, predicate, object, and adjective. Narrow focus is assigned to one of the words in the sentence, so that each sentence appears 4 times in the test with a different word carrying narrow focus, totaling 20 sentences. In this subtest, the meaning of narrow focus is to eliminate other possibilities related to the same lexical-grammatical category. For example, in the sentence “I hold an *ORANGE book” the meaning of “narrow focus” is to emphasize that the book is orange as opposed to any other color. Thus, the listener has to identify the meaning conveyed by narrow focus among 4 written alternatives (“I hold an orange book”, and not: /him/, /drop/, /green/, /notebook/), where each of the alternatives refers to the grammatical role of the words in the sentence. In order to succeed in this task, the listener has to know that the presence of narrow focus excludes other alternatives related to the lexical-grammatical role of the stressed word.

Subtest C assesses the ability to infer the meaning conveyed by narrow focus in compound sentences, as eliminating a mistake done by the addressee, e.g., “Mom I wanted *RED blue and yellow candies.” The listener is asked a question related to what the addressee (e.g., Mom) did not bring. In the present example, the question is “Which candy didn’t Mom bring?”: /red/, /blue/, /yellow/, /orange/. The 3 alternatives are words that were mentioned

in the sentence (/red/, /blue/, /yellow/) and 1 alternative is a word that was not mentioned but is semantically related to the other alternatives (e.g., /orange/). This subtest includes sentences with compound elements in either the subject, verb, object, or adjective. Each sentence contains between 6 and 7 words. In order to reduce the possibility that the child would automatically choose as an answer the alternative which contained the word with narrow focus, 4 sentences (25%) are used as fillers. These 4 sentences are followed by a positive question (e.g., “Which candies did Mom buy?” /green/, /red/, /orange/, /blue/). In these cases, the answer is one of the unstressed adjectives (e.g., /blue/). Each sentence is presented twice with focused stress on a different word, totaling 20 sentences. In order to succeed in this subtest, the listener has to identify the communication breakdown between the speaker and the addressee and to infer that the stressed word refers to the mistake made by the addressee.

A total of 60 sentences were recorded by 2 female Hebrew-native speakers. The speakers read the sentences and emphasized the word carrying narrow focus. Each speaker recorded 30 sentences. We used 2 speakers in order to exclude the possibility that the way in which narrow focus was uttered by a particular speaker influenced the results. The recordings were made directly to a computer via a microphone (ECM-MS907), using the Sound Forge software (version 7.0) at a sampling rate of 48,000 Hz and a 16-bit quantization level. The intensity between the sentences did not differ by more than 1/2 dB. This intensity range was obtained by normalizing the sentences without changing the ratios between words within the sentences. The focused stress word in the sentence was characterized with greater changes in vocal fundamental frequency (F0), higher intensity, and longer duration compared to the other words in the sentence, as shown in the example in the Appendix. Acoustic measurements of F0, amplitude, and duration were conducted on the stressed vowels using the PRAAT software [62]. For each of the subtests, the measured acoustic parameters (duration, F0, and amplitude) were significantly greater in the stressed vowels that carried the “narrow focus” in the sentence compared to those that did not. The study protocol has been approved by the ethical committees of Tel Aviv University.

Results

In the group of TD adolescents, 4 participants in subtest A performed below Q1 (96.88). However, in subtests B and C, there were no outliers across the 3 groups of participants. No participant was excluded from the study. The mean correct responses (in percentages) for all the 3 subtests of the HNFT were calculated for each group of participants (Fig. 1–3).

The results of subtest A that assess the ability to identify the word creating narrow focus in the sentence are summarized in Figure 1. It can be seen from the figure that TD adolescents showed high scores of correct responses (mean = 98.53, SD = 2.73) compared to adolescents with ASD (mean = 86.03, SD = 14.07) and TD 8- to 9-year-old children (mean = 90.84, SD = 10.26). A one-

Fig. 2. Group results in percent correct responses on subtest B: comprehension of the meaning of the word carrying narrow focus as eliminating other alternatives.

way analysis of variance (ANOVA) test confirmed that the 3 groups of participants differed in their performance ($F_{2,46} = 6.52, p = 0.003, \eta^2 = 0.22$). Further multiple comparisons (Holm-Sidak method since equal variances were not assumed) showed a significant difference between TD adolescents and adolescents with ASD ($p = 0.002$). No correlation was found between TD adolescents and TD children ($p = 0.11$) and between ASD adolescents and TD children ($p = 0.46$).

