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THE PHONETICS OF MARKING FOCUS IN AUTISM

One aspect that impacts the social communication of people with Autism Spectrum Disorder (ASD) is abnormal voice patterns. Previous studies have shown heterogeneity in acoustic properties of the phonetic encoding of focus phenomena. The main aim of this study is to investigate whether ASD speakers with different language abilities mark focus in the same way as neurotypical (NT) speakers. Thirty native speakers of Greek (16-27 years old) took part in a question-answer task. Maximum F0 and duration of the subject and the object nouns of their responses (productions) were measured in different focus conditions. Descriptive analyses revealed that ASD speakers with moderate language abilities differ from NT speakers from ASD speakers with high language abilities. Thus, the level of language abilities seems to play a role in the way they encode focus phonetically and this should be taken into account before applying any intervention strategy.

Keywords: Autism, Focus, Phonetics, Greek

1. INTRODUCTION

Autism is a neurodevelopmental disorder often characterized by repetitive, restricted, stereotyped behavior, interests, and/or activities and is usually associated with failure to initiate or respond to social interactions and communication DSM-V (American Psychiatric Association 2013: F84.0); ICD-11 (World Health Organization 2022: 6A02). The communication abilities of people with Autism Spectrum Disorder (ASD) can vary from nonverbal to advanced conversational skills. One aspect that impacts the social interactions of people with ASD who communicate verbally is impaired voice patterns. Voice patterns not only play a crucial role in everyday life communication with family and friends but are also important in the learning process and are relevant for school, academic, and career assessment.

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Voice patterns have been found to be atypical in individuals with ASD. For example, Shriberg et al. (2001: 1109–1111) found inappropriate accent placement and DePape et al. (2012: 6–11) observed inappropriate usage of pitch and duration in sentence productions. Voice patterns are particularly relevant in order to mark focus. The focus phenomenon refers to the marking of new information in an utterance by using prosodic prominence. Focus is part of the information structure theory [see e.g., Krifka (2008: 243–262)]. In a few words, utterances contain new and old information. Old (or given) information is already known by the listener and therefore does not receive focus marking, while new information is more prominent and usually receives focus marking. Consider the following questions (1a, 1b, 1c), which always lead to the same answer ("Mary cut the yarn"), but differ in the element that is in focus:

(1) a. *Broad Focus* (neutral condition – all information is new)
What happened?
[Mary cut the yarn.]

b. *Narrow Focus Subject* (Mary– the subject is the new information)
Who cut the yarn?
[MARY] cut the yarn.

c. *Narrow Focus Object* (yarn – the object is the new information)
What did Mary cut?
Mary cut the [YARN].

The answer "Mary cut the yarn" is the same lexically and syntactically in all three conditions above, but it differs acoustically in each one. In particular, a different element is new and prominent in 1b and 1c. Subsequently, the following questions arise: How can we measure this prominence? What are the acoustic features that mark the prominent element?

For Greek, studies investigating prosody report that H* and H*+L signal broad focus and L+H* signals narrow focus (Baltazani 2003: 89; Arvaniti, Ladd & Mennen 2006: 424–429). Recently, Lohfink, Katsika and Arvaniti (2019: 701–704) made a new distinction between the above H* and H*+L signals of broad focus, including more parameters from pragmatics. They propose that both pitch accents indicate that the accented item is new in discourse, but H*+L additionally indicates that the speaker has a familiarity with the focused item. Turning to phonetics, earlier studies in Greek (Baltazani & Jun 1999: 1305–1308; Botinis & Bannert 2003: 105–108) did not find robust evidence regarding the phonetic representation of focus and the unit that the focus affects. Thus, while Baltazani

and Jun (1999: 1305–1306) argued that focus lengthens the focused word, Botinis and Bannert (2003: 106–107) implied through their results that focus affects mainly the duration of a stressed syllable.

Cross-linguistically, it seems that F0 maximum and duration are the two central acoustic features in focus phenomena of neurotypical populations. In English, for example, Breen et al. (2010: 1056–1058) show that duration, mean F0, maximum F0, and maximum intensity are the four – out of the twenty-four candidate acoustic features that they examined – most important markers encoding differences among focus conditions. Moreover, Rao et al. (2017: 110–120) show that duration first and F0 second are probably the most significant acoustic features in the distinction of focus conditions in Marathi.