The results of subtest B assessing the ability to infer the meaning of narrow focus as eliminating other alternatives, are summarized in Figure 2. It can be seen from the figure that TD adolescents showed high scores of correct responses (mean = 93.38, SD = 7.15) compared to adolescents with ASD (mean = 66.54, SD = 28.63) and TD 8- to 9-year-old children (mean = 60.44, SD = 30.58). A one-way ANOVA confirmed that the 3 groups differed in their performance ($F_{2,46} = 8.58, p = 0.001, \eta^2 = 0.27$). Further multiple comparisons (Holm-Sidak method) showed a significant difference between TD adolescents and adolescents with ASD ($p = 0.007$) and between TD adolescents and TD children ($p = 0.001$). No significant difference was found between adolescents with ASD and TD children ($p = 0.86$).

The results of subtest C that assesses the ability to infer the meaning conveyed by narrow focus in compound sentences, as eliminating a mistake done by the addressee are summarized in Figure 3. It can be seen from Figure 3

Fig. 3. Group results in percent correct responses on subtest C: comprehension of the meaning of the word carrying narrow focus as indicating a mistake.

that TD adolescents showed high scores of correct responses (mean = 81.61, SD = 14.05) compared to adolescents with ASD (mean = 59.55, SD = 31.49) and TD 8- to 9-year-old children (mean = 38.76, SD = 32.22). A one-way ANOVA confirmed a significant difference between the 3 groups ($F_{2,46} = 10.05, p = 0.001, \eta^2 = 0.30$). Additional multiple comparisons (Holm-Sidak method) showed a significant difference between TD adolescents and adolescents with ASD ($p = 0.04$), between adolescents with ASD and TD children ($p = 0.03$), and between adolescents with ASD and TD children ($p = 0.001$).

The relationship between performance on the HNFT and autism severity measured by the AQ questionnaire, as well as cognitive and linguistic measures (Raven test, "Kave" test for expressive vocabulary, forward and backwards digit span, and the WISC-V verbal comprehension) was evaluated using a Pearson correlation statistic. The level of significance was set to $p < 0.05$. Of the possible correlations tested with the data of the ASD group, only the Raven scores correlated with subtest B of the HNFT ($r = 0.69, p = 0.002$) and subtest C of the HNFT ($r = 0.67, p = 0.001$) as shown in Table 2.

The results of the correlations in the group of TD children are summarized in Table 3. Significant correlations were found between forward digit span and subtests A and B of the HNFT ($r = 0.64, p = 0.01, p = 0.67, p = 0.005$, for subtests A and B, respectively), and between backward digit span and subtests A, B and C of the HNFT ($r = 0.63$,

Table 2. Pearson correlations between the Hebrew Narrow Focus Test, the AQ questionnaire, the Raven test, the Kave test, forward and backward digit span, and the WISC-V verbal comprehension in the group of adolescents with ASD

		AQ	Raven	Kave	Forward	Backward	WISC-V
Subtest 1	Pearson correlation	-0.29	0.299	0.277	0.219	0.355	0.26
	Sig. (2-tailed)	0.25	0.243	0.282	0.434	0.195	0.35
Subtest 2	Pearson correlation	-0.20	0.690**	0.299	0.171	0.391	0.39
	Sig. (2-tailed)	0.43	0.002	0.243	0.542	0.149	0.15
Subtest 3	Pearson correlation	-0.26	0.667**	0.008	0.216	0.326	0.26
	Sig. (2-tailed)	-0.31	0.003	0.975	0.440	0.236	0.36

AQ, autism spectrum quotient; ASD, autism spectrum disorder. ** Correlation is significant at the 0.01 level (2-tailed).

Table 3. Pearson correlations between the Hebrew Narrow Focus Test, the Raven test, the Kave test, and forward and backward digit span in the group of typically developing children

		Raven	Kave	Forward	Backward
Subtest A	Pearson correlation	0.155	0.259	0.641*	0.631*
	Sig. (2-tailed)	0.580	0.352	0.010	0.012
Subtest B	Pearson correlation	0.472	0.113	0.673**	0.736**
	Sig. (2-tailed)	0.076	0.689	0.006	0.002
Subtest C	Pearson correlation	0.226	0.141	0.272	0.614*
	Sig. (2-tailed)	0.417	0.615	0.328	0.015

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

$p = 0.01$, $p = 0.74$, $p = 0.001$, $r = 0.61$ $p = 0.01$ for subtests A, B and C, respectively). No other significant correlations were found between cognitive and linguistic measures (Raven test, forward and backwards digit span, and the “Kave” test for expressive vocabulary) in the group of TD adolescents.

Discussion

The first goal of the present study was to explore whether adolescents with ASD identify and comprehend narrow focus similarly to TD age-matched peers or similarly to younger TD children matched for cognitive and vocabulary abilities. The second goal was to assess the associations between cognitive-linguistic measures and identification and comprehension of narrow focus. Our findings suggest that adolescents with ASD showed *re-*

duced performance in their ability to identify and comprehend narrow focus compared to TD peers across all the subtests of the HNFT. However, adolescents with ASD performed similarly to TD children with similar cognitive and linguistic (vocabulary) abilities, and no associations were found between autism severity and the ability to identify and understand the meaning of narrow focus in adolescents with ASD. Associations were found between nonverbal IQ and comprehension of narrow focus in adolescents with ASD. In the remainder of the discussion, we elaborate and clarify the implications of these findings.

The first subtest of the HNFT required identification of the stressed word, that is, narrow focus, in 4-word sentences. Overall, adolescents with ASD were able to identify around 85% of the stressed words in sentences. The performance of adolescents with ASD was less accurate compared to age-matched peers who recognized around

99% of the stressed words in sentences. One explanation is that adolescents with ASD had some difficulty in frequency discrimination, which limited their ability to follow changes in F0, an important cue for the identification of the stressed word [68]. This possibility, however, is less likely because previous studies did not find deficits in frequency discrimination by ASD participants [20] while others found evidence of enhanced perceptual abilities [30, 69, 70]. This finding does not support enhanced perceptual abilities, at least in a group of adolescents with ASD with additional cognitive-linguistic difficulties. Another explanation is that higher cognitive factors such as working memory and attention contributed to performance. Although this was not supported by the results which showed no association between working memory measured by forward and backward digit span and the identification of narrow focus, there is a possibility that a more complex memory task with higher cognitive demand may explain the difficulty in identifying narrow focus in this population. Future studies should address the contribution of different perceptual and cognitive factors to the identification of narrow focus.

Once adolescents with ASD had to infer meaning to the stressed word (subtests B and C), their performance dropped compared to subtest A. This is explained by the difficulty of the tasks in subtests B and C both linguistically and cognitively. Subtest B requires comprehension of narrow focus as eliminating other possibilities related to the lexical category of stressed word ("I hold an *ORANGE book"), and subtest C requires comprehension of narrow focus as indicating a mistake done by the addressee ("Mom, I wanted *RED blue and yellow candies"). Taking into consideration that adolescents with ASD showed imperfect performance even in the basic task of identifying narrow focus in the sentence (subtest A), it is not surprising that more complicated tasks of comprehension (subtests B and C) were much more challenging for them compared to peers. The reduced performance of the adolescents with ASD on cognitive-linguistic measure compared to TD peers (Table 1) may further explain their difficulties in comprehension of narrow focus. The present findings are in agreement with a previous study showing reduced comprehension of narrow focus in children compared to TD children [21]. However, young adults with ASD who had preserved cognitive-linguistic abilities did not show reduced comprehension of narrow focus compared to peers [20]. Thus, it is plausible that cognitive-linguistic factors play an important role in the ability of ASD individuals to comprehend narrow focus.