The studies presented above investigate neurotypical speakers. To date, little is known about acoustic features and prosodic patterns of individuals with ASD. McCann and Peppé (2003: 325–327) conducted one of the first literature reviews including sixteen studies of individuals with ASD. The majority of these studies used subjective measures from which no clear conclusion can be drawn. Two (Baltaxe, Simmons & Zee 1984: 713–718; Fosnot & Jun 1999: 1925–1928) out of the sixteen studies included acoustic measurements. These two revealed contradictive results, as Fosnot and Jun (1999: 1925–1928) observed atypical acoustic patterns of speech whereas Baltaxe, Simmons and Zee (1984: 713–718) did not. More recently, Fusaroli et al. (2017: 386–403) systematically reviewed the literature on distinctive acoustic patterns in ASD and could not find a predictor for severity of clinical features. They interpret the lack of evidence as a matter of methodology, namely, that the methods used in the studies were too diverse and therefore not comparable to each other. On the other hand, acoustic analysis together with perceptual judgments of prosody clearly demonstrates that prosody is impacted in ASD (Patel et al. 2020: 3039–3043) [i.e., flat monotone voice, unusual modulation or stress, increased volume]. For instance, Paul et al. (2008: 116–119) found that individuals with ASD produced less lengthening on stressed syllables, as well as a pattern of increased F0 range for both stressed and unstressed syllables compared to neurotypical participants. Further studies (Diehl et al. 2009: 385–401; Nadig & Shaw 2012: 499–510) took into account the functionality of the participants with ASD and differences in pitch range have been observed when high-functioning individuals with ASD are compared to neurotypical controls. Importantly, both Diehl et al. (2009: 390) and Nadig and Shaw (2012: 501–507) included the language level of the participants as well, which is important because focus is a linguistic phenomenon, hence, is expected it to be associated with general linguistic abilities. Subsequently, DePape et al. (2012: 6–11) and Krüger et al. (2018: 182–185), taking into account the language level of the participants, investigated the voice patterns in focus. Particularly,

Krüger et al. (2018: 182–185) discovered a reduced ability of individuals with ASD to mark focus via pitch. Furthermore, DePape et al. (2012: 6–11) found that ASD participants with high language functioning did not mark focus appropriately, despite the fact that they used the same pitch range as neurotypical adults. However, participants with ASD and moderate language functioning used a smaller pitch range, but they marked it appropriately with longer word duration, in the same way as the neurotypical speakers did.

To date, there is no study which solely focuses on prosody and information structure in autism, including focus in Greek. Studies of Greek participants with ASD emphasize the syntactic and pragmatic domain of information structure (Marinis et al. 2013: 321–335; Terzi et al. 2014: 4–40; Terzi, Marinis & Francis 2016: 2692–2705). For instance, Terzi et al. (2016: 2704–2705) conjecture that high-functioning children with ASD had difficulties mapping morphosyntax and prosody with the consequence that they erroneously used clitics in focus structures, but did not investigate prosody or acoustic results. A case study that investigated pitch range and duration, but without relating these patterns to information structure, is the study of Tripolitou and Chaida (2011). In this study, a female 43-years-old adult with ASD used pitch and duration appropriately in order to mark polar questions and statements when reading them. The participant was compared to a control group of five female neurotypical speakers, without further specification of the age of the control participants. There are two methodological problems in the above study: First, the researchers did not refer to the participants' language abilities. Second, it is implied that the speakers were reading the sentences. This technique creates validity issues because productions read aloud are not considered as natural. Therefore, these findings raise the question of the relationship between language abilities and usage of the acoustic cues of the individual with ASD.

To sum up, there are two open questions: First, do people with ASD differ in marking focus compared to neurotypical people? Second, do ASD people's language abilities play a role in this marking? To address the shortcomings of the aforementioned studies, a question-answer task for the three focus conditions was created and 10 neurotypical Greek and 20 Autistic Greek speakers with moderate and high language abilities were tested.