When comparing the ASD group with younger children with similar averaged vocabulary knowledge and cognitive abilities, performance was comparable in subtests A and B of the HNFT and better on subtest C. The somewhat better performance on subtest C is surprising because the two groups were cognitively matched. It is possible that the group of ASD participants had some linguistic advantage that was not evaluated in the present study. Further studies should assess additional linguistic measures including inferences and integration of information presented in sentences in order to gain more knowledge on the abilities of adolescents with ASD compared to younger children. Overall, these findings support the notion that cognitive-linguistic factors are involved in the comprehension of narrow focus in ASD participants. Moreover, a strong association was found between nonverbal intelligence measured by the Raven test and performance on subtests B and C suggesting that nonverbal cognitive abilities underlay performance of narrow focus comprehension. In contrast, the lack of association between the AQ questionnaire that assessed autism severity and the 3 subtests of the HNFT implies that there is no dependency between autism severity and prosodic-linguistic comprehension. Taken together, these findings may suggest that cognitive-linguistic abilities and not the definition of autism or autism severity are related to identification and comprehension of narrow focus in this population of adolescents with ASD.

Although the present study was not aimed to separate between the different cognitive theories that explain autistic behaviors, the findings of the present study may be explained within the framework of the executive dysfunction hypothesis. The ED hypothesis suggests that individuals with ASD may have difficulties in cognitive domains such as planning, inhibition, attention shifting, and working memory [24–26]. Although the present study did not assess executive functions directly, except working memory, the general pattern of findings support the influence of cognitive factors on comprehension of narrow focus. The correlation between performance on the Raven test and the comprehension of narrow focus suggests that analytical thinking and reasoning are involved in the process of comprehending narrow focus in participants with ASD. Analytical thinking and reasoning abilities are linked to executive functions [26]. Thus, executive functions might be the elementary processes influencing performance on both the Raven task and comprehension of narrow focus. However, the association between performance on additional measures of executive functions and comprehension of narrow focus should be

addressed in future studies. The role of the 2 other cognitive theories of autism, the ToM and the weak CC, as explaining comprehension of narrow focus in adolescents with ASD should also be taken into consideration in future research. For example, it would be of interest to use other tasks, such as the false belief task, for assessing ToM, and integrating information in sentences for assessing CC, in order to assess the contribution of these processes to the comprehension of narrow focus.

Clinical Implications

From a clinical viewpoint, it is important that SLPs include identification and comprehension of narrow focus as part of their assessment and treatment of individuals with ASD, especially when additional cognitive and linguistic disabilities accompany the core deficits of autism. Assessing and treating different levels of understanding focused stress, in parallel to the 3 subtests of the HNFT, may provide a valuable tool for facilitating comprehension of narrow focus in this population. Furthermore, incorporating training of narrow focus identification and comprehension by SLPs who work with autistic children and adolescents can advance their understanding of peers and adults in everyday conversations at school and at home.

Further studies should investigate comprehension of narrow focus in ASD participants with higher and lower cognitive abilities in order to define prosodic comprehension in different subgroups within the autistic spectrum. Adding a control group of adolescents with intellectual impairment with no autistic traits and/or a group of adolescents with language impairment may be valuable in confirming the results of the present study that comprehension of narrow focus is not influenced by the autism severity but by cognitive-linguistic factors.

Disclosure Statement

The authors declare no conflicts of interest.

Appendix

Acoustic changes in duration and amplitude (in the upper row) and in fundamental frequency (in the lower row) in the sentence (/ani oxel tapuax adom/; in English: /I eat a red apple/) with narrow focus on the first word /ani/ (in English /I/).

References

- 1 Lehiste I: Suprasegmentals. Cambridge, MIT Press, 1970, pp 120–242.
- 2 Ladd DR: Intonational Phonology. Cambridge, Cambridge University Press, 1996.
- 3 Halliday MAK: Notes on transitivity and theme in English. Part 2. *J Linguist* 1967;3: 199–244.
- 4 Brown G: Prosodic structure and the given/new distinction; in Cutler A, Ladd DR (eds): *Prosody: Models and Measurements*. Berlin, Springer, 1983, pp 67–77.
- 5 Rooth M: A theory of focus interpretation. *Nat Lang Semant* 1992;1:75–116.
- 6 McCann J, Peppé S: Prosody in autism spectrum disorders: a critical review. *Int J Lang Commun Disord* 2003;38:325–350.
- 7 McCann J, Peppé S, Gibbon FE, O'Hare A, Rutherford M: Prosody and its relationship to language in school-aged children with high functioning autism. *Int J Lang Commun Disord* 2007;42:682–702.
- 8 Wang AT, Lee S, Sigman M, Dapretto M: Neural basis of irony comprehension in children with autism: the role of prosody and context. *Brain* 2006;129:932–943.
- 9 Baltaxe C: Use of contrastive stress in normal, aphasic, and autistic children. *J Speech Hear Res* 1984;27:97–105.
- 10 Baltaxe CAM, Simmons J: Prosodic development in normal and autistic children; in Schopler E, Mesibov G (eds): *Communication Problems in Autism*. New York, Plenum Press, 1985, pp 95–125.
- 11 Baltaxe C, Simmons JQ: A comparison of language issues in high-functioning autism and related disorders with onset in childhood and adolescence; in Schopler E, Mesibov G (eds): *High-Functioning Individuals with Autism*. New York, Plenum Press, 1992, pp 201–225.
- 12 Green H, Tobin Y: Prosodic analysis is difficult... but worth it: a study in high functioning autism. *Int J Speech Lang Pathol* 2009;11: 308–315.