2. METHODOLOGY

2.1. Participants

Thirty native speakers of Greek (12 females and 18 males) aged from 16 to 27 years took part in a question-answer task. Twenty were individuals with ASD (12 males: age M±sd = 21.75+/-4.14 and 8 females: age M±sd = 19.63+/-3.99), who had all been diagnosed according to the ICD-10 criteria: F84.0 (Childhood

autism: Autism disorder). They were recruited from rehabilitation centers in Athens. In addition, ten neurotypical controls (6 males: age M±sd = 21.17+/-3.60 and 4 females, M±sd = 19.75+/-2.88) were recruited from the experimenter's social circle. All participants completed the short version of the Boston Naming Test (BNT), as translated and standardized in Greek (Simos, Kasselimis, et al., 2011; Simos, Sideridis, et al., 2011). Depending on their BNT score, the ASD participants were divided into two groups. Thus, in this study there are three groups (10 participants/group, 6 males and 4 females). For every participant of the ASD group with high language abilities (HL-ASD group) there is one participant with ASD and moderate language abilities (ML-ASD) and one NT control of the same gender[2] and similar age.

None of the participants had any hearing or visual problems. Participation in the study was voluntary and participants gave written informed consent before taking part in it.

2.2. Material

The task consisted of short video clips, where participants saw a picture[3] and listened to a prerecorded question[4] corresponding to different focus types: Wide focus (WF), Narrow Focus, Subject (FS), and Narrow Focus, Object (FO). Questions had to be answered with a full sentence. In order to make the productions as comparable as possible, the extraction of acoustic features as easy as possible, and to avoid semantic effects, the following three criteria were taken into account in constructing the testing items:

a) Length and stress: All testing items were disyllabic words with first syllable stress.
b) Sonority: All testing items were comprised mostly of sonorant phonemes based on the sonority scale in Papakyritsis, Kastani & Nerantzini (2019: 756–760).
c) Semantic effect: All testing items were proper names or mostly common inanimate objects.

Based on these criteria, thirteen sets (12 testing sets and 1 set for

[2] As a reviewer points out "It is well known that male and female utterances differ, sometimes considerably, both in their overall f0 height (i.e., female voices have higher f0 than male ones) and in their f0 range (i.e., the extent of difference between the min and max f0 value in the utterance, with females, but not males, often producing quite high f0 values in focused items)". In this study, participants were mached in gender in order to avoid masking differences in the results of f0.

[3] Real-life actions were photographed by the researcher.

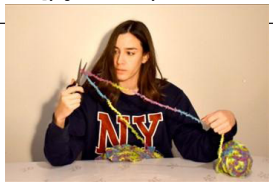
[4] The questions were recorded by the researcher, who is a phonologically trained female native speaker of standard Greek, using Audacity (Version 2.3.3).

familiarization) were created. A sample set is presented in Table 1 and Figure 1.

Table 1 | Sample set

Target sentence:	Η Μαίρη έκοψε το νήμα. (Greek)	
	[i ‘Meri]$_S$ [‘ekopse]$_V$ [to ‘nima]$_O$	
	“Mary cut the yarn. “	
Condition	**Focus location**	**Set up question**
0	Wide Focus	[ti ˈejine eðo] “What happened here?”
1	Narrow Focus Subject	[pços ˈekopse to ‘nima] “Who cut the yarn?”
2	Narrow Focus Object	[ti ‘ekopse i ˈmeri] “What did Mary cut?”

Figure 1 | Example set

[ti ˈejine eðo]	[pços ˈekopse to ‘nima]	[ti ‘ekopse i ˈmeri]
		
Wide Focus	Narrow Focus Subject	Narrow Focus Object
Target sentence: [i ‘Meri ‘ekopse to ‘nima]		

2.3. Procedure

Data collection took place in person and the experiment was conducted via PsychoPy (Version 2020.1.3). The protocol included a short familiarization[5] part, followed by the experimental part, which was divided in three blocks, corresponding to the three focus types. Total duration was approximately 15 minutes.