- 13 Diehl JJ, Bennetto L, Watson D, Gunlogson C, McDonough J: Resolving ambiguity: a psycholinguistic approach to understanding prosody processing in high-functioning autism. *Brain Lang* 2008;106:144–152.
- 14 Koning C, Magill-Evans J: Social and language skills in adolescent boys with Asperger syndrome. *Autism* 2001;5:23–36.
- 15 Paul R, Augustyn A, Klin A, Volkmar FR: Perception and production of prosody by speakers with autism spectrum disorders. *J Autism Dev Disord* 2005;35:205–220.
- 16 Peppé SJE, Cleland J, Gibbon FE, O'Hare AE, Martínez-Castilla P: Expressive prosody in children with autism spectrum conditions. *J Neurolinguistics* 2011;24:41–53.
- 17 Shriberg LD, Paul R, McSweeney JL, Klin A, Cohen DJ, Volkmar FR: Speech and prosody characteristics of adolescents and adults with high-functioning autism and Asperger syndrome. *J Autism Dev Disord* 2001;44:1097–1115.
- 18 Baron-Cohen S, Leslie AM, Frith U: Does the autistic child have a “theory of mind”? *Cognition* 1985;21:37–46.
- 19 Rutherford MD, Baron-Cohen S, Wheelwright S: Reading the mind in the voice: a study with normal adults and adults with Asperger syndrome and high functioning autism. *J Autism Dev Disord* 2002;32:189–194.
- 20 Globerson E, Amir N, Kishon-Rabin L, Golan O: Prosody recognition in adults with high-functioning autism spectrum disorders: from psychoacoustics to cognition. *Autism Res* 2015;8:153–163.
- 21 Peppé S, McCann J, Gibbon F, O'Hare A, Rutherford M: Receptive and expressive prosodic ability in children with high-functioning autism. *J Speech Lang Hear Res* 2007;50:1015–1028.
- 22 Grzadzinski R, Huerta M, Lord C: DSM-5 and autism spectrum disorders (ASDs): an opportunity for identifying ASD subtypes. *Mol Autism* 2013;4:12.
- 23 Hill EL, Frith U: Understanding autism: insights from mind and brain. *Philos Trans R Soc Lond B Biol Sci* 2003;358:281–289.
- 24 Griffith EM, Pennington BF, Wehner EA, Rogers S: Executive functions in young children with autism. *Child Dev* 1999;70:817–832.
- 25 Robinson S, Goddard L, Dritschel B: Executive functions in children with autism spectrum disorders. *Brain Cogn* 2009;71:362–368.
- 26 Friedman NP, Miyake A, Corley RP, Young SE, DeFries JC, Hewitt JK: Not all executive functions are related to intelligence. *Psychol Sci* 2006;17:172–179.
- 27 Baron-Cohen S, Leslie AM, Frith U: Does the autistic child have a “theory of mind”? *Cognition* 1985;21:37–46.
- 28 Frith U: *Autism: Explaining the Enigma*. Blackwell, Oxford University Press, 1989.
- 29 Happe F, Frith U: The weak coherence account: detail-focused cognitive style in autism spectrum disorders. *J Autism Dev Disord* 2006;36:5–25.
- 30 Mottron L, Peretz I, Ménard E: Local and global processing of music in high-functioning persons with autism: beyond central coherence? *J Child Psychol Psychiatry* 2000;41:1057–1065.
- 31 Shah A, Frith U: Why do autistic individuals show superior performance on the block design task? *J Child Psychol Psychiatry* 1993;34:1351–1364.
- 32 Jolliffe T, Baron-Cohen S: Are people with autism or Asperger syndrome faster than normal on the embedded figures test? *J Child Psychol Psychiatry* 1997;38:527–534.
- 33 Norbury CF, Bishop DV: Inferential processing and story recall in children with communication problems: a comparison of specific language impairment, pragmatic language impairment and high-functioning autism. *Int J Lang Commun Disord* 2002;37:227–251.
- 34 Happé FG: Central coherence and theory of mind in autism: reading homographs in context. *Br J Dev Psychol* 1997;15:1–12.
- 35 Kanner L: Autistic disturbances of affective contact. *Nervous Child* 1943;2:217–250.
- 36 Baron-Cohen S, Staunton R: Do children with autism acquire the phonology of their peers? An examination of group identification through the window of bilingualism. *First Lang* 1994;14:241–248.
- 37 Diehl JJ, Paul R: Acoustic and perceptual measurements of prosody production on the profiling elements of prosodic systems in children by children with autism spectrum disorders. *Appl Psycholinguist* 2013;34:135–161.
- 38 Diehl JJ, Paul R: Acoustic differences in the imitation of prosodic patterns in children with autism spectrum disorders. *Res Autism Spectr Disord* 2012;6:123–134.
- 39 McCaleb P, Prizant B: Encoding of new versus old information by autistic children. *J Speech Lang Hear Res* 1985;50:230–240.
- 40 Baltaxe CA, Guthrie D: The use of primary sentence stress by normal, aphasic, and autistic children. *J Autism Dev Disord* 1987;17:255–271.
- 41 DePape AM, Chen A, Hall GBC, Trainor L: Use of prosody and information structure in high functioning adults with autism in relation to language ability. *Front Psychol Behav Sci* 2012;3:72.
- 42 Simmons JQ, Baltaxe C: Language patterns of adolescent autistics. *J Autism Child Schizophr* 1975;5:333–351.
- 43 DeMyer MK, Barton S, DeMyer WE, Norton JA, Allen J, Steele R: Prognosis in autism: a follow-up study. *J Autism Child Schizophr* 1973;3:199–246.
- 44 Paul R, Shriberg LD, McSweeney J, Cicchetti D, Klin A, Volkmar F: Brief report: relations between prosodic performance and communication and socialization ratings in high functioning speakers with autism spectrum disorders. *J Autism Dev Disord* 2005;35:861–869.
- 45 Mesibov G: Treatment issues with high-functioning adolescents and adults with autism; in Schopler E, Mesibov G (eds): *High Functioning Individuals with Autism*. New York, Plenum Press, 1992, pp 143–156.
- 46 Van Bourgondien ME, Woods AV: Vocational possibilities for high-functioning adults with autism; in Schopler E, Mesibov G (eds): *High Functioning Individuals with Autism*. New York, Plenum Press, 1992, pp 227–239.
- 47 Boucher J, Lewis V, Collis GM: Voice processing abilities in children with autism children with specific language impairments, and young typically developing children. *J Child Psychol Psychiatry* 2000;41:847–857.
- 48 Hobson R, Ouston J, Lee A: Naming emotion in faces and voices: abilities and disabilities in autism and mental retardation. *Br J Dev Psychol* 1989;7:237–250.
- 49 Lerner MD, McPartland JC, Morris JP: Multimodal emotion processing in autism spectrum disorders: an event-related potential study. *Dev Cogn Neurosci* 2013;3:11–21.
- 50 Stewart ME, McAdam C, Ota M, Peppé S, Cleland J: Emotional recognition in autism spectrum conditions from voices and faces. *Autism* 2013;17:6–14.
- 51 Brennan R, Schepman A, Rodway P: Vocal emotion perception in pseudo-sentences by secondary-school children with autism spectrum disorder. *Res Autism Spectr Disord* 2011;5:1567–1573.
- 52 Grossman RB, Bemis RH, Skwerer DP, Tager-Flusberg H: Lexical and affective prosody in children with high-functioning autism. *J Speech Lang Hear Res* 2010;53:778–793.
- 53 Grossman RB, Tager-Flusberg H: Quality matters! Differences between expressive and receptive non-verbal communication skills in adolescents with ASD. *Res Autism Spectr Disord* 2012;6:1150–1155.
- 54 Lambrecht K: *Information Structure and Sentence Form. Topic, Focus, and the Mental Representations of Discourse Referents*. Cambridge, CUP, 1984.
- 55 Wells B, Peppé S, Goulondris N: Intonation development from five to thirteen. *J Child Lang* 2004;31:749–778.
- 56 World Health Organisation: *The ICD-10 Classification of Mental and Behavioural Disorders*. Geneva, World Health Organisation, 1993.
- 57 American Psychiatric Society: *Diagnostic and Statistical Manual for Mental Disorders – Fourth Edition*. Washington, American Psychiatric Publishing, 1994.
- 58 Lord C, Risi S, Lambrecht, Cook EH, Leventhal BL, DiLavore PC, Rutter M: The Autism Diagnostic Observation Schedule – Generic: a standard measure of social and communication deficits associated with the spectrum of autism. *J Autism Dev Disord* 2000;30:205–223.
- 59 Bennetto L, Pennington BF, Rogers SJ: Intact and impaired memory functions in autism. *Child Dev* 1996;67:1816–1835.