[5] Familiarization with the stimuli is important in order for the productions to sound as natural as possible. To familiarize themselves with the stimuli, the participants had to first to watch a short video (two and a half minutes) with pictures in which the characters, the objects and the actions of the stimuli were presented to them. Afterwards, they had to name the pictures. Participation in the experiment was possible only if they named correctly at least 23 out of the 26 pictures.

The order of the three blocks was randomized. Each block consisted of twelve questions for each of the three information structure conditions of interest: Wide Focus (WF), Narrow Focus Subject (FS), and Narrow Focus Object (FO), and six filler items. All blocks employed the same verbs and characters, which were pseudorandomized within blocks so that they did not appear in consecutive sentences. The participants saw a picture and listened to a "who"- or a "what"-question and had to answer each question (see Figure 1). The participants were instructed to listen carefully and produce aloud a complete sentence with subject, verb, and object. Participant responses were recorded at a rate of 44.1 kHz for offline acoustic analysis.

In total, the data sample contained 2160 tokens. Out of those 292 (7%) were discarded because (1) the speaker failed to use the correct lexical items; (2) the speaker was disfluent; or (3) the production was poorly recorded. The remaining 1868 tokens were subjected to the acoustic analyses in Praat, in which each utterance was annotated manually at the word level. Figure 2 and Figure 3 show screenshots of the Praat interface with a segmented utterance. Finally, using a Praat script, duration and F0 maximum (F0max) of the Subject and the Object of each utterance were extracted and analyzed in R (2021: Version 4.2.1).

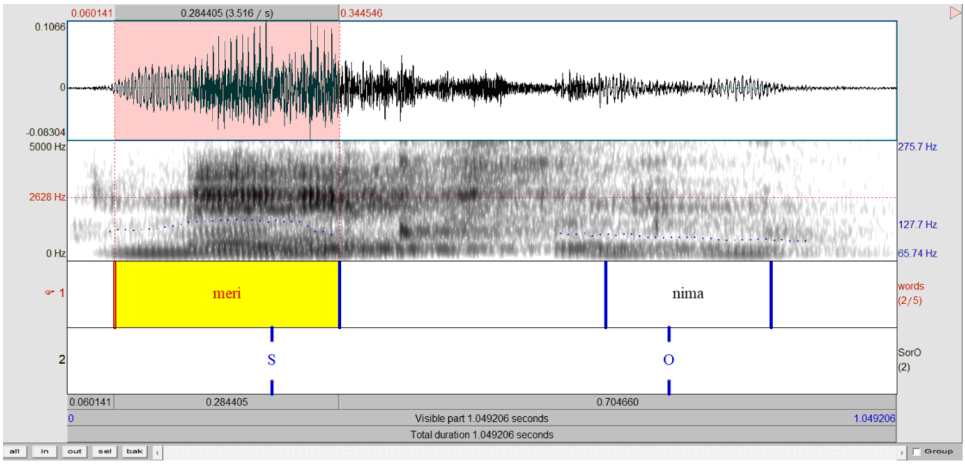


Figure 2. Screenshot of Praat views of waveform and spectrogram of an utterance with the words boundaries marked at the Narrow Focus Subject (FS) condition. The utterance in this example is the following: /i meri ekopse to nima/ (Mary cut the yarn). In the second layer (point tier), S (Subject) corresponds to /meri/ (Mary) and O (Object) corresponds to /nima/ (yarn).

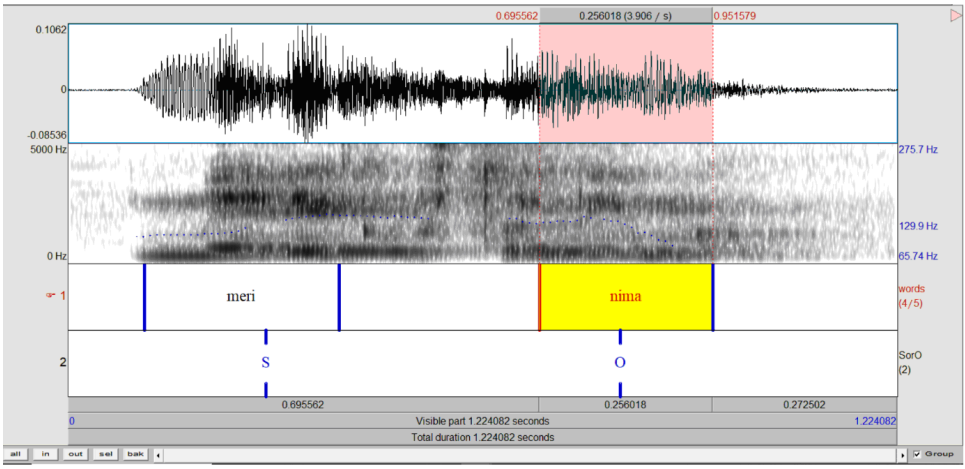


Figure 3. Screenshot of Praat views of waveform and spectrogram of an utterance with the words boundaries marked at the Narrow Focus Object (FO) condition. The utterance in this example is the following: /i meri ekopse to nima/ (Mary cut the yarn). In the second layer (point tier), S (Subject) corresponds to /meri/ (Mary) and O (Object) corresponds to /nima/ (yarn).

3. RESULTS

Greek has a flexible word order with SVO (Subject-Verb-Object) being the predominant word order and VSO a frequent alternative (Holton et al. 2016: 518-521). In the present study, the majority of the participants' sentences (>75%) had an SVO structure. Therefore, the figures reflect this word order, i.e., in the horizontal axis, the subject is presented first followed by the object. The figures present the mean values of F0max and duration. On the right vertical axis, the three focus conditions are presented: Wide Focus (WF), Narrow Focus Subject (FS), and Narrow Focus Object (FO). F0max was measured in Hz and duration was measured in seconds.

Overall, results show for the WF condition that F0max falls or stays at the same level and, similarly, duration becomes shorter or stays at the same level (Figures 2-4). The experimental conditions FS and FO are analyzed in detail below. An overview of the results is presented by first comparing the ASD group with the NT group and in a subsequent step the ASD group is divided into two subgroups based on the participants' language abilities.

3.1. ASD factor in participants

The participants were divided into two groups (ASD and NT) depending on the diagnosis of autism (language abilities were not taken into account in this

grouping). Figure 4 presents the results for F0 and Figure 5 the results for duration. The exact value of each data point (subject and object in different conditions for the two groups) are found in Table 2 and Table 3, for F0 and duration respectively. In both figures the ASD group (blue line) is compared to the NT group (red line). Overall, results show higher F0max and longer duration in the produced elements of the ASD group, for both subject and object, reflected across all three conditions.

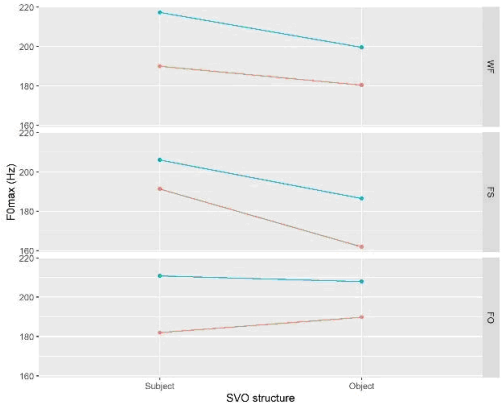


Figure 4. NT Vs. ASD in F0 (Hz)

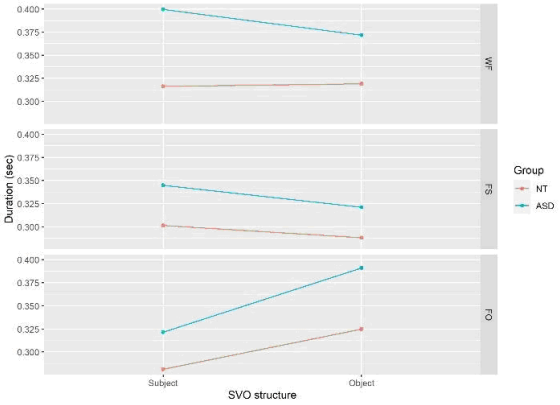


Figure 5. NT Vs. ASD in duration (sec)

The NT group shows higher F0max and longer duration in the target element when it was focused, in both FS and FO conditions (i.e., focus on subject in FS and focus on object in FO). The ASD group did not show a similar pattern in all the conditions. In the FO condition, the focused object was produced with similar or a slightly lower F0max than the unfocused subject. In contrast, the duration in the ASD group shows a steeper rise compared to the NT group and it is the only case in which the focused object is longer compared to the subject of the same condition (FO). In the FS experimental condition, the ASD group showed a slighter drop compared to the NT group in both measurements (F0max and duration).

Table 2: NT vs. ASD in F0 (Hz)

Group	Condition	Subject	Object
NT	WF	190	180
	FS	191	162
	FO	182	190

ASD	WF	217	200
	FS	206	187
	FO	211	**208**

Table 3: NT vs. ASD in duration (sec)

Group	**Condition**	**Subject**	**Object**
NT	WF	0.32	0.32
	FS	0.30	0.29
	FO	0.28	0.33
ASD	WF	0.40	0.37
	FS	0.34	0.32
	FO	0.32	0.39

3.2. Language factor in the ASD groups

In this section we are concerned with the language abilities of the ASD participants and how they impact their performance on focus. Recall that, the ASD participants were matched for age and gender with the NT participants (Group 1) and two ASD groups (Group 2 and 3) were created. Group 2 and Group 3 had participants with ASD but each with different language abilities. Group 2 (HL-ASD) was matched on language abilities with Group 1, so that both groups had participants with high language abilities, while Group 3 (ML-ASD) had participants with moderate language abilities.

Looking more closely at these two new subgroups of autistic participants, some differences are revealed. Figure 6 and Table 4 show F0max in Hz and Figure 7 and Table 5 show the duration in seconds. In both figures, the ML-ASD group shows a higher F0max and longer duration in almost all conditions compared to the HL-ASD group. The F0max in the object of FS condition and the duration in the subject of the FS and FO condition are the only exceptions in which the HL-ASD group has higher values than the ML-ASD group.

Table 4: Language level in F0 (Hz)

Group	**Condition**	**Subject**	**Object**
NT	WF	190	180
	FS	191	162
	FO	182	190
HL-ASD	WF	211	194
	FS	**202**	189
	FO	206	**205**

ML-ASD	WF	224	206
	FS	210	184
	FO	216	**211**

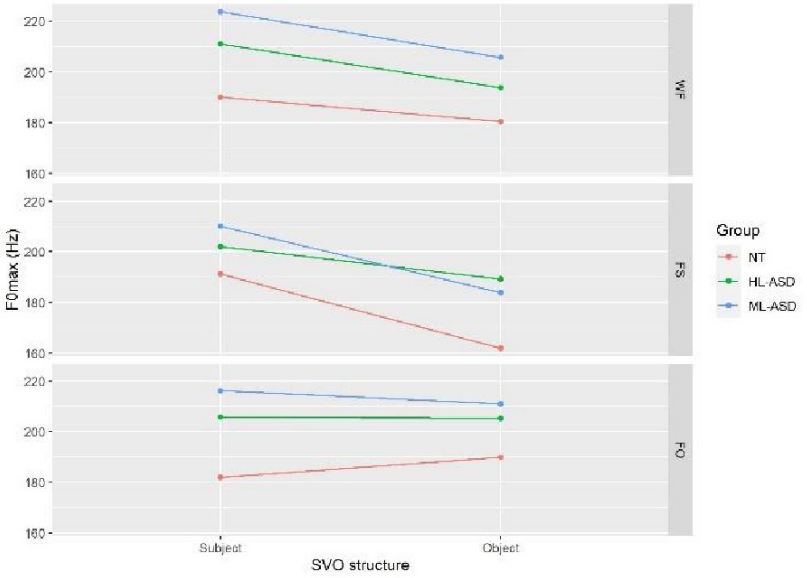


Figure 6. Language level in F0 (Hz)

More specifically, in the FS condition the HL-ASD group has a more expressed slight fall of F0max and a steep decrease of duration compared to the ML-ASD group. However, both ASD groups keep the focused subject in higher F0max and with longer duration than the object in the same condition. In contrast, in the FO condition F0max of the object is almost similar or slightly lower than the one of the subject. However, the duration on the focused object was longer than the (unfocused) subject in both groups in the FO condition. Note that the duration of the object in the FO condition is 100 ms (0.41-0.31=0.1 sec) longer than the subject in this condition for the ML-ASD group.

Table 5: Language level in duration

Group	Condition	Subject	Object
NT	WF	0.32	0.32
	FS	0.30	0.29
	FO	0.28	0.33

HL-ASD	WF	0.39	0.36
	FS	0.35	0.31
	FO	0.33	0.38
ML-ASD	WF	0.41	0.39
	FS	**0.34**	0.33
	FO	0.31	0.41

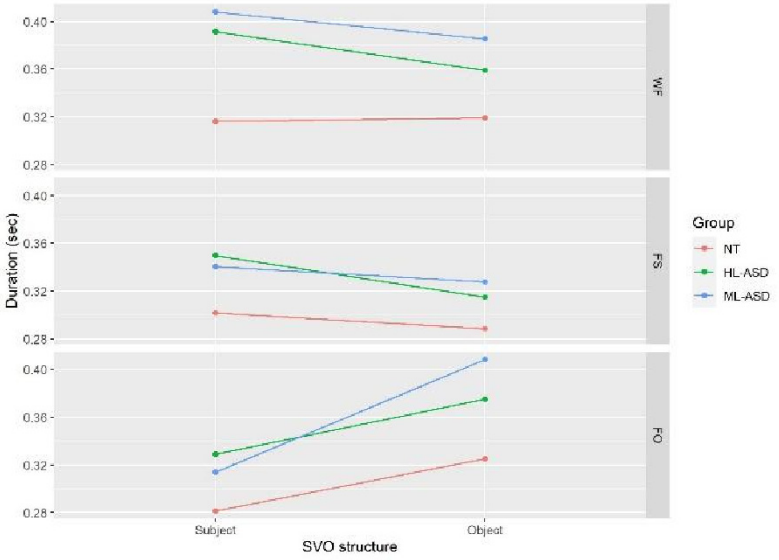


Figure 7. Language level in duration (sec)

4. DISCUSSION

An elicitation task in which the participants see a picture and listen to a pre-recorded question was created in order to measure F0max and duration of the subject and the object of simple SVO sentences in three conditions. In the first condition, the question "What happened?" required a wide focus (WF) answer. The second question, "Who did something?" was used in order to elicit an answer with focus on the subject (FS) and the third question "What did somebody do?" was used to elicit an answer with focus on the object (FO). Thirty participants took part in this study, 20 had been diagnosed with ASD; 10 of them with high language abilities and 10 with moderate language abilities. The study investigates whether Greek speakers with ASD differ from NT speakers in the way they mark Focus when producing simple SVO sentences and if their language abilities play

a role.

Overall, ASD participants, and especially ML-ASD participants, produced all elements (subject and object) in all conditions with higher F0max and longer duration compared to their NT controls. Thus, the general observation is that the participants with ASD produced sentences with higher F0max and with longer duration.

Comparing the two focused elements (subject-object) at the two experimental conditions (FS and FO), we see that the NT group showed higher F0max and longer duration on the element which was focused, in line with previous studies. In other words, when the subject was in focus in FS, it was the most prominent element of the sentence and was produced with higher F0max and longer duration compared to the object of the same sentence. However, the ASD participants did not show the same behavior.

Another aspect of the results becomes obvious when the unfocused element in the experimental conditions (i.e., the object in the FS and the subject in the FO condition) is compared with the corresponding element in the WF condition. All groups produced the unfocused element in the FS and FO conditions with lower F0max and shorter duration compared to the same unfocused element in the WF condition. For instance, in HL-ASD, the unfocused object in FS was 189 Hz, which was lower than the 194 Hz of the unfocused object in the WF condition. This suggests that ASD participants may be aware of a difference in marking focus but are facing difficulties when it comes to expressing this difference.

To sum up, in line with previous studies, the present study showed differences between NT and ASD participants when marking focus. Furthermore, results show differences in terms of how to mark focus even within the ASD group, i.e., comparing ASD participants with moderate language abilities to ASD participants with high language abilities. This finding highlights the relevance of language abilities when investigating the production of focus marking of ASD speakers. Thus, future studies should take into account the general language abilities of ASD speakers, even when addressing prosodic abilities, such as focus.

The findings of the present study combined with findings of previous studies, reveal that voice patterns in ASD are affected and should be further investigated in depth. The precise nature of voice patterns in ASD remains unclear. To address this gap, future studies should include phonology for analyzing the contours and investigate whether, how, and where the F0 contours differ between ASD groups or even between ASD individuals. Another issue that arises for the present study is whether the target word was indeed focused. This can be resolved with a perception experiment administered to a group of NT speakers.

The present study constitutes one of the first attempts to investigate phonetic measurements of ASD speakers in Greek. It included a relatively small number

of participants, and therefore, the results are presented only descriptively and should be interpreted with caution. Future studies investigating focus marking in ASD speakers will be important for speech-language pathologists. This is because it is crucial to first understand the underlying nature of focus marking of ASD speakers with different levels of language abilities in order to attain successful speech-language intervention strategies.

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ΦΩΝΗΤΙΚΑ ΧΑΡΑΚΤΗΡΙΣΤΙΚΑ ΤΗΣ ΕΣΤΙΑΣΗΣ ΣΤΟΝ ΑΥΤΙΣΜΟ

Περίληψη

Ένας παράγοντας που επηρεάζει την επικοινωνία των ατόμων με Διαταραχή Αυτιστικού Φάσματος (ΔΑΦ) είναι η χρήση μη τυπικών μοτίβων στην ομιλία. Προηγούμενες έρευνες σε αυτόν τον πληθυσμό, έχουν δείξει ανομοιογένεια στα μετρήσιμα ακουστικά χαρακτηριστικά που χρησιμοποιούνται ως δείκτες της εστίασης. Στόχος της παρούσας έρευνας ήταν να ερευνήσει κατά πόσο τα αυτιστικά άτομα με διαφορετικές γλωσσικές ικανότητες μαρκάρουν την εστίαση με τον ίδιο τρόπο όπως οι νευροτυπικοί ομιλητές. Στην έρευνα συμμετείχαν τριάντα μονόγλωσσοι Έλληνες ομιλητές, 16-27 ετών, οι οποίοι ολοκλήρωσαν μία δοκιμασία κατά την οποία έβλεπαν μια εικόνα, άκουγαν μια ερώτηση και έπρεπε να απαντήσουν με μία ολοκληρωμένη πρόταση. Οι ερωτήσεις καθόριζαν τα διαφορετικά είδη εστίασης της κάθε απάντησης/εκφοράς: Ευρεία Εστίαση, Περιορισμένη Εστίαση στο Υποκείμενο, Περιορισμένη Εστίαση στο Αντικείμενο. Η μέγιστη θεμελιώδης συχνότητα και η διάρκεια του Υποκειμένου και του Αντικειμένου μετρήθηκαν σε όλες τις συνθήκες. Η περιγραφική ανάλυση αυτών των μετρήσεων αποκάλυψε ότι τα άτομα με ΔΑΦ διαφέρουν από τους νευροτυπικούς ομιλητές. Ειδικότερα, οι αυτιστικοί με μέτριες γλωσσικές ικανότητες παρουσίασαν διαφορές τόσο από τους νευροτυπικούς όσο και από τους αυτιστικούς με υψηλές γλωσσικές ικανότητες. Επομένως, το επίπεδο των γλωσσικών ικανοτήτων είναι ένας παράγοντας που σχετίζεται με τον τρόπο που κωδικοποιείται η εστίαση. Τα αποτελέσματα αυτής της έρευνας καταδεικνύουν ότι είναι σημαντικό οι λογοπαθολόγοι-λογοθεραπευτές να εξερευνούν λεπτομερώς τους φωνητικούς δείχτες του κάθε ατόμου με ΔΑΦ πριν προχωρήσουν στην δημιουργία της θεραπευτικής παρέμβασης.

Λέξεις-κλειδιά: Αυτισμός, Εστίαση, Φωνητική, Ελληνική