- 60 Baron-Cohen S, Wheelwright S, Skinner R, Martin J, Clubley E: The autism spectrum quotient (AQ): evidence from Asperger syndrome/high functioning autism, males and females, scientists and mathematicians. *J Autism Dev Disord* 2001;3:5–17.
- 61 Woodbury-Smith MR, Robinson J, Wheelwright S, Baron-Cohen S: Screening adults for Asperger syndrome using the AQ: a preliminary study of its diagnostic validity in clinical practice. *J Autism Dev Disord* 2005;35:331–335.
- 62 Wheelwright S, Baron-Cohen S, Goldenfeld N, Delaney J, Fine D, Smith R, Wakabayashi A: Predicting autism spectrum quotient (AQ) from the systemizing quotient-revised (SQ-R) and empathy quotient (EQ). *Brain Res* 2006;1079:47–63.
- 63 Hoekstra RA, Bartels M, Cath DC, Boomsma DI: Factor structure, reliability and criterion validity of the Autism-Spectrum Quotient (AQ): a study in Dutch population and patient groups. *J Autism Dev Disord* 2008;38:1555–1566.
- 64 Kurita H, Koyama T, Osada H: Autism-Spectrum Quotient: Japanese version and its short forms for screening normally intelligent persons with pervasive developmental disorders. *Psychiatry Clin Neurosci* 2005;59:490–496.
- 65 Golan O, Gold R, Fridenzon S: The Hebrew version of the autism spectrum quotient (AQ-Heb) as a screening instrument for adults with autism spectrum conditions. Poster presented at the 8th Annual International Meeting for Autism Research (IMFAR), Chicago, 2009.
- 66 Kavé G: Standardization and norms for a Hebrew naming test. *Brain Lang* 2005;92:204–211.
- 67 Raven J, Raven JC, Court JH: Manual for Raven's Progressive Matrices and Vocabulary Scales. San Antonio, Harcourt Assessment, 1998, section 1: General overview.
- 68 Xu Y, Xu CX: Phonetic realization of focus in English declarative intonation. *J Phon* 2005;33:159–197.
- 69 Bonnel A, Motttron L, Peretz I, Trudel M, Galun E, Bonnel AM: Enhanced pitch sensitivity in individuals with autism: a signal detection analysis. *J Cogn Neurosci* 2003;15:226–235.
- 70 Heaton P, Hudry K, Ludlow A, Hill E: Superior discrimination of speech pitch and its relationship to verbal ability in autism spectrum disorders. *Cogn Neuropsychol* 2008;25:771–782